A Third Industrial Revolution Master Plan to Transition Rome into the World's First Post-Carbon Biosphere City

Prepared by the Office of Jeremy Rifkin and the Third Industrial Revolution Global CEO Business Roundtable

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We would like to thank the contributing members of the Third Industrial Revolution Global CEO Business Roundtable and the Global Sustainability Team including but not limited to: Luigi Giampiero and Valerio Faccenda (Acciona); Gordon Gill, Robert Forest and Chris Drew (Adrian Smith & Gordon Gill Architecture); Axel Friedrich (Alwitra); Woodrow W. Clark II (Clark Strategic Partners); Enric Ruiz Geli (Cloud 9); Adel El Gammal (EPIA); Joe Cargnelli (Hydrogenics); Angelo Consoli (Hydrogen University); Luca Galofaro (Ian +); Carlo Drago (IBM); Pier Nabuurs (KEMA); Andrew Linowes (Office of Jeremy Rifkin); Aldo Bigatti and Laura Teruzzi (Philips Lighting); Byron McCormick (Prepared Minds International); Mauro Di Fiore (Q-Cells International); Robert Niederkofler (Ropatec); Christophe Juillet (Schneider Electric); and Carlo Petrini (Slow Food International).

We would also like to thank the Energy Policy Coordinator of the City of Rome Livio de Santoli, for his coordination and technical support of the local energy network, as well as the numerous companies and individuals that participated in the workshop in December 2009.

We also express our deep appreciation for the guidance and insight of the Mayor of Rome Gianni Alemanno. Without his invaluable contribution, none of this would have been possible.

A Letter from the President

The human species marked a milestone in 2007, when more than half of the world's population was living in cities. For most of human existence, human beings have lived off the land, planting and harvesting to meet their daily needs. The great agricultural age, which spanned more than 12,000 years, has now been eclipsed by urban life. In 1950, only 83 cities on Earth hosted more than one million residents; by 2007, this number was 468.[1] Today, these megacities—boasting populations of millions—pose new environmental challenges as well as opportunities to create an interconnected, interdependent world.

While agricultural life is no longer the dominant activity of our species, it is still the basis of our survival. The primary economy on Earth is photosynthesis and all of our other economic activity is built on its foundation. Our scientists tell us that the nearly seven billion human beings now inhabiting the Earth make up less than one percent of the total biomass of all the Earth's consumers.[2] Yet, with our complex global economic and social infrastructure, we are currently consuming nearly 24 percent of the net primary production on Earth—"the net amount of solar energy converted to plant organic matter through photosynthesis."[3] With the human population expected to increase to more than ten billion people by 2050, the strain on the Earth's ecosystems is likely to have devastating consequences for the future survival of all forms of life.[4] Indeed, many scientists now wonder if we might be entering a new phase of the evolutionary sojourn on Earth, with the prospect of a mass extinction occurring over the next century.

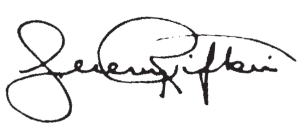
The problem of overpopulation is now coupled with the equally troubling prospect of a catastrophic shift in the earth's temperature from spewing two centuries of carbon dioxide, methane and nitrous oxide into the atmosphere. Scientists warn that a two to three degree Celsius rise in the temperature on Earth in this century could destabilize ecosystems around the world and further hasten the extinction of a vast number of species.

Never before in history has the human species found itself in such a precarious state. With our own survival on Earth now in question, an increasing number of scientists, government and business leaders, and civil society organizations are asking how to rethink urban life in a way that will allow our species to flourish while ensuring the well-being of our fellow creatures and the ecosystems which sustain all life on the planet.

The Third Industrial Revolution Global CEO Business Roundtable and the City of Rome have entered into a collaborative partnership to rethink the very idea of the city in the 21st century. The mission is to prepare Rome to make the transition to a post-carbon Third Industrial Revolution economy between now and 2050 and to become the first city of the Biosphere Era. Toward this end, we have developed a new concept of urban living that will bring both city and countryside together, creating a seamless social milieu for sustaining our species for centuries to come. The plan we have outlined—the first of its kind—would remake Rome, embedding it within a surrounding biosphere park that would provide its inhabitants with a locally sustainable economic existence far into the future.

We look forward to achieving this goal together.

Sincerely,



Jeremy Rifkin

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1 http://www.citypopulation.de/world/Agglomerations.html

2 Miller, G. Tyler, and Scott Spoolman. Sustaining the Earth. Florence, KY: Cengage Learning, 2008.

3 Haberl, H., K. H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, W. Lucht, and M. Fischer- Kowalski. "Quantifying and Mapping the Human Appropriation of Net Primary Production in Earth's Terrestrial Ecosystems." Proceedings of the National Academy of Science USA. Vol. 104. No. 31. 2007. p. 12,942.

4 http://ipsnews.net/news.asp?idnews=46080

Contents

1 Introduction:

The global economy has shattered. The fossil fuel energies that propelled an industrial revolution are sunsetting and the infrastructure built off these energies is barely clinging to life. Making matters worse, we now face catastrophic climate change from spewing industrial induced CO_2 into the atmosphere for more than two centuries. The entropy bill for the industrial age has come due, with ominous and far-reaching consequences for the continuation of life on Earth.

What is happening to our world? The human race finds itself groping in a kind of twilight zone between a dying civilization on life support and an emerging civilization trying to find its legs. Meanwhile, old identities are deconstructing while new identities are still too fragile to grasp. To understand our current plight and future prospects, we need to step back and ask: what constitutes a fundamental change in the nature on civilization?

The great changes in civilization occur when new energy regimes converge with new communication revolutions, creating new economic eras. The new forms of communication become the command and control mechanisms for structuring, organizing and managing the more complex civilizations made possible by the new energy regimes. For example, in the early modern age, print communication became the means to organize and manage the technologies, organizations and infrastructure of the coal, steam and rail revolution. It would have been impossible to administer the First Industrial Revolution using script and codex.

Communication revolutions not only manage new, more complex energy regimes, but also change human consciousness in the process. Forager/hunter societies relied on oral communications and their consciousness was mythological. The great hydraulic agricultural civilizations were, for the most part, organized around script communication and steeped in theological consciousness. The First Industrial Revolution of the 19th century, managed by print communication, ushered in ideological consciousness. Electronic communication became the command and control mechanism for arranging the Second Industrial Revolution in the 20th century and spawned psychological consciousness.

Today, we are on the verge of another seismic shift in communication technology and energy regimes. Distributed information and communication technologies are converging with distributed renewable energies, creating the infrastructure for a Third Industrial Revolution.

1.1 THE THIRD INDUSTRIAL REVOLUTION

In the 21st century, hundreds of millions of human beings will transform their buildings into power plants to harvest renewable energies on-site, store those energies in the form of hydrogen and share electricity with each other across continental inter-grids that act much like the Internet. The open source sharing of energy gives rise to collaborative energy spaces—not unlike the collaborative social spaces on the Internet.

The Third Industrial Revolution is built upon a foundation of increased energy efficiency—using less energy to provide the same level of energy service, while maximizing utility from increasingly scarce resources. From this foundation the four pillars of the Third Industrial Revolution can be constructed:

- The expanded generation and use of **renewable energy** resources—gathering the abundant energy available across our planet, wherever the sun shines, the wind blows, biomass and garbage are available, the tides wax and wane, or geothermal power exists beneath our feet.
- The use of **buildings as power plants**—recognizing that homes, offices, schools and factories, which today consume vast quantities of carbon producing fossil fuels, could tomorrow become renewable energy power plants.
- The development of **hydrogen and other storage technologies**—storing surplus energy to be released in the times when the sun isn't shining or the wind isn't blowing.
- A shift to **smart-grids and plug-in vehicles**—the development of a new energy infrastructure and transport system that is both smart and agile.

The creation of a renewable energy regime, loaded by buildings, partially stored in the form of hydrogen and distributed via smart intergrids, opens the door to a Third Industrial Revolution. It should have as powerful an economic impact in the 21st Century as the convergence of print technology with coal and steam power in the 19th Century, and the coming together of electrical forms of communication with oil and the internal combustion engine in the 20th Century.

1.2 BIOSPHERE CONSCIOUSNESS

The new communication revolution not only organizes renewable energies, but also changes human consciousness. We are in the early stages of a transformation to biosphere consciousness. When each of us is responsible for harnessing the Earth's renewable energy in the small swath of the biosphere where we dwell, but also realize that our survival and well-being depends on sharing our energy with each other across continental land masses, we come to see our inseparable ecological relationship to one another. We are beginning to understand that we are as deeply connected with one another in the ecosystems that make up the biosphere as we are in the social networks on the Internet.

This new understanding coincides with cutting edge discoveries in evolutionary biology, neuro-cognitive science and child development, revealing that human beings are biologically predisposed to be empathic and that our core nature is not rational, detached, acquisitive, aggressive and narcissistic, but, rather, affectionate, highly social, cooperative and interdependent. *Homo sapien* is giving way to *Homo empathicus*. Historians tell us empathy is the social glue that allows increasingly individualized and diverse populations to forge bonds of solidarity across broader domains so that society can cohere as a whole. To empathize is to civilize.

Empathy has evolved over history. In forager/hunter societies, empathy rarely extended beyond tribal blood ties. In the great hydraulic agricultural age, empathy extended beyond blood ties to associational ties based on religious identification. Jews began to empathize with fellow Jews as a fictional extended family. Christians began empathizing with fellow Christians, Muslims with Muslims, etc. In the Industrial Age, with the emergence of the modern nation-state, empathy extended once again, this time to people of like minded national identities. Italians began to empathize with Italians as an extended family, French with French, Japanese with Japanese, etc. Today, on the cusp of the Third Industrial Revolution, empathy is beginning to stretch beyond national boundaries to biosphere boundaries. We are coming to see the biosphere as our indivisible community and our fellow creatures as our extended evolutionary family.

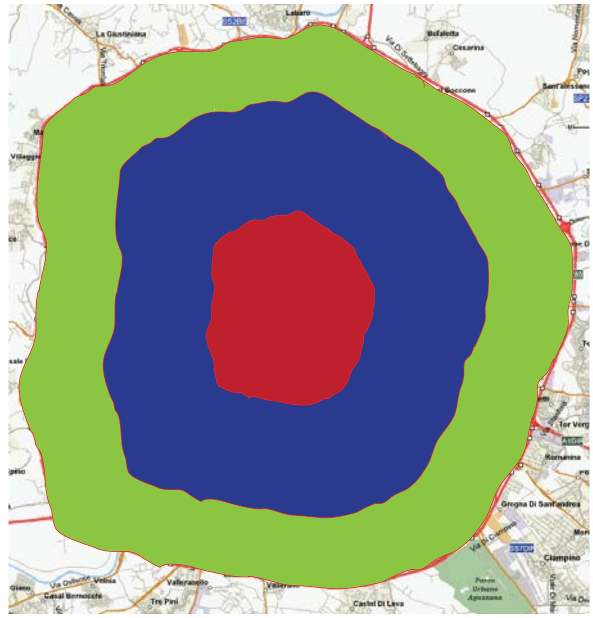

Figure 1: The Roman Biosphere Model

The realizations that we are an empathic species, that empathy has evolved over history and that we are as deeply interconnected in the biosphere as we are in the blogosphere, has profound implications for rethinking the future of the human journey.

What is required now is a leap in human empathy, beyond national boundaries to biosphere boundaries. We need to create social trust on a global scale if we are to establish a seamless, integrated, just and sustainable planetary economy.

This is beginning to happen. Classrooms around the world are quickly becoming laboratories, preparing young people for biosphere consciousness. Children are becoming aware that everything they do—the very way they live—leaves a carbon footprint, affecting the lives of every other human being, our fellow creatures and the biosphere. Students are beginning to take their empathic sensibilities to the biosphere itself, creating social trust on a global scale.

We can no longer afford to limit our notion of extended family to national boundaries, with Americans empathizing with fellow Americans, Chinese with Chinese and the like. A truly global biosphere economy will require a global empathic embrace. We will need to think as a species—as *Homo empathicus*—and prepare the groundwork for an empathic civilization.

Two thousand years ago all roads led to Rome, a city which laid the foundations for the future of Western Civilization through its combination of engineering brilliance, sophisticated transportation systems and early form of democracy.

The Roman Empire was a centralized energy/communication regime with economic and political power flowing from the top-down and the center-out. In the biosphere era, Rome becomes the first of thousands of urban nodes, each nestled in its swath of the biosphere, yet connected and sharing renewable energy across contiguous land masses via smart grids. When communities around the world take responsibility for stewarding their part of the biosphere and sharing the energy they generate with millions of others across continental land masses, we begin to extend the notion of family to all of the human race and our fellow creatures on Earth; we create biosphere consciousness. Rome's great mission in the Third Industrial Revolution is to serve as a lighthouse to facilitate the transition from geopolitics to biosphere politics and help replenish the earth for future generations.

The biosphere envelope is less than forty miles from ocean floor to outer space. Within this narrow band, living creatures and the Earth's geochemical processes interact to sustain each other. Scientists are beginning to view the planet more like a living creature, a self-regulating entity that maintains itself in a steady-state conducive to the continuance of life. According to the new way of thinking, the adaptation and evolution of individual creatures become part of a larger process, the adaptation and evolution of the planet itself. It is a continuous symbiotic relationship between every living creature and the geochemical processes that ensure the survival of the planetary organism and the individual species within the biospheric envelope.

Our dawning awareness that the Earth functions like an indivisible organism requires us to rethink our notions of the meaning of the human journey. If every human life, the species as a whole and all other life forms are entwined with one another and with the geochemistry of the planet in a rich and complex choreography, then we are all dependent on and responsible for the health of the whole organism. Carrying out that responsibility means living out our individual lives in our neighborhoods and communities in empathic ways to promote the general well-being of the larger biosphere.

The Roman Biosphere is made up of three concentric circles. The Inner circle is comprised of the historic core and residential neighborhoods. Beyond the dense core of the city center is an industrial and commercial ring with many open spaces. Outside of the industrial/commercial area, the land becomes even more open, forming the rural hinterland that surrounds the metropolitan city.

The Third Industrial Revolution economic development plan would transform the region of Rome into an integrated social, economic and political space embedded in a shared biosphere community. The Third Industrial Revolution model emphasizes zonal interconnectivity—bringing together the surrounding agricultural region with the commercial zone and the historic/residential core, into one seamless relationship connected by locally generated renewable energies, shared across a smart distributed electricity power grid.

The Third Industrial Revolution vision for Rome is intended to show how the areas surrounding the city center can be reconnected and work together to support each other in a holistic way in a biosphere framework. Each of the city circles will be explained below, starting with the inner historic core of Rome.

1.3 HISTORIC/RESIDENTIAL

The city center will be an attractive, connected and lively place, with accessible open space and traffic-free roads, allowing pedestrians to reclaim the streets and enjoy the historical surroundings. Improved public transport, cycle paths and pedestrian routes will be needed to encourage this transition. High quality sustainable housing and energy efficient apartment-living will also be needed to increase inner-city population density and help maintain a sense of a vibrant community in the ancient heart of the city. These housing initiatives will also result in more opportunities for public transport, a critical element in achieving high levels of urban sustainability. Maintaining inner-city population density, while at the same time optimizing public transport and energy efficient living, is critical to achieving a high level of urban sustainability. Yet the current trend is de-population of the city center, due to a lack of housing to meet modern needs, along with severe traffic congestion and air pollution.

Although central Rome has a shortage of social housing, it has a surplus of office space. Therefore, one solution would be to

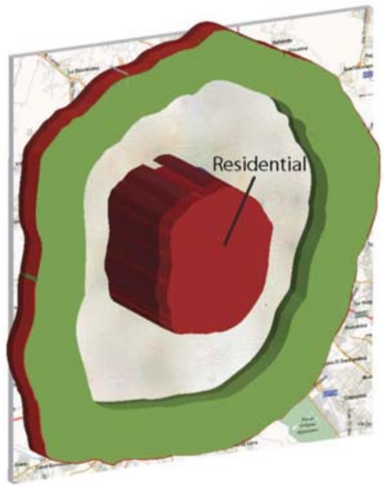

Figure 2: **The Historical/Residential Ring**

transform now defunct commercial buildings into new residential blocks, using innovative architectural techniques that echo some of the best elements of ancient Roman building design. This could be done without damaging the architectural heritage of central Rome if such buildings were rebuilt as flats, leaving the historical facades intact, while excavating the central core to make room for communal gardens—emulating those of ancient Roman villas. Renovating buildings in this way would maintain the aesthetic value of Roman architecture, but also begin to build the city's reputation as a vibrant community for sustainable living (see figures 3a, b and c).

The greening of Rome will also include thousands of small public gardens scattered in neighborhoods across the historic/residential core. Carlo Petrini and the Slow Food Movement have initiated a public project with Mayor Alemanno to lay out gardens in the city's school yards to be attended by Rome's students. Thousands of other small gardens will be placed in public areas around the city as part of the long term-plan to transform Rome into a sustainable biosphere park.

1.4 INDUSTRIAL/COMMERCIAL

Surrounding a newly revitalized residential city center will be the green industrial/commercial circle—the dynamic hub of Rome's economy, providing accessible jobs for the population.

This circle needs the same level of connectivity as the city center so that movement between the two areas can easily be achieved by mass transit, cycling and walking, while

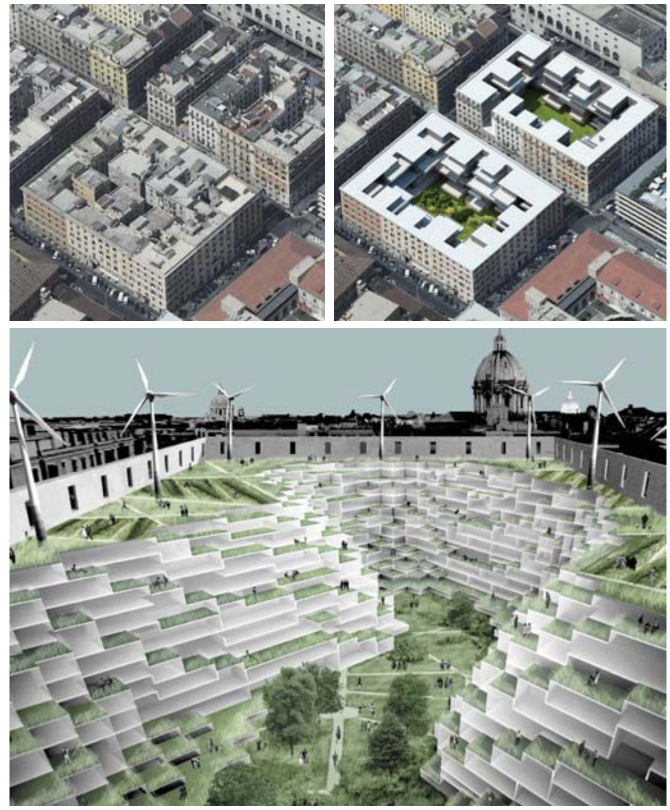

Figure 3a, 3b and 3c: **Excavating Buildings in the City Center for Residential Use**

minimizing the need for private vehicles.

The industrial/commercial ring should become a vast laboratory for developing the technologies and services that will transform Rome into a model low-carbon economy, while providing a high quality of life for its citizenry. Leveraged by the Mayor's support for a low-carbon Rome, there is tremendous opportunity for a new generation of Roman entrepreneurs to develop a range of Third Industrial Revolution industries and services that will grow on the back of local demand and expand to compete successfully across Europe.

The Third Industrial Revolution plan envisions the creation of biosphere science and technology parks scattered across the industrial/commercial ring. These science and technology campuses will house university extension centers, high-tech startup companies and other businesses engaged in the pursuit of Third Industrial Revolution technologies and services. The Walqa Technology Park in Huesca, Spain, nestled in a valley in the Pyrenees, is among a new genre of technology parks that produce their own renewable energy on-site to power virtually all of their operations. There are currently a dozen office buildings in operation at the Walqa Park. The facility is run

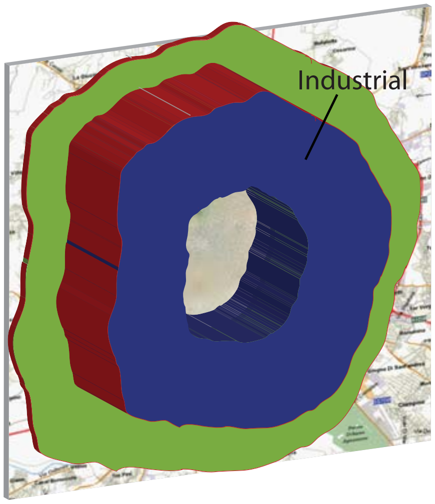

Figure 4: The Commercial/Industrial Ring

almost entirely by renewable forms of energy, including wind power, hydropower and solar power. The park houses leading high-tech companies, including Microsoft, Deloitte, Accenture, Vodaphone and other ICT and renewable energy companies.

The potential of local demand and smart regulation to create whole new sectors of the economy can be clearly seen in the recent experience of the German economy, which has rapidly become a global market leader in the production and installation of photovoltaics. In 2000, renewable energy contributed just 6% to Germany's national electricity mix. When Parliament set a target of 12% by 2010 and brought in a 'Feed-in Tariff' to achieve this objective, they also enacted legislation ensuring that homeowners and commercial building owners were paid a premium price for all electricity sold back to the grid. Only eight years later, Germany had not only exceeded its 2010 target and achieved 14% renewable energy in the grid mix, but

Photo 1: Walqa Technology Park

had created 200,000 jobs and established itself as the world's leading photovoltaic manufacturer.

The industrial/commercial ring will be designed as an attractive working environment, with significant green space, populated with self-sufficient buildings and factories, powered by renewable energies and connected to combined heat, power and distributed energy systems.

1.5 AGRICULTURAL

In the twentieth century model of urban development, cities became increasingly divorced from the production of the food they consumed. The production and transportation of energy and food have also become increasingly large sources of greenhouse gas emissions. This problem is frequently underestimated as urban carbon models tend to focus only on emissions generated by processes within the city boundaries, with less attention focused on emissions embedded in the energy and food consumed by city dwellers but produced elsewhere. Ecological footprint data suggests that food consumption forms a large, possibly the largest portion, of a city's ecological footprint.[5]

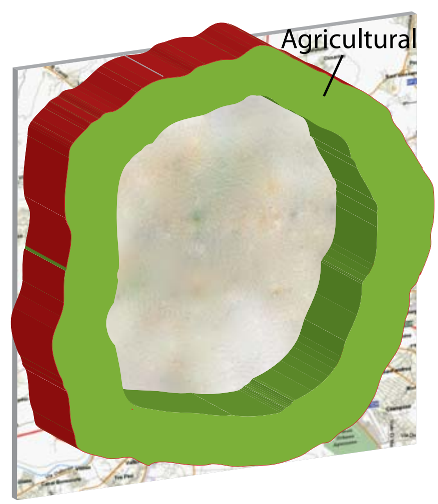

Figure 5: The Agricultural Ring

[5] The Ecological Footprint (EF) is a measure of the consumption of natural resources by a human population. A country's EF is the total area of productive land or sea required to produce all the crops, meat, seafood, wood and fiber it consumes, to sustain its energy consumption and provide space for its infrastructure.

80,000 of the 150,000 hectares of land which modern Rome occupies is designated as green space,[6] a currently under-used resource which could be made more agriculturally productive, serve as a site for large scale renewable energy generation and be used for leisure activities.

By investing in locally grown produce, becoming more self-sufficient in food production and promoting a Mediterranean diet, Rome will be able to enjoy greater food security and a reduced carbon footprint. A city's ecological footprint can be significantly impacted by its dietary choices. A beef based diet, in particular, increases the emission of methane, nitrous oxide and carbon dioxide, the critical Green House Gases that have a significant impact on climate change. The diverse Italian cuisine, which emphasizes large amounts of fruits, vegetables and grains, and small amounts of meat, will be displayed across the agricultural ring and promoted around the world.

The Third Industrial Revolution vision will transform the agricultural region into a modern biosphere community: a place that can provide food for the industrial/commercial and historic/residential sectors, while preserving the local flora and fauna of the region for future generations. The agricultural region will be a living showcase of the Italian Slow Food Movement, combining state-of-the-art agricultural ecology and biodiversity practices. Open-air country markets, country inns and restaurants will feature local cuisine and promote the ecological and nutritional benefits of a Mediterranean diet.

Agricultural research centers, animal sanctuaries, wildlife rehabilitation clinics, plant germ plasim preservation banks and arboretums will be established in the rural circle to revitalize the Roman biosphere.

Photo 2: Photovoltaic Modules in the Agricultural Ring

Rome's green outer circle also offers a tremendous opportunity as a site for large-scale renewable energy projects, which utilize wind, solar photovoltaic and biomass energies. Renewable energy parks will be situated throughout the agricultural ring and integrated seamlessly into the rural landscape.

All of these far-reaching innovations are designed to rejuvenate the Roman biosphere and transform the region into a relatively self sufficient ecosystem that can provide much of the basic energy, food and fiber to maintain the Roman population. With imaginative planning and marketing, this biosphere park could be turned into another of Rome's tourist attractions, a highly visible sign of Rome's exemplary embrace of the Third Industrial Revolution vision.

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[6] Introductory remarks by Livio de Santoli, Third Industrial Age Rome workshop, 5 Dec 2009

2 The Economic Development Potential

Rome, like any city or community that wants to maintain a high quality of life for its citizens, must constantly invest in new facilities, buildings, transportation systems, power supplies and commercial enterprises. It must also continually expend time and resources to ensure the ongoing maintenance and repair of its existing infrastructure and services. For Rome, the working estimate is that this annual investment now approaches €26 billion, which is about 21 percent of its total annual economic activity (measured as Gross Domestic Product (GDP), using constant 2008 Euros). In short, regular on-going investments are already a critical part of the city's economic development routine. Rome's transition to the Third Industrial Revolution will be made possible by a smart redirecting of existing economic development expenditures toward a more productive pattern of investments that accelerates the deployment of both energy efficiency and the four pillars. As we shall see, the benefits of redirecting this economic enterprise will include energy bill savings, new industry and business development, as well as new job skills and core competencies within the city. The benefits will also include improved environmental quality and a significantly reduced carbon footprint.

Normal economic activity within Rome results in a significant use of energy and release of greenhouse gas emissions, which most experts now believe are the key drivers behind Global Climate Change. The majority, or 13.3 MT, of these greenhouse gas emissions are from the release of carbon dioxide, as a result of our use of carbon-rich fossil fuels such as coal, oil and natural gas. Another 1.1 MT are the result of other gases emitted by agricultural activities, such as the methane released by domestic animals or changes in land-use patterns—which disrupts soil and plant life and causes a further release of emissions. The growth of the Roman economy will slightly increase these emissions over the next 20 years and beyond. This of course will add to the environmental burden as greenhouse gases accumulate in the atmosphere.

The key trends for two different greenhouse gas emissions pathways are shown in Figure 6. Beginning with a working estimate of emissions for the City of Rome in 2008, the chart highlights a business-as-usual (BAU) reference case in which Rome's economy grows 30 percent over the period 2010 through 2030. At the same time, normal market efficiencies and new investments drive down the intensity of total emissions per dollar of income by about 23 percent in 2030 (compared to 2010). If that occurs, and if the City's economy grows by about 30 percent over the same time horizon, then total greenhouse gas emissions will rise only four percent, increasing from an estimated 14.5 million tonnes (again, expressed as carbon dioxide or CO_2 equivalents) in 2010, to about 15.1 MT in 2030. So in fact, normal market efficiencies do moderate both energy demand and the emissions of greenhouse gases compared to what might be expected if we look only at the normal growth patterns within the Roman economy.

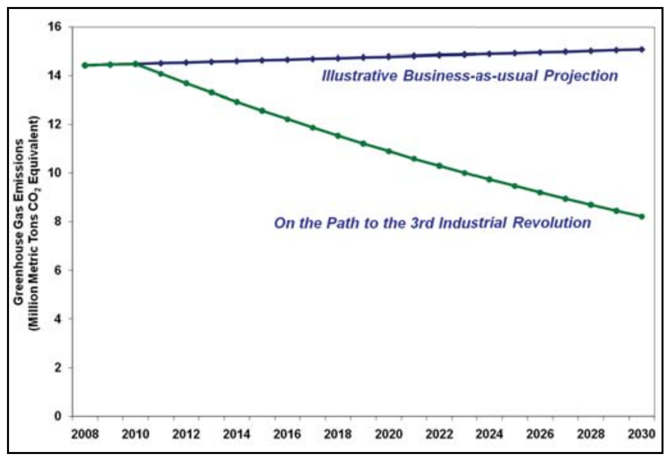


Figure 6: Rome Greenhouse Gas Emissions 2008 to 2030

At the same time, however, an increasing number of scientists suggest that emissions should be reduced by 80 percent or more from current levels by 2050. To reduce greenhouse gas emissions to the 20-20-20 target enacted by the European Parliament in 2007 and then to achieve further reductions by 2030 as suggested by the transition to the Third Industrial Revolution, Rome will need to reduce its emissions by nearly 46 percent, lowering total greenhouse gases from 15.1 MT to about 8.2 MT by 2030. Hence, the normal market gains are only a down payment on what must be achieved over the next four decades or so.

Informed behaviors and productive investments in energy-efficiency and the family of smart technologies underpinning the four pillars can get the job done. Before this report explains these opportunities in more detail, this section highlights the overall magnitude of investments necessary to move Rome onto a trajectory leading to the Third Industrial Revolution. It also summarizes the energy savings benefits that would likely follow any investment strategy that places Rome on the path to the Third Industrial Revolution.

As with any new market or economic strategy, it takes money to make money. For Rome, this will mean thinking through ways to make better use of normal investment dollars and expanding investments in both people and technologies. Moving Rome from a business-as-usual case of a four percent increase in overall greenhouse gas emissions to a transition that greatly reduces emissions will require somewhere on the order of €10 billion of smart investment directed toward this purpose.[7] To clarify once more, this is an economy-wide estimate which covers productivity benefits and emission reduction technologies across all sectors and fuels within the area economy. It includes all energy uses within residential and commercial buildings, all processes and operations within industry sectors, and all forms of transportation in and around the City of Rome.

While this seems like a large amount of money, as we mentioned earlier in this section, the City requires a much larger amount of routine investments just to keep the local economy going. This is true whether we are talking about new streets, new schools, new cars and trucks, or new industrial equipment, transmission lines and power plants. In fact, it appears that Rome will make an average annual investment in its economy on the order of €33 billion a year between now and 2030. In other words, if Rome can free up the equivalent of just over three months of normal investments over the course of the next 20 years, and, instead, divert those Euros into the kinds of productive technologies described later in this report, then the economy will be well on its way toward transitioning to the Third Industrial Revolution.

[7] This investment total reflects the incremental investment above what might normally be made in standard systems and technologies. For example, if a conventional technology costs €50, but the more energy-efficient version of that same technology costs €60, then the incremental cost is said to be €10.

The important factor to emphasize is that there is a substantial return on this investment. The productivity gains are substantial—especially in the form of energy bill savings paid back over time. It turns out that the energy bill savings over the period 2010 through 2030 is likely to be about 50 percent more than the needed investments over that same 20-year period. Equally important is that this level of productive investment and the resulting energy bill savings can be re-spent within the City's economy, which will directly benefit both income and local employment.

The Third Industrial Revolution Green Economic Recovery Plan will spawn entire new industries and businesses and create tens of thousands of new jobs, putting Rome at the forefront of efforts to revitalize the Italian economy. To achieve its goal, Rome will need to redirect 1.3% of its normal economic investment (approximately 450–500 million Euros per year) or .3% of its overall GDP over 20 years.

Throughout this report, we will occasionally reference company recommendations, proposals and projects, which can be found in the second half of this document under: "Extended Recommendations and Projects from the Member Companies of the Third Industrial Revolution Global CEO Business Roundtable." Here you will find elaborate proposals prepared by our global team of experts, which refine the broad economic estimates discussed thus far. As each project is explored on a deeper level, estimates must be revisited and updated to reflect the actual costs, returns and CO_2 reductions.

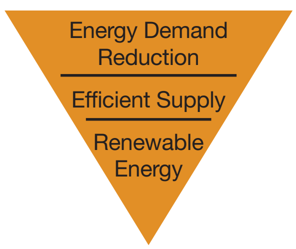
The remainder of this report outlines how Rome can achieve its goals along with social and economic sustainability and competitiveness, based upon the Four Pillars of the Third Industrial Revolution:

(i) the expanded generation and distribution of renewable energy resources
(ii) the use of buildings as power plants
(iii) the development of hydrogen and other storage technologies, and
(iv) the creation of a new smart energy infrastructure and transport system

3 Energy Efficiency

Constructing the four pillars necessitates large technological and infrastructural innovations. Although increasing renewable energy production will require significant short-term capital costs, the long-term dividends will provide a handsome return on investment for the city. In order to ease the financial burden, however, and help smooth the capital shortfalls, the first steps in making the transition to a Third Industrial Revolution are to improve the efficiency of our current energy use and reduce wasted energy in order to cut the scale of demand for renewable energy generation. Methodologically this can be expressed in the following hierarchy:

Figure 7: Demand Side Management/ Supply Pyramid



In the Climate Change Action Plan for the city of London, an estimated 60 percent reduction in carbon emissions by 2025 could be most efficiently achieved through roughly equal efforts in each of these areas.[8] Since 1990 across the European Union, two thirds of new energy demand has been met by energy efficiency, only one third by new supply.[9]

In most cities, there are a handful of principle opportunities for energy efficiency which are cost-effective; that is, opportunities which pay for themselves over time. Some of the most popular include:

- improving the thermal performance of buildings
- optimizing energy demand in buildings
- achieving transport modal shift
- reducing water usage and waste

[8] http://www.london.gov.uk/mayor/environment/climate-change/docs/ccap_fullreport.pdf

[9] John Skip Laitner, presentation at the Third Industrial Revolution Rome workshop, 5 December 2009

Reducing demand for energy doesn't necessarily mean large sacrifices, but it does require the participation of a significant proportion of citizens. As the former Mayor of London Ken Livingstone said when launching London's climate change plan, "We don't have to reduce our quality of life to tackle climate change. But we do have to change the way we live."

In most developed countries, fossil fuel prices have remained low enough to encourage a high degree of wastefulness in energy use, both at a commercial level and by individual citizens. In London, more than 20% of energy consumption is entirely unnecessary.[10] This waste is attributable to large-scale commercial problems, such as a lack of building management systems that control energy use, and smaller scale domestic actions, such as excessive heating/cooling or leaving lights on in unoccupied rooms. Even when the marginal cost of fuel is low and if one excludes the long-term environmental and societal consequences, the wasteful use of energy is always irrational.

Reducing demand for energy through behavioral changes can be partially achieved through the use of technology. One can imagine the role that Internet technology, in particular, can play to significantly improve energy efficiency in the future. For example, consider the production and sale of shoes. Currently shops have to stock a wide range of sizes and styles to accommodate its customers. However, if the shop took a digital imprint of a customer's foot, this could be fed back to the central production facility where the shoe would be made to measure and sent directly to the customer. This technology would reduce transportation costs and carbon emissions, free up space the shop is using to stock shoes in all shapes and sizes, and ultimately produce a better shoe.

Changing established behavior will require either a strong price mechanism, such as road pricing in Stockholm and London, or a significant change in mindset. For example, in the UK's low-carbon mixed use development, Bed Zed, energy use has been monitored since it was first occupied in 2002. Despite

[10] That is, it does not deliver any benefit to the individual consumer or to society at large. London Climate Change Action Plan, Greater London Authority, 2007

identical building fabrics, however, there is as much as a 40% difference in per capita energy use—even between adjacent apartments—as a direct result of the different lifestyles of the inhabitants.

Italy's largest hotel chain, NH Hoteles, is exploring new business models to encourage more sustainable use patterns and reward those who are already making environmentally conscious decisions. Through its "intelligent room" pilot project, the hotel will develop real-time monitoring of energy consumption patterns and, thus, be able to adapt each guest's room to his/her preferred light and temperature levels before arrival. After establishing baseline conditions, the hotel will then reward its guests with more "eco-responsible" attitudes through its "rewards program," and hopefully be able to encourage others to follow suit.

Another significant opportunity to reduce energy demand is through building retrofits, which is now of particular interest to cities around the world. At least twenty of the C40 Cities (a grouping of 40 of the world's most prominent cities) have programs to retrofit municipally owned buildings. The city of Berlin has, through its Berlin Energy Saving Partnership, retrofitted over 1,300 buildings and has reduced CO_2 emissions by an average of 27% per building (the equivalent of avoiding 64,000 tonnes of CO_2 emissions and over 10 million Euros in annual energy costs). The return has been consistent with the average payback for building retrofits of 8-12 years.[11]

Rome has signed up to be part of the C40 scheme and could benefit from a comprehensive retrofit of its buildings. Afterall, 40% of the City's building stock was built between 1960 and 1980; thus, it has relatively low levels of insulation and energy efficiency. The Mayor is already taking steps to reduce residential energy consumption from lighting and appliances, cutting average consumption from 35 kWh/sm to 20 kWh/sm by 2020, and plans to reduce residential demand for thermal energy from 87kWh/sm to 35 kWh/sm.

The full benefits of energy efficiency are likely to be even larger than what is immediately apparent. As Christophe Juillet of Schneider Electric related at the Third Industrial Revolution Rome Workshop, every unit of electricity saved in the home or office translates into three units saved at the power plant because of the inefficiencies in transmission and distribution.

[11] www.c40cities.org/bestpractices/buildings/berlin_efficiency.jsp

Typically, the largest energy savings through building retrofits come from improving thermal efficiency to cope with hot summers, cold winters, or both. How well the building is insulated and sealed also determines the size and output of air conditioning and heating units. To improve upon thermal performance, cavity walls can be filled, solid walls lined, and high performance doors and windows installed. The next generation of high performance windows not only improves thermal performance, but when combined with integrated building management systems, can save energy by automatically adjusting to outside lighting and weather conditions.

Photo 3: Chicago City Hall Green Roof

Another increasingly popular and effective way to improve thermal mass is through the use of green roofs. Green roofs not only provide a moderate insulation value and even a small cooling effect (through evapotranspiration), but can also help reduce the impact of flooding by absorbing and slowly releasing rainwater. Large green-roof programs are already underway in North American cities such as Chicago and Toronto.

Retaining hot and cool air within a building is critical. However, in Rome's climate, natural measures which allow for ventilation can be equally as important. Although these 'systems' can be as simple as opening a window, most natural ventilation systems in commercial buildings are carefully designed to adjust to outside conditions. Once the building envelope has been sufficiently insulated and thermal mass considerations have been accounted for, other technical efficiency measures can be considered. Building management systems utilizing motion sensors and other devices can control various systems—such as lighting, air conditioning, heating or ventilation—to maximize efficiency in response to activity within buildings, and can optimize heating and cooling generation. There are various commercially available tools that enable building owners to assess the potential of retrofitting their own buildings, such as Arup's DECODE product, developed for the UK's Carbon Trust.[12]

Perhaps the most easily achievable energy efficiency improvement is in lighting. In commercial buildings, the largest contribution to greenhouse gas emissions (after space heating and cooling) comes from the electricity consumed by lighting and computing. Lighting accounts for 19% of global electricity consumption, but around 80% of existing lighting infrastructure is aging and inefficient.

Philips estimates that 16% of electrical demand in Italy is used for lighting and approximately 75% of this is due to inefficient or obsolete technology. Urban areas are responsible for 75% of energy consumed by lighting, 15% of which is from street lighting. Despite this, the switch-over rate to modern efficient street lighting is 3% per year; for offices, this is 7%. Philips attributes this slow adoption to customers not being aware of the savings associated with newer products and a general reticence to undergo the required initial investment. Even though there is only a seven-year payback period for switching to energy efficient lighting.

In Europe, improved lighting could result in an average of 40% electricity savings (which amounts to 99 million tonnes of $C0_2$ per year). Philips states that a 40% energy efficiency savings on lighting in Italy would save 10.8 million tonnes of carbon per year (equivalent to the output of 12 average-sized power stations). As the case studies illustrate, the energy savings alone can be significant enough to make LED lighting cost-free over a relatively short investment horizon. In addition, LED lights provide a better quality light for a safe, enjoyable environment.

The EU is accelerating this shift with its "Eco-Design of Energy-Using Products" directive to phase out tungsten bulbs by 2012. The landscape of the lighting industry is changing fast in relation to these energy-efficiency imperatives, legislative pressures and the world of possibilities opened up by LED lighting.

[12] Decode is a software tool that identifies the impact of various interventions within new and existing buildings. This enables the user to understand what low carbon non-domestic building stock could entail and the actions that should be taken. The tool uses data from an evidence base of existing work and assumptions based on our extensive experience in low and zero-carbon development. Output includes the level of carbon abatement achievable at sector, national and end-use level, the economic cost of the interventions and the consequences of various demolition and build rates.

The Mayor of Los Angeles began to explore the benefits of LED lighting by recently starting a program to upgrade all 209,000 streetlights. It is expected that the scheme will save 40,000 tonnes of carbon emissions per year and that the €38.5 million in capital costs will be offset by a savings of over €6.7million per year. Part of the cost savings emanates from the fact that LED bulbs have an eleven year life-span; hence maintenance and replacement costs are greatly reduced when compared to conventional tungsten bulbs.

Ultimately, the most successful strategy for energy efficiency, consistent with the overall strategy for the Third Industrial Revolution, is likely to be that which combines communication and energy solutions. For example, installing a building management system will deliver efficiencies on its own, but these can be maximized with state-of-the-art communication technologies to provide information to consumers and energy operators, encouraging a reduction in energy demand and improving supply efficiency.

Although energy efficiency and retrofit solutions are often deployed on a private contract basis, retrofitting many buildings at once allows energy companies to achieve economies of scale and to reach customers that they otherwise could not serve. This also enables long-term infrastructure improvements as monetary guarantees are more easily secured.

A municipality could also benefit from this model by implementing or overseeing a city-wide initiative. Queensland, Australia for example, has developed a home service as part of the Government's ClimateSmart Living initiative. It was designed to help Queenslanders fight climate change by reducing the carbon footprint in their own homes. For around €33 per household, residents can sign up online to receive a one hour energy appointment. Following this assessment, an energy service company (ESCo) can be appointed to install energy efficiency measures in a building and guarantee a set level of energy savings, out of which the ESCo receives its fee. This offers a financial savings over a period of years to the consumer and transfers capital costs to the ESCo, rather than the owner or occupier of the building, through a process known as performance contracting.

Performance contracting can be one of the most cost effective investments for governmental entities as it often requires no direct cash outlays. Established energy companies, such as Philips and Schneider, provide energy efficient installations and retrofits and guarantee a minimum level of energy efficiency gain. In other words, these companies are paid back through the energy savings; the customer is not actually spending any more money than it previously would have.

In Rouen, France, Philips is moving beyond providing lighting products and efficiency measures to now offer a public safety service. Philips found a financial partner to help capitalize the project. The plan includes a closed network electronic system, which provides traffic management, video surveillance, and of course, lighting. Improving upon lighting also improves upon quality of life. The LED lighting scheme that Phillips installed in the London Borough of Redbridge not only had energy savings of 50%, but also decreased crime rates and raised property values.

3.1 OPPORTUNITIES IN ROME

The large number of buildings in Rome and the economic and cultural importance attached to maintaining architectural heritage means that the most significant and the most difficult demand-side carbon savings will come from retrofitting existing buildings.

There is technical and economic potential for a large-scale building retrofit in Rome. But in order to exploit this potential, the City needs to coordinate action and build capacity, similar to the Building Energy Efficiency Program in London or the Berlin Energy Savings Partnership (see Adrian Smith & Gordon Gill Architecture's Decarbonization Plan and Schneider Electric's retrofitting proposal).

In addition to retrofitting building systems, Philips sees a huge savings potential in outdoor lighting by switching to the new energy efficient LEDGINE solution (by using additional dimming facilities, the energy saving can be enhanced up to 80%).[13] This project would involve selecting an area of Rome and installing new LED technology to reduce electricity consumption (see Philips proposal).

3.2 ISSUES

Building retrofits can be disruptive—varying from minimal disturbances for minor work, to having to vacate the building for two years during a complete refurbishment. While there are many generic building retrofit measures, each building requires a unique combination of such interventions. The architectural heritage of the buildings in Rome makes retrofitting especially sensitive and costly. Again there are tools available to enable building owners to determine what level of refurbishment is needed and what will be the financial impact.[14]

In terms of lighting, the initial cost of investment in new LED technology will inevitably be higher than maintaining the existing infrastructure. But it is important to note that total lifetime cost will be much less due to a reduction in energy consumption, far lower maintenance costs and a longer unit life. Thus, the main obstacle to overcome is raising the initial capital. This, however, could be easily attained through public borrowing, an energy performance contracting approach or through the establishment of a municipal Energy Services Company.

3.3 ECONOMICS

A new study of the costs of climate mitigation within Europe suggests that moving to the equivalent of a Third Industrial Revolution reduction might require as much as 0.5 percent of GDP by 2030.[15] As mentioned earlier, for Rome it appears the investment magnitude might be somewhat lower, closer to 0.3 percent of GDP. This implies an annual €450–€500 million per year investment to transform the economy. At the same time, improving energy efficiency has the potential to reduce the cost of living in Rome and, thus, release significant resources back into the local economy for other productive investment. At current energy prices, if Rome were to achieve its target of a 20% improvement in energy efficiency per unit of GDP, the city would save €800 million per year (expressed in constant 2008 Euros).[16] Assuming that these savings were consumed or invested in line with current economic patterns, the energy savings could be expected to generate an additional €230 million of economic growth per annum.[17]

[13] LEDGINE is a new technology developed by Philips that will be introduced in May 2010, Philips contends it is a new step in the LED revolution.

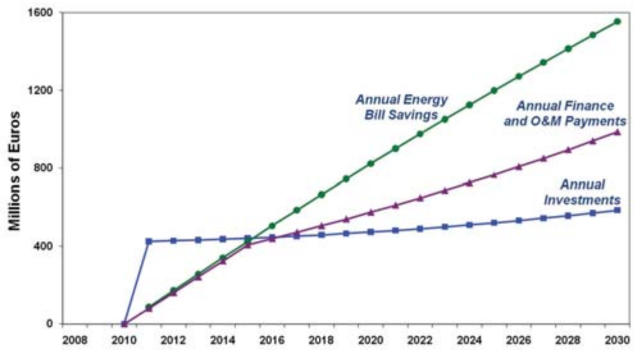
[14] See Arup's 'Existing Buildings Survival Strategy' toolkit and associated FIT costing tool.

[15] Eskeland, Gunnar S., et al. "Transforming the European Energy System," in Mike Hulme and Henry Neufeldt, editors, Making Climate Change Work for Us: European Perspectives on Adaptation and Mitigation Strategies, Cambirdge, UK: Cambridge University Press, 2010.

[16] John A. "Skip" Laitner, ibid.

[17] John A. "Skip" Laitner, ibid.

Figure 8: Energy Savings Financing and Investment 2010–2030



As shown in the figure above, investments to move Rome on a path to the Third Industrial Revolution will approach 10 billion Euros over the period 2010 through 2030. But as people and businesses borrow money to finance energy efficiency (generally assumed over a 5-year period) and other infrastructure (generally over a 20-year period), and as businesses pay about 40 percent of non-efficiency investments (including renewable energy and other reductions in GHG emissions) for additional operational upkeep and expenses, the net present value (assuming all costs and all energy bill savings are discounted at 5 percent annually), is about 1.5. In other words, over the 20-year period from 2010 through 2030, one Euro of investment will generate a total of 1.50 Euros in energy bill savings.[18]

3.4 BENEFITS

There will be commercial, social and public benefits to implementing the energy efficiency projects outlined below. Throughout this report, the categorization "commercial" refers to businesses and corporations, "social" to individual residents of Rome and "public" relates to Roman society as a whole.

Commercial	Businesses would be able to reduce their energy bill and their carbon emissions. Furthermore, they would be able to increase the value of their assets and enjoy greater security against the long-term impact of rising energy prices.
Social	Evidence across Europe demonstrates that domestic energy efficiency can deliver significant reductions in household energy costs, particularly for low-income families.
Public	Reduced fossil fuel consumption will improve air quality and make Rome's commercial sector leaner and more competitive, creating new opportunities for growth and job creation.

3.5 PROJECT ONE: BUILDING RETROFITS

Schneider Electric, a global specialist in energy management, offers integrated solutions that make energy safer, more reliable, efficient and productive within energy infrastructure, industry, data centres and networks, buildings and residential markets. With sales of €18.3 billion in 2008, the company's 114,000 employees in 102 countries help individuals and organizations make the most of their energy use.

3.5.1 OVERVIEW

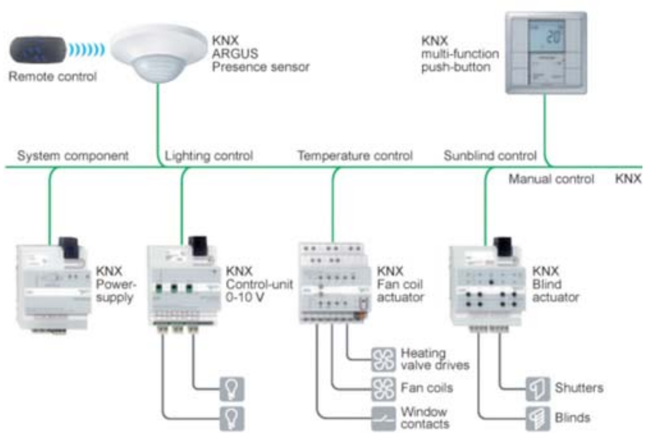
Schnieder Electric proposes that Rome implement a system entitled KNX to manage public buildings' lighting and air-conditioning, which takes into account occupancy, orientation and natural light. The KNX system would:

- Combine a variety of room-level controls for dramatic cost savings.
- Incorporate sensors and fan and blind actuators, which interact automatically, eliminating manual and inefficient activation and deactivation.
- By combining presence and brightness detectors with timers to control lighting, blinds, heating and air conditioning, dramatic savings can be realized while increasing the occupant's comfort and safety.
- Lights are switched on only when areas are occupied and adjusted for changes in natural light. Heating and air conditioning are automatically regulated, switching to standby mode in the event of prolonged absence or if a window is open.
- Blinds are activated according to room temperature.

[18] As previously noted, this estimate does not include learning-by-doing, where greater experience and new production techniques might lower the costs. Nor does it include economies of scale, where larger scale requires a smaller unit cost. It also does not include upgrading of the utility grid, which utilities will do anyway.

This benefits end-users by aligning energy consumption with room use and occupant behavior, while also eliminating waste by combining climate control, lighting, and blinds in a single flexible, automated system.

Figure 9: Schneider Electric KNX Building Management System



3.5.2 COST

2.5–3 thousand Euros is assumed to be the difference between a traditional installation and a high-level automation system, with an expected return on investment somewhere between three and eight years, depending on the building class.

3.5.3 CARBON SAVINGS

About 90% of the thermal consumption in the residential and building sectors is related to heating systems. Based on this assumption, about 10.255 GWh would be saved in the residential sector and about 4.215 GWh could be saved in the buildings sector.

About 30% (approximately 1.264 GWh/y) or 255 kTon CO_2 savings might be achievable in the thermal "buildings" sector (offices). On the residential side, one can expect to save about 19% (about 1.948 GWh/y) or 394 kTon CO_2/y. In total, we estimate savings somewhere near 650 kTon CO_2/y.

3.6 PROJECT TWO: OUTDOOR LIGHTING IMPROVEMENTS

Philips Lighting, a founding division of the Philips brand, operates in all areas of lighting, from lamps and lighting components, to interior and exterior fixtures and LEDs. In 2005, Philips futher positioned itself as a leader in providing high-powered LEDs through its acquisition of Lumileds, a leading manufacturer of LED modules. Today Philips is a complete lighting solutions provider in all applications: homes, offices, outdoor, industry, retail, hospitals, entertainment and healthcare.

3.6.1 OVERVIEW

To start reducing its carbon emissions, Philips proposes that Rome change its outdoor lighting to a new, more efficient "LEDGINE" solution. Philips' LEDGINE solution allows the LED (inside of the luminaire) to be continuously upgraded without replacing the entire fixture. Philips and Acea are currently working on a pilot area by Lake Garden in the EUR district of Rome, to implement this new LEDGINE technology, with approximately 35 replacement light points. Once installed, each light point will save somewhere around 70%.

Photos 4a and 4b: Examples of Philips Solutions

3.6.2 COST

According to Philips, the average cost of a LED solution is approximately 50,000 Euros; this is highly dependent upon size. However, the potential cost savings is 50% and the payback time is eight years on average. Not only do these solutions save on energy, they also reduce maintenance costs, as conventional lamp replacement is usually required every two years.

3.6.3 CARBON SAVING

If one assumes the energy usage for each luminaire in the pilot study is reduced from 124W to 35W, an energy savings of 89W per unit is achieved. Therefore, in one year, 374 kWh (4,200 hours/year) could be saved and 157 kg of CO_2. emissions (0.42 kg/kW/h) could be avoided.

Assuming that the average power for each streetlight in Rome is 180W and that it is possible to save 50% of the energy. Therefore, taking these assumptions forward, in one year it would be possible to save 378 kWh (4,200 hours/year) and to avoid 159 kg of carbon for each light point. This would mean that in one year, by changing 100,000 luminaries, 15,876 tonnes of carbon can be avoided.

3.7 PROJECT THREE: INDOOR LIGHTING

Schools and colleges put special demands on lighting. Lighting solutions are very important in school buildings as they must properly illuminate desks and vertical surfaces such as blackboards and wall displays. However, from improvements in lighting it is possible to save from 10% to 80%, depending on specific circumstances.

3.7.1 OVERVIEW

Philips proposes auditing the University of La Sapienza/Faculty of Architecture for indoor and outdoor lighting to devise the right lighting solution. The first action would be to substitute all the 2,000 TLD lamps with TLD eco lamps and to add an associated control system.

Philips would substitute all fluorescent tubes with new TL-D Eco and TL5 Eco. This simple replacement would potentially save 10% of energy, without need for new installations.

3.7.2 COST

The investment needed for this university proposal would be approximately 7,200 Euros. To provide a point of comparison, on a similar project that Philips completed for a public administration (office) building, 15,120 kg of carbon were saved in one year. The capital cost was 10,800 Euros and the savings in energy and maintenance costs were 6,930 Euros. This resulted in a 0.9 year return on investment.[19]

3.7.3 CARBON SAVING

Philips states that on average, 2,000 eco lamps can save 10,080 Kg of carbon. If these projects are successful and were scaled to include all of Rome's public buildings, somewhere on the order of 11,113 tonnes of CO_2 could be saved.

[19] Here investment is calculated as the difference between the old installation (including business as usual lamp replacement and installation costs) and the new retrofit.

4 Pillar 1: Renewables

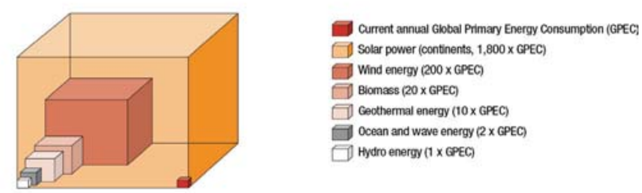
Renewable forms of energy—technologies that draw on solar heat and light, wind resources, hydropower, geothermal energy, ocean waves and biomass fuels—anchor the first of the four pillars of the Third Industrial Revolution.

While these sunrise energies currently account for a small percentage of the global energy mix, they are growing rapidly as governments mandate targets and benchmarks for their widespread introduction into the market and their falling costs make them increasingly competitive. With businesses and homeowners seeking to reduce their carbon footprint and become more energy efficient and independent, billions of Euros of public and private capital are pouring into research, development and market penetration. As these incentives take hold and the market expands, the costs of these renewable energy technologies will become increasingly competitive.

Pillar One of the Third Industrial Revolution rests upon the concept of distributed renewable energy—a highly-dispersed and locally-managed resource—in contrast to outdated centralized power sources. Larger systems, typical of the Second Industrial Revolution, are managed by large firms and are typically encumbered by complicated regulations. Distributed renewable energy systems are increasingly characterized as "agile energy systems," especially when coupled with or enabled by smart grid technologies.[20] Distributed renewable energy systems provide a broad range of new civic-based market investment opportunities. The fact that these systems are dynamic, progressive and cost-effective, as well as readily adaptable to a wide variety of economic circumstances, are reasons why more and more business and community leaders are moving towards a Third Industrial Revolution energy-based economy.

The potential energy from the sun is illustrated in the diagram by the European Photovoltaic Industry Association (EPIA). Solar energy alone accounts for 1,800 times the current global primary energy consumption. Thus, according to EPIA estimates, in Europe, photovoltaics could account for 12% of the total electricity demand by 2020.[21] Rome raised concerns regarding product lifecycles. However, on this front, photovoltaics are very efficient; they take 1-2 years of operation to pay back the environmental costs of construction. Furthermore, the price of photovoltaics is constantly falling as worldwide production increases. By the end of 2010, generation costs are estimated to be €10 per kWh for industrial applications and €15 for residential, which compares favorably to €20 per kWh for fossil fuel electricity.

Figure 10: EPIA Global Primary Energy Consumption



Solar photovoltaics and solar thermal electricity will increasingly dominate the energy market in the coming decades, as Figure 11 illustrates. Thus, Rome has a short window of opportunity to embrace this new technology and capitalize on this emerging market.

ACEA, Rome's energy operator and Italy's second largest electricity distributor, has installed 4MW of photovoltaic capacity and hopes to increase this to 18MW by the end of 2010. This capacity generates 132MWh of electricity which has a carbon saving of 78,000 tonnes CO_2 per annum.[22] ACEA is currently working with the Government of Rome to locate new sites for further photovoltaic installations, including schools and car parks.

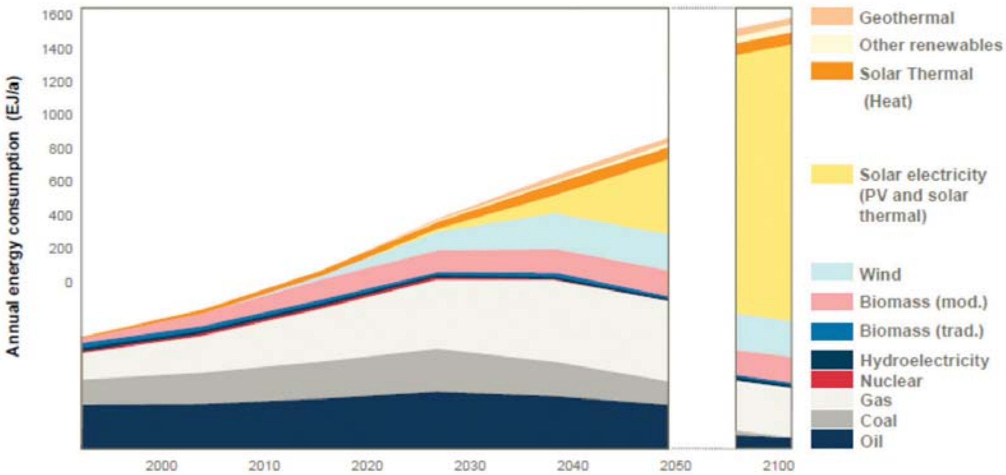
In addition to photovoltaics, there are four different types of concentrated solar thermal energy, including: parabolic troughs,

[20] Clark, Woodrow, W, "Agile Energy Systems: Global lessons from the California Energy Crisis" Elsevier Press, 2004.

[21] Gammal, A (2009) EPIA

[22] Messina, A ACEA (2009)

Figure 11: Change in Energy Consumption — Germany Advisory Council on Global Change (2003)



power towers, linear and solar dishes. The advantage of concentrated solar thermal technology (compared to photovoltaics) is that energy production is consistent rather than only produced at high levels during certain times of the day. However, such an installation does require a large land area—a 100MW solar trough plant would require 700 acres of open space. This type of plant would be best suited for the industrial and agricultural areas of Rome.

There are also numerous other forms of renewable energy such as wind, waste and geothermal that, when coupled with combined heating and cooling systems, can considerably improve the efficiency of energy supply and significantly reduce carbon emissions.

Photo 5: Concentrated Solar Thermal Trough Plant

Combined Heat and Power (CHP) describes a system of energy generation and distribution that captures the heat generated in the process of creating electricity and uses it directly to meet heating needs. Trigeneration, or Combined Cooling Heat, and Power (CCHP), can use this otherwise wasted heat and convert it into both cooling and heating.

CCHP systems can be employed over a wide range of sizes, applications, fuels and technologies. In its simplest form, CCHP employs a gas turbine, an engine or a steam turbine to drive an alternator; the resulting electricity is then used on-site, either wholly or partially. The heat produced during power generation is recovered, usually in a heat recovery boiler, and can also be used to produce steam for a number of industrial processes, to provide hot water for space heating or, as mentioned above, for cooling.

CCHP can achieve overall efficiencies in excess of 90% at the point of use. In contrast, the efficiency of conventional coal-fired and gas-fired power stations, which discard heat energy—usually because their rural locations are too far removed from large scale heat demand in urban centers—is typically around 38% and 48% respectively. Efficiency is lower at the point of use because of the significant losses that occur during transmission and distribution. In contrast, CCHP is an archetypal decentralized energy technology. CCHP systems are typically installed onsite, directly supplying customers with cooling, heat and power at the point of generation, therefore, avoiding the losses that occur in transmission from the plant to customer.

CCHP systems have been successfully employed around the world, particularly in Europe. The Finnish capital city of Helsinki generates 84% of its heating (and more power than it consumes) from combined heating and power systems.[23] On a smaller scale, the Barkantine Combined Heat and Power project in London serves 600 homes and saves 1,700 tonnes of CO_2 per year.[24]

4.1 OPPORTUNITIES IN ROME

Rome has a wide variety of opportunities to exploit renewable energy potential as a result of its open space, solar irradiance and progressive government. Rome also has attractive feed-in tariffs and relatively high energy prices which, in turn, create an environment conducive to the capital city becoming a leader in the solar industry.[25]

The best opportunity for large-scale renewable energy generation is in the outer circle of the industrial zone and, more particularly, in the rural hinterland. The latter area offers opportunities for large concentrated solar thermal and photovoltaic farms that could have the capacity to generate electricity to power a significant proportion of the city. A large photovoltaic farm, which could form part of an energy campus in the rural hinterland, is outlined by Q-Cells in section 4.5.

There are also opportunities for Rome to develop combined heating, power and cooling generation across an entire section of the city: a Single Site Combined Heat and Power Facility and a Rome District Heat Network are both included in the project proposals**.** These projects would involve selecting a group of integrated buildings, such as those on a university campus, and linking them to a local grid powered by low carbon energy.

4.2 ISSUES

Rome's historical legacy extends out of the city along Roman roads that are preserved as heritage sites. While these sites offer huge potential for renewable energy generation, owing to the open space, they are heavily protected and development would be strongly contested. These restrictions extend all over the city and will, therefore, need to be carefully considered so that solutions are designed to be empathetic to the heritage of Rome's built environment.

4.3 ECONOMICS

At this point, renewable energy technologies cost more than conventional energy resources. However, the evidence suggests that by 2020, the combination of economies of scale and improvements in manufacturing and installation techniques will reduce costs below the electricity rates that industrial and residential customers might otherwise pay for traditional energy sources.[26] In effect, by investing in renewable energy over the next decade, the City of Rome will be investing in a competitive advantage that will help lower the costs of renewable energy technologies, while providing new jobs in a climate-friendly economy.

4.4 BENEFITS

Commercial	Photovoltaic installations will ultimately generate cheaper electricity than fossil fuels and do not produce carbon emissions. The latter point is likely to be become a key issue for businesses in the coming years as the EU and Italian Government tighten their regulations on carbon emissions.
Social	Individuals will also benefit from the reduced price of electricity from renewable energy sources and from the job opportunities created from manufacturing and installation.
Public	Becoming an early adopter of renewable energy will make Rome more competitive and improve its energy security in the long-term.

4.5 PROJECT FOUR: PHOTOVOLTAIC ENERGY CAMPUS

The Q-Cells Group ranks among the leading photovoltaics companies world-wide. The extensive product

[23] Helsinki has also developed a combined cooling, heating and power system in the most densely populated sector, but the total connected cooling load is expected to grow to approximately 250MW by 2020(www.helen.fi/sljeng).

[24] London Climate Change Agency, Barkantine Combined Heat and Power Plant Case Study: April 2008 (source: www.lcca.co.uk/upload/pdf/Barkantine_Combined_Heat.pdf)

[25] Q Cells

[26] Adel El Gamal, Secretary General, European Photovoltaic Industry Association, "Solar PV Electricity Rome Sustainable Plan," December 2009.

portfolio ranges from solar cells and modules to complete photovoltaic systems. Q-Cells develops and manufactures its products at the company's headquarters in Bitterfeld-Wolfen, Germany and markets them through a global sales network. A second production site exists in Malaysia. More than 200 scientists and engineers are employed at Q-Cells, accelerating the development of the technology in order to achieve the company's goals: to quickly and permanently reduce the costs of photovoltaics and to make the technology competitive. The close intermeshing of research, development and production enables Q-Cells to transfer innovations as quickly as possibly into mass production and thus to acquire a leading technological position in the photovoltaics industry. In Italy, two local subsidiaries are operating: Q-Cells International Italia srl and Q-Cells Service Italia srl.

4.5.1 OVERVIEW

Q-Cells proposes a simple, rapid demonstration project to implement photovoltaics in Rome utilizing car park shelters. They can be positioned in various locations throughout the city with flexibility, capacity and size.

Secondly, in an agricultural or industrial area outside of the city center, approximately 20 hectares could be set aside to create an energy park of 10 MWp. If all the appropriate authorizations were in place, this could be implemented within only three months.

4.5.2 COST

Costs in the photovoltaic market are continually being reduced. Therefore, the Q-Cells strategy is based on technological progress and reducing costs while maximizing quality. Cutting costs always takes priority: through economies of scale, reducing material use and by honing new technologies. Rome, with its remarkable solar irradiation, attractive feed-in tariffs and relatively high energy prices will undoubtedly reach grid parity soon.

4.6 PROJECT FIVE: HOSPITAL COMBINED HEAT AND POWER

Arup is a global firm of planners, economists, designers, engineers and business consultants, providing a diverse range of professional services to clients around the world. Arup has extensive experience in the design and procurement of Combined Heat and Power schemes, from designing a new city-wide heat network in London, to creating a campus-wide sustainable energy infrastructure for the University of Lancaster. Arup covers all phases of work from the development of an energy strategy to the detailed design of CHP plants and procurement.

4.6.1 OVERVIEW

CHP can function efficiently on a small or large scale. To test the benefits of CHP for Rome, the City could start by requesting a design for a CHP system to supply low carbon heat and electricity to a large, single site facility, such as the St. Andrea hospital.[27]

This site would be suitable for a demonstration as it has a large enough heat load for CHP to be financially competitive with conventional energy supply and, over time, could also be extended to a larger catchment area.

A CHP unit could supply the baseload of the hospital's heating demand and generate 1.8 MWe of electricity. The remaining heating demand could be supplied by gas or biomass boilers. If this initial unit is successful, the hospital CHP could become the nexus of a wider scheme, connecting homes and other buildings around the hospital.

4.6.2 COST

Experience in implementing CHP systems at this scale elsewhere in Europe demonstrates that it is likely to be a highly cost-effective method of reducing CO_2 emissions.

The approximate budget for the installation of a Combined Heat and Power (CHP) plant depends on the infrastructure already in place: the existence of a heating distribution system inside the Hospital and the compatibility of the current heating system with the heat network. If the hospital heating system is fully compatible with the CHP plant, the budget required could range between €2M–€3M and the likely payback period on the investment would be 10-15 years.

4.6.3 CARBON SAVING

A site-wide gas CHP system could be expected to reduce the hospital's carbon emissions by around 20-40%.[28] Further

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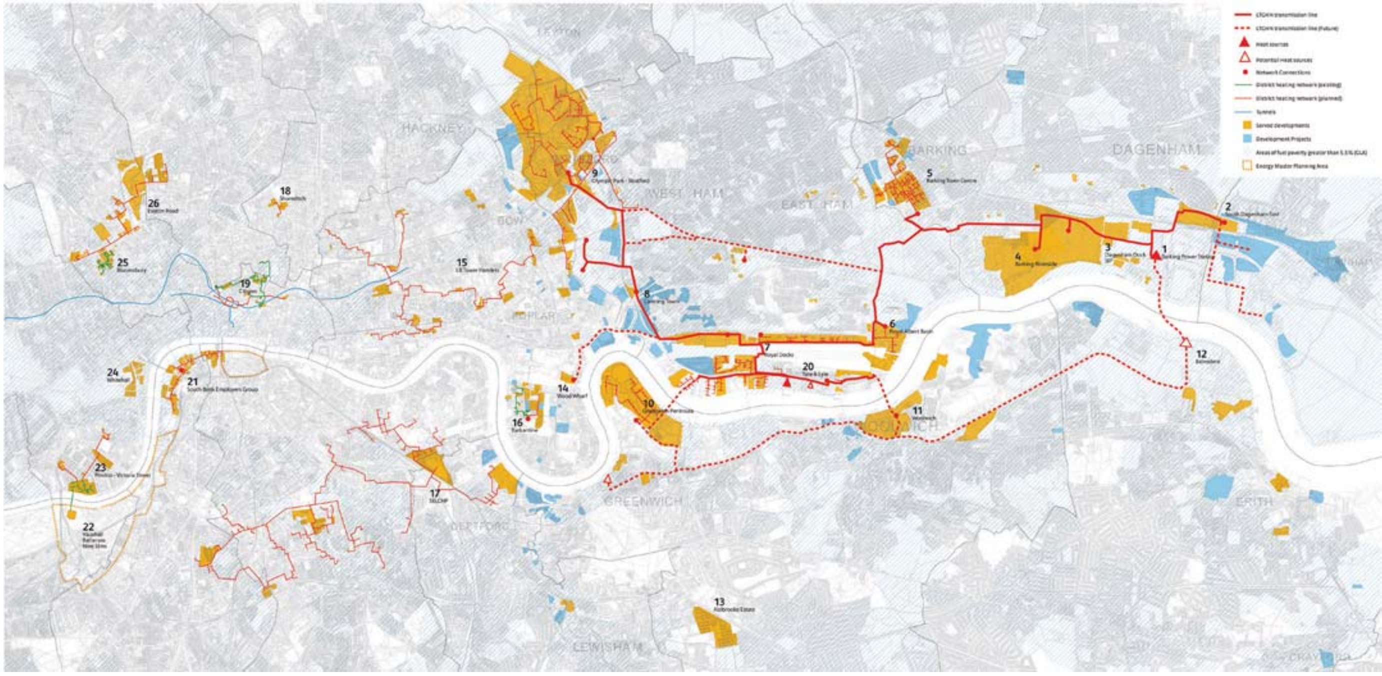
[27] RomaEnergia—Workshop 5, 6 and 7 December 2009—Rome 20-20 -20 Towards a Low Carbon Era

[28] Estimate based on the following assumptions: the savings arise from the reduced carbon emissions compared to the same hospital supplied by gas boilers and electricity from the grid.

Figure 12: **The London Thames Gateway Heat Network Plan (image courtesy of the LDA)**



emission reductions could be achieved if the gas used came from renewable sources, such as from the anaerobic waste digestion.

4.7 PROJECT SIX: ROME DISTRICT HEAT NETWORK

CHP functions well at the relatively small scale of a hospital or residential development. However, it can provide an even more cost-effective carbon reduction solution if applied at a larger scale—district heating and cooling.

Arup has extensive experience in the design and procurement of district heating schemes, including a major ongoing contract with the London Development Agency (LDA)—which reports to the Mayor of London—to help design and manage its "Decentralised Energy Programme." The aim of the programme is to move 25% of London's energy generation off the national grid and onto decentralised supply systems within London, fulfilling a portion of the Mayor's Climate Change Action Plan to reduce London's CO_2 emissions 60% by 2025.

The largest project under development in London is the Thames Gateway Heat Network. The aim of the project is to establish a heat transmission line in the London Thames Gateway which will connect diverse ranges of affordable low carbon heat, including heat from Barking Power Station, to any consumer who requests it. The map shows the network stretching 13km along the Thames Gateway. Once fully developed, hot water from the network could serve 120,000 homes and displace up to 100,000 tonnes of CO_2 each year.[29]

To date, the programme has established a pipeline of projects that could deliver about 5% of the Mayor's target reduction of 120,000 tonnes/year. Numerous other projects are currently under development by Arup and its Decentralized Energy Team, including natural gas CHP, biomass boilers, biomass CHP and waste to energy plants.

4.7.1 OVERVIEW

Rome has the potential to develop a significant district heating system. Like London, Arup suggests that Rome begin with a large demonstration project in an existing mixed-use development area. Constructing district heating infrastructure in a new development is likely to prove both technically simpler and more cost-effective than building in existing developments, as disruption costs are less and available space for infrastructure is easier to identify. Connecting to a mixed-use development—housing, commercial and leisure facilities—is likely to provide sufficient heat and cooling across the day, enabling the CHP facility to run at its

[29] For more information see www.LTGHeat.Net

optimum level. From this, the City can begin to map out a much wider, inter-connected heat network.

4.7.2 COST

The approximate budget for a retrofit district heating scheme depends on the infrastructure already in place: the existence of a district heating network, the density of the buildings and the compatibility of the current heating systems with the heat network. The cost of implementing a district heating scheme ranges from €3,000–€4,000 per residential unit. In the most successful schemes, the payback on the investment can be 10–15 years. However, we must stress the importance of targeting only the most appropriate developments. London is scanning the potential for district heating through a citywide heat mapping exercise that will show the most promising areas for such projects.

4.7.3 CARBON SAVING

As a general rule, a gas CHP district heating scheme is able to save around 20-40% of the carbon emissions derived from a development.[30]

[30] Estimate based on the following assumptions: the savings that arise from the reduced carbon emissions compared to the same development supplied by gas boilers and electricity from the grid.

5 Pillar 2: Buildings as Power Plants

5.1 INTRODUCTION

While renewable energy is found everywhere and new technologies are allowing us to harness it more cheaply and efficiently, we still need infrastructure to load it. This is where the building industry steps to the fore, to lay down the Second Pillar of the Third Industrial Revolution. Within the European Union, buildings account for 40% of all energy consumption and are responsible for equal percentages of CO_2 emissions.

For the first time, new technological breakthroughs make it possible to renovate existing buildings and design and construct new buildings that create some, or even all of their own energy from locally available renewable energy sources, allowing us to re-conceptualize buildings as "power plants." The economic implications are vast and far-reaching for the real estate industry and, for that matter, the world.

A new generation of commercial and residential "buildings as power plants" is going up now. In the United States, Frito-Lay is retooling its Casa Grande plant, running it primarily on renewable energy and recycled water. The concept is called "net-zero." The factory will generate virtually all of its energy on-site by installing solar roofs and recycling the waste from its production processes and converting it into energy.

The creation of a network of distributed power plants made up of buildings could also help maintain a stable and reliable electricity grid. If these buildings are energy efficient and can create more energy than is consumed at certain times of the day or week, the excess energy can be stored or transmitted to nearby neighbors.

One particular benefit to locally-sited renewable energy infrastructure and low-carbon forms of energy generation is that heat and transmission losses are virtually eradicated. In meeting a local electricity demand, for example, a locally-sited wind turbine removes the need for almost twice the energy required to produce the same amount of electricity at a coal-fired power station.

There has recently been growth in renewable wind generation from "mini" and "micro" turbines. Ropatec is one of a number of companies specializing in vertical wind systems. The Ropatec wind turbines are versatile, as they can be installed in a broader range of locations compared to conventional wind turbines. They are also silent, (less intrusive in residential areas), and cheaper; a 60kW installation costs €3,000 per kW.

Photo 6: Examples of Ropatec Vertical Wind Turbines

Insulation is another very important factor in reducing the carbon emissions from buildings. Alwitra, a flat roofing company, has designed a roofing membrane that can support green roofs or photovoltaics which insulates, keeps buildings cool and generates energy. Alwitra has developed the first single ply roofing membrane, termed Evalon Solar, which has 92% reflectivity and, hence, helps maintain building temperatures and provide insulation. Evalon solar is highly flexible for installation on most roof types and can support green roofs or photovoltaic panels.

The design evolution for photovoltaics has progressed substantially in recent years and can now be effectively integrated into different building types and styles. This is particularly pertinent for Rome—a city whose identity is closely linked to its architecture and historical monuments. The many new options for installing photovoltaics were highlighted by Silke Krawietz,

Photo 7a and 7b: Examples of Green Roofs and Photovoltaics on Roofing Membrane

from the Institute for Renewable Energy, who emphasized that photovoltaics can be incorporated into balcony sides, facades or veranda's, in addition to the roofs of buildings.

5.2 OPPORTUNITIES IN ROME

The Department of Housing owns roughly 400,000 buildings; 20,000 of which are social housing and a large portion of which require refurbishment[31]. This is a significant problem for Rome, especially given the high price of land. However, there are opportunities for the City to take a leading role by setting higher building and energy efficiency retrofit standards.

There is considerable scope to reduce wasteful energy use in this sector, given the fact that 60% of buildings in Rome were built before the 1970s[32]—many with poor heat insulation or cooling facilities. However, even these buildings can integrate renewable energy systems into their infrastructure.

Rome has already begun to set efficiency standards for new buildings via the 'Building Code of Rome' introduced in February 2006. In this code, new buildings are required to generate 30% of their energy from renewable energy sources and 50% of the energy to heat their own water.[33] Furthermore, there are tax incentives offered for energy efficient building construction.[34]

[31] Lora, P (2009)

[32] Casini, M (2009)

[33] Cafaro, M (2009)

[34] Casini, M (2009)

The renovation of the Willis Tower (formerly the Sears Tower) in Chicago by Adrian Smith & Gordon Gill Architecture demonstrates how improving the energy efficiency of one building can have broader impact. Prior to its renovation, the Tower had only 65% occupancy, and had reduced its energy consumption since 1976 by approx 50%. However since the proposed renovation, it stands at approximately 90% occupancy and energy use has been reduced by 80% in the base building (approximately 40% overall). To provide a reference of scale, a 10% reduction in this building is the equivalent of approx 2,500 single family homes in Chicago.[35] Furthermore, the financial savings from reducing wasteful energy use from the tower has since been used to power the adjacent building, which shares energy with the tower—as its peak usage is during the night, while the tower peaks during the day.

Rome is bidding to host the Olympics in 2020 and, therefore, needs to build a stadium suitable to host the Games. Project Eight sets out how Rome could achieve this goal through a zero-carbon stadium design. This building could mark itself as the first zero-carbon stadium in the world constructed as a power plant. Acciona's zero carbon office in Spain was the first building to reach this level of efficiency and the costs of its maintenance and energy use were returned after ten years.[36&37]

5.3 ISSUES

Enforcement of building regulations is one of Rome's principal challenges, and has been identified as such by the Mayor, as a third of the buildings are thought to have been constructed without authorization. This is compounded by restrictions on excavation around areas of cultural heritage that limit what can be built.[38]

Rome has some building codes in place for large developments. Regulation began in 1934 and, therefore, should be updated to take into account advancements in building and energy efficiency.[39] Nevertheless, there are positive steps being taken, such as an obligation for buildings to produce electricity

[35] Gill, G (2009) Gordon Gill and Adrian Smith Architects

[36] Faccedna, V (2009) Acciona

[37] This is compared to the costs of heating, cooling, and supplying electricity to an average building using conventional fossil fuel sources.

[38] Santoli, L (2009)

[39] Cafrao, M 2009

and hot water from renewable energy sources and to capture rain water.[40]

The high temperatures in the summer months and the corresponding increase in the use of air conditioning, make this time of year a critical problem for Rome. This peak period of energy use needs to be addressed in order to reduce carbon emissions. Air conditioning is a major cause of carbon emissions worldwide, so a focus on low-carbon cooling methods is also critical.

5.4 ECONOMICS

Improving overall lighting and operating efficiencies in ways that save money and integrating PV and other power production opportunities within Rome's building infrastructure will give the City an opportunity to "build out" a competitive advantage for the regional economy. Again, although initially a more expensive option, the cost savings and job creation benefits will ensure a robust economic opportunity for both businesses and consumers.

5.5 BENEFITS

Commercial	By turning buildings into power plants, companies will be less reliant on the national grid and, in some cases, able to sell electricity back to the grid.
Public	The same benefits in the commercial sector apply to the public sector, particularly as Rome owns 400,000 buildings. It is in the government's interest to lead the way and showcase best practices in public buildings. Similarly, the general public would benefit from reduced energy bills by turning private buildings into power plants.
Social	Converting all buildings into power plants has the potential to generate a large amount of related jobs.

[40] Cafaro, M (2009)

5.6 PROJECT SEVEN: BUILDING RETROFIT

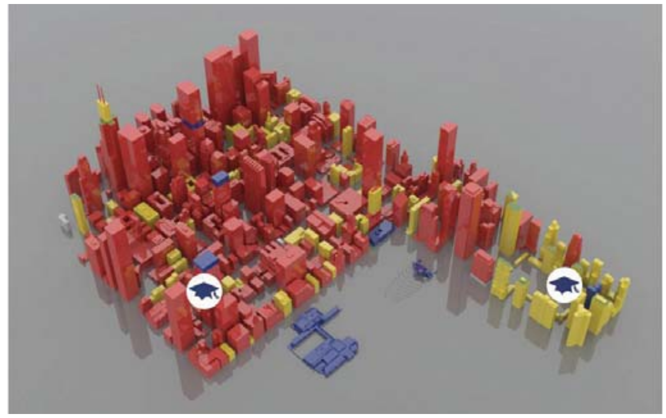


Figure 13: Adrian Smith + Gordon Gill Architecture Decarbonization Model

Adrian Smith and Gordon Gill Architecture, in conjunction with Positive Energy Practice, propose a decarbonization plan for Rome. A "decarbonization plan" is a systematic, dynamic approach for maximizing ecological and economic efficiency. The model would help policy makers identify opportunities for tapping energy potential in the historic core, while leveraging these savings to allow for planned development to come online with little or no impact.

Although climate change would be the thematic integrator, the larger model would aggregate key performance indicators across a broad spectrum of categories including: energy, water, waste, land use, health and mobility in an open source networked virtual city model (The UrbanOS©). This virtual model could then be adapted as Rome explored other opportunities for improvement. Because of its open source nature, the UrbanOS© also provides a platform for social marketing and public consensus building.

5.7 PROJECT EIGHT: ZERO CARBON STADIUM

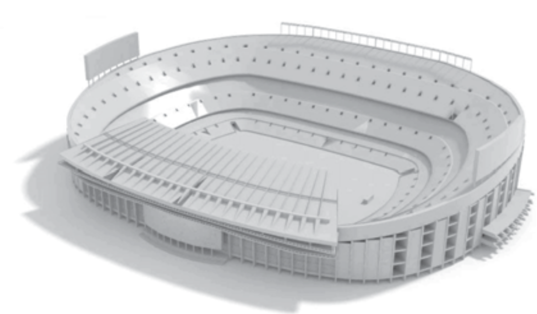


Figure 14: Zero Carbon Stadium

Two, world-reknown architects and members of the Third Industrial Revolution Architect Roundtable Enric Ruiz Geli, from Cloud 9 Studio, and Luca Galafaro of Ian +, have offered their vision of a Zero-Carbon Stadium for Rome. Utilizing the four pillars of the Third Industrial Revolution, the Stadium will be a high tech structure, utilizing renewable energy, hydrogen and smart grid technology, while taking advantage of state-of-the-art communication advances, such as social robots to provide spectators with information and sanitary services. In addition, the stadium must be viewed as a public space within the city, taking into account its total economic potential even after the games. With a holistic plan for the entire life-cyle of the structure, the building could be converted to serve multiple housing or retail needs; or perhaps taking advantage of Rome's tourist population, it could be a museum or hotel.

6 Pillar 3: Hydrogen Storage

6.1 INTRODUCTION

The introduction of the first two pillars of the Third Industrial Revolution—renewable energy and "buildings as power plants"—requires the simultaneous introduction of the third pillar, hydrogen storage capacity. To maximize renewable energy and minimize cost, it will be necessary to develop storage methods that facilitate the conversion of discontinuous energy supplies into reliable assets.

The need for storage is necessitated by the fact that renewable energy is intermittent. The sun is not always shining, the wind is not always blowing and water tables can be down. When renewable energy is not available, electricity cannot be generated and economic activity grinds to a halt. But, if some of the surplus electricity can be used to extract hydrogen from water, which can then be stored for later use, citizens can have a continuous power supply.

What many fail to consider is that when significant amounts of renewable energy are present on the grid, an increased number of power generators are needed on standby to handle large power fluctuations. At penetration levels between 10-20%, grids seem to hit the limits of their ability to handle the fluctuations. To move beyond those limits, energy storage is a necessity. If there was a way to store large quantities of energy and provide a means to balance load and power, the need for grid stabilization services would be better met and there would be greater capacity to take on more renewable energy.

Today the most popular form of energy storage for utility companies is pumped hydro. This simple storage method involves pumping water to a high elevation and, when it is released, it flows downhill to drive a hydroelectric turbine. Unfortuantely this storage form is limited by stringent requirements for excess energy, a plentiful water supply and variable topography.

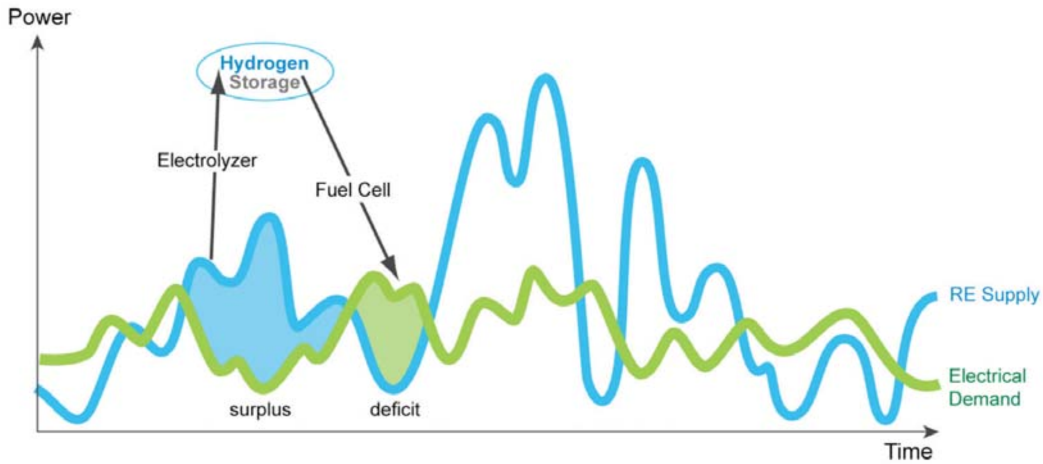
Another technology for utility-scale energy storage is Compressed Air Energy Storage (CAES). This system pumps air where it is stored until needed, and upon release, mixes the high velocity air with natural gas, which it is then co-fired as a clean fuel in a regular natural gas combustion turbine. Overall, this process uses 30–40% of the natural gas compared to a regular turbine. At present, there are only two CAES plants worldwide, one in Germany and the other operated by the PowerSouth Energy Cooperative in McIntosh, Alabama. PowerSouth pumps the compressed air into a 19 million-cubic-foot underground cavern. While CAES energy storage is not reliant on water and nearby high elevations like pumped hydro, it does require the presence of a hydrocarbon-based fuel in order to be co-fired, and therefore, has a somewhat higher level of greenhouse gas emissions. Both CAES and pumped hydro energy storage technologies are large and expensive systems, and thus, are mostly restricted to centralized utility-scale applications.

There is one storage medium, however, that is both widely available and capable of a vast number of uses. Hydrogen is a universal medium that "stores" all forms of renewable energy to assure that a stable and reliable energy supply is available for power generation and for transport. Our spaceships have been powered by high-tech hydrogen fuel cells for more than 40 years. It is also the lightest and most abundant element in the universe and, when used as an energy source, the only by-products are pure water and heat.

There are a large number of options to store hydrogen gas at a variety of pressures for a low incremental cost compared to more traditional electrical energy storage devices such as batteries. Hydrogen's real value, however, is its ubiquitous, universal nature. Hydrogen can easily be obtained and used in a number of industrial processes, and it can be used in a variety of applications—including compression and storage.

Combining renewable energy potential with hydrogen also unveils new market opportunities through ancillary services or demand response and load control. This is in contrast to the more expensive option of ramping up power generation from standby mode. Renewable energy can produce electricity to split water into hydrogen and oxygen via a process called electrolysis. An electrolyzer can be turned off and on very rapidly, or follow a power signal, allowing it to be used for grid

Figure 15: Supply and Demand- Hydrogen Solution (Hydrogenics)



stabilization.[41] In this scenario, hydrogen generation is the by-product of grid stabilization.

Using hydrogen as an energy storage and transmission media in this way has an additional economic benefit. As shown in the image below, combining wind or solar generation assets with hydrogen provides a more efficient way of developing electricity than conventional forms of power generation. Traditional generation methods operate in a steady-state fashion, often referred to as "baseload power." The drawback to these assets is that they don't respond to load demand very well. In other words, they continue to produce the same amount of power whether the grid demands it or not. But by coupling renewable energy with hydrogen storage, one cannot only handle the intermittency of the renewable power source, but provide a means to match the load demand moving up and down over the course of the day. This can prove to be a more effective use of power generation since there is no wasted power. A renewable energy/hydrogen plant, sized to meet a typical load profile, may actually be less expensive, on a capital cost basis, than some large-scale conventional baseload power plants.

In 1997, the German state of Bavaria partnered with 14 companies to develop hydrogen buses, generation systems and refueling infrastructure at the Munich Airport. The hydrogen gas used in these buses is obtained from the waste of a local petroleum refinery and then used in a pressurized electrolyzer. Meanwhile, the airport uses liquefied hydrogen in an automated refueling station (with robot dispensers) for small tanks in passenger cars. The first five years of this project costs about €14 million, but has resulted in over 13 thousand visitors and it is set to be expanded in subsequent stages.

The price of hydrogen and the associated infrastructure has, to date, been one of the biggest barriers to hydrogen's widespread adoption. Nevertheless, the cost of fuel cells has decreased five-fold in the last five years and the durability has risen ten-fold in the last three years. Another misconception about hydrogen is its safety when stored and used in vehicles. However, this problem of perception can be overcome as more people become familiar with the technology through everyday applications such as hydrogen buses; at least this has been the case in Germany.[42]

As one kilogram of hydrogen contains roughly the same amount of energy as one gallon of gasoline, and given present-day prices at the pump, producing hydrogen can be competitive with gas. According to Hydrogenics, hydrogen has storage capacity costs of €68 kWh.[43]

Researchers are currently experimenting with new methods of hydrogen synthesis that can produce gas even more cheaply and cleanly. Electrolysis can produce hydrogen, and if the electricity is from a clean energy source, this process emits no greenhouse gases. In the future, "bio-hydrogen" may even be produced using food, sewage or crops as a substrate. As the Munich Airport has demonstrated, it is possible and profitable today to create an integrated system for the production, distribution and consumption of hydrogen at a local level.

[41] Hydrogen can be extracted directly from biomass without electrolysis. However, this method produces carbon emissions as a by-product.

[42] http://www.ieahia.org/pdfs/bavarian_proj.pdf

[43] Presentation by Daryl Wilson—Hydrogenics

Photo 8: Example of Hydrogen Storage

Implementing hydrogen technology for utility-level storage will require a coordinated effort from the utilities and the City of Rome. Only a systems approach will lead to the realization of the full potential of hydrogen technology. Optimizing an overall hydrogen energy system on a broader basis will take insightful planning across several agencies in the community.

6.2 OPPORTUNITIES IN ROME

Rome is in a perfect strategic position to be a nexus for developing a hydrogen infrastructure network across Europe. The first step is to develop opportunities for hydrogen fuelled vehicles. It makes sense to start with fleet vehicles, such as buses, that return to one or more central refueling depots each day as it minimizes the need for initial refueling infrastructure. If powered by hydrogen and generated by renewable energy sources, these vehicles would be carbon neutral.

Rome could also take advantage of the synergies that exist between hydrogen and methane, given that a proportion of the city's transport already runs off the latter. Two hydrogen fuelling stations within the city are proposed below to serve the city bus fleet, which could be developed alongside an existing methane fuelling station.

In parallel with the hydrogen infrastructure being developed, the Hellenic Hydrogen Association, together with companies such as Tropical S.A, The Center for Renewable Energy Sources and Bredamenarinbus Spa, among others, propose investing in hydrogen vehicles, such as cars and vans.

6.3 ISSUES

The location of hydrogen fuelling stations needs careful consideration, as they should be in the most accessible location for their customers. At this stage, it will also be important to give consideration to the type of hydrogen vehicles being used, as these parameters will determine the network initially needed for infrastructure. This would require joint collaboration between the automotive industry and the energy companies who own the stations; ensuring underused capacity does not inflate the price of hydrogen.

There is also the issue of what the government should invest in first: the fleet of hydrogen vehicles or the infrastructure to fuel them. The short answer is that both need to be introduced simultaneously, but this will require a large outlay of investment, the return on which is likely to be slow.

Hydrogenics also notes from its previous experience that there is a unique technical challenge in the supply of hydrogen infrastructure in Italy/Rome. Engineering calculations need to show that what is delivered complies with code for discreet areas in Italy. However, Hydrogenics states that it will provide full code compliance to all applicable regional, country and EU specific requirements for equipment and work with local agencies to supervise and install the stations. Hydrogenics has also offered to train workers and monitor the station. Furthermore, these issues can be resolved with the use of third-party engineering firms who provide complete engineering calculations on equipment and certify that all work meets seismic code compliance.

6.4 ECONOMICS

Securing adequate energy storage is a vital part of Rome's economic development infrastructure. While this may in some ways be seen as an expensive "first cost," the increased storage will provide Rome with a cheaper and more stable set of long-term fuel and electricity prices. Moreover, as experience builds, the City will be able to reduce overall infrastructure costs, while ensuring an adequate and manageable energy supply. In the long-run, the experience of developing and managing this new infrastructure will provide Rome with new technical skills and employment opportunities.

6.5 BENEFITS

Commercial	Securing hydrogen as a main fuel would provide businesses with energy security and efficiency, in turn leading to more stable prices.
Social	Cheaper and stable fuel prices
Public	The most notable benefits to the public from the movement away from fossil fuel vehicles would be improvement in air quality in the city center as well as reduced noise pollution from diesel and petrol engines.

6.6 PROJECT NINE: HYDROGEN FUELLING STATION

Hydrogenics' Toronto division provides fuel cell products and renewable hydrogen systems for community power and renewable energy connections. Hydrogenics' Belgium division provides advanced electrolyzer systems and complete hydrogen fueling stations. Hydrogenics is the largest manufacturer of electrolyzers in the world today and has installed over thirty-five hydrogen fueling stations in countries such as the United States, Canada, Brazil, France, Germany, Holland, Spain and Sweden. The company is publically owned and listed on the Nasdaq (US) and Toronto (Cdn) stock exchanges with a $35M US market cap.

6.6.1 OVERVIEW

ATAC Rome is currently rebuilding a bus terminal designed to house and service Rome's large fleet of minibuses. This new bus terminal could be retrofitted to include an electrolyzer hydrogen filling station to fuel a fleet of ten minibuses. Rome currently has the largest fleet in the world of minibuses serving its tight city center. These minibuses are manufactured by the Italian company Tecnobus. Tecnobus, together with Hydrogenics, has delivered several hydrogen fuel cell buses to Germany and Spain, which are in regular daily service.

6.6.2 COST

The approximate budget for a complete hydrogen electrolyzer station (HyStat 60), which would be capable of fueling over ten Tecnobus sized buses per day, would be 1,000,000 Euros. Hydrogenics would work with the City to specify the type of station(s) that best suit the buses that Rome is looking to run on hydrogen.

6.6.3 CARBON SAVING

As a general example, a hydrogen electrolyzer fuelling station producing 120 kg of hydrogen per day, using renewable energy technology would save approximately 1400 kg of CO_2 per day (when used in a 30 person hydrogen fuel cell city bus).

6.7 PROJECT TEN: HYDROGEN VEHICLES

Leading hydrogen technology companies/organizations which form the Hellenic Hydrogen Association have developed a series of proposals to assist Rome in implementing a hydrogen network within the city. Alexander S. Vrachnnos, the founding member of the association, is a current board member and has a wealth of knowledge in waste management, renewable energy, green development and hydrogen. The other partner companies include: Tropical S.A, which specializes in vehicle air-conditioning, hydrogen technology, and renewable fuel sources; The Center for Renewable Energy Sources (CRES); The National Centre for Scientific Research; The Agricultural University of Athens; and Bredamenarinbus Spa, an Italian hydrogen bus company.

6.7.1 OVERVIEW

In addition to the hydrogen fuelling stations, the Hellenic Hydrogen Association recommend that the city of Rome initially invest in hybrid-hydrogen vehicles. Two hydrogen fuelling stations would be necessary for this project and could be located at the main entrances of Rome, in sparsely populated areas. However, since the fuelling stations will take their energy from renewable sources, locating them in proximity to these resources would also have efficiency benefits.

The Hellenic Association has suggested two hydrogen-hybrid buses which would carry twenty-five passengers and ten hydrogen-hybrid service vehicles (two and four seated). These buses could operate continuously for eight hours between fuelling and the service vehicles (cars) could operate up to ten hours before refuelling. To refuel this fleet, a fuelling station would be required with a daily capacity of $1000Nm^3$, suggesting a land-take of $1000\text{-}1500m^2$. Alternatively, two fuelling stations can be constructed with $500Nm^3$ daily capacity each, to be located in opposite parts of the city or wherever designated.

Photo 9a and 9b: Hydrogen Vehicles

6.7.2 COST

The first rough estimate of the cost of delivering two hydrogen fuelling stations and the hydrogen hybrid vehicles is approximately €2,400,000 The hydrogen stations, which include water electrolyzers, hydrogen tanks, compressors, filling units, and a safety and fire house is somewhere on the order of €750,000 for one 1000 Nm^3 capacity station and about €1,150,000 for two 500Nm^3 capacity stations. The rough cost for the previously mentioned hydrogen vehicles is €1,450,000.[44] The payback time and cost savings are hard to calculate without specific parameters, but based on other projects, the payback period should be between 8-10 years. Other factors, such as oil prices and the costs of environmental impacts would also affect payback periods.

6.7.3 CARBON SAVING

Assuming the hydrogen fuelling stations have a combined capacity of 1000 Nm^3 of hydrogen, an estimated 1050 kg of carbon could be saved per day. Of course, this is only possible if the hydrogen comes from renewable energy sources.

[44] It should be noted that these costs do not include country taxes or the cost of the land.

7 Pillar 4: Smart Infrastructure and Transport

7.1 INTRODUCTION

By benchmarking a shift to renewable energy, advancing the notion of buildings as power plants, and funding, supporting and integrating an aggressive hydrogen fuel cell technology R&D program, Rome will have erected the first three pillars of the Third Industrial Revolution.

The fourth pillar is the smart reconfiguration of Rome's larger infrastructure. This includes reconfiguring the transportation system, the communications network and the power grid along the lines of the Internet—what some are beginning to call the Smart Web. This "intelligent utility network" will enable the community to produce and share more forms of their own energy in more cost-effective ways. The smart grid will also provide energy companies and utility systems with the means to increase system reliability, enhance market robustness and reduce overall energy system costs. Finally, an intelligent utility network will allow businesses and homeowners to provide, move and ship goods and services in new and different ways.

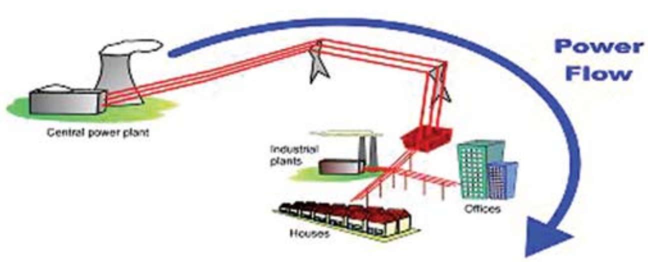


Figure 16: Centralized Energy Production

A smart intergrid that allows producers and consumers to tap into multiple resource options by way of several different energy providers will not only give end users more power over their energy choices, but will create significant new efficiencies and business opportunities in the distribution of electricity. The intergrid is a stark contrast from today's centralized distribution of energy resources.

Current power systems are, in organizational terms, a serial process, having the sources and coordination at one end and the demand and users at the other. The diagram above is a simplified representation of classical grids.

If we compare the classical energy system with the smart grid, there are several differences with more than technical implications. There are implications related to the roles within the system, the processes and the information. As described in the other pillars, distributed Renewable Energy Resources (RES), including wind, solar, biomass and gas-based micro technologies are expected to supply more and more energy in the coming years. Small to medium sized conversion technologies, including high speed micro and mini power turbines, reciprocal machines, fuel cells, power electronics and energy storage, will soon be installed on the electrical network. As a consequence, the future power system (a smart grid) looks like an energy web. At first glance, one can't help but notice this is a much less hierarchical electricity system.

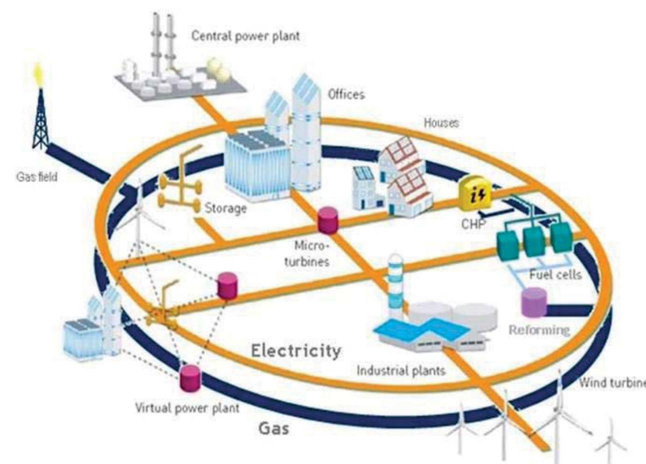


Figure 17: Decentralized Energy System

The shift from our current, top-down energy system, to the new distributed energy system will change the roles and relationships of many different stakeholders. These differences are summarized in Table 1.

The classical grid design is robust, reliable and cost effective. The flow of energy goes from a few large energy production companies toward end users (in one direction). Although more and more distributed generation and renewable energy sources are becoming part of today's power system, end users today are not responsible for overall power system management. This "fit and forget" policy is only possible because the share of these sources is low and sufficient headroom exists so that operational limits for the network are not encroached. However, if this continues, the system will reach a point where it becomes increasingly difficult to manage, with high connection costs, inefficiencies, decreased reliability and more outages. Therefore, the future of smart grid will require new technological solutions such as: fault level limitation, voltage control and automatic protection systems, which must be introduced to intercept otherwise inevitable power system faults.

7.1.2 CUSTOMERS

As described before, customers are now passive users. When smart grids evolve, however, customers become active or even pro-active users. They will produce their own energy and, therefore, have more choices: either satisfy their own personal demand; or sell electricity back to the grid when electricity prices have peaked. When these opportunities arise and users become "prosumers," more participants will be involved in the processes. This, of course, will not be possible without more intelligent appliances and a smarter distribution grid.

7.1.3 ENERGY PRODUCTION

Although it was previously mentioned that production of energy will be generated by the end-user, it is important to keep in mind that the end-user is not limited to a single household; the user could also be a school, a shopping mall or an industrial area. All locally produced energy, however, must be integrated with the grid. In the past, energy production companies were the only ones investing in large power plants or in their connection to the grid. With local energy production, the investment for both the installation and the connection to the grid must also be supported by local funding. This new system, then will give rise to new commercial opportunities.

7.1.4 INFORMATION

In the classic system, the only information that customers receive is via their energy bill. Even here, they only receive the total amount of energy consumed per month or per year. But this situation is changing. New possibilities are coming on the market, including the smart meter and many other monitoring and feedback systems. This, coupled with appliances connected to the internet will give end-users additional information

Table 1: Differences between the current energy system and the future energy system

Topics	Classical energy system	Future energy system (Smart grid)
Direction of energy	One way	Two ways
Customers	Reactive, passive users Few players involved No incentives	Pro-active contribution with personal production Many players involved Incentives for participation and energy awareness
Production of energy and its integration within the grid	Centralized production, Demand from consumers Investments at production location from energy companies	Central and decentralized production Demand from prosumers Investments at local level
Information and awareness of end users	Not a lot of technical monitoring and feedback systems for end-users Little information, Awareness low	A lot of technical monitoring and feedback systems for end users More information More possibilities for end-users to become directly informed about their energy
Energy storage	No substantial energy storage in the system	Energy storage possible at different levels of the system
Electrical vehicles + infrastructure	Very limited	Charge points at homes, in offices, factories and public buildings Fast charging points available in certain areas

regarding: real-time production; real-time demand; advice on energy savings; and, for very active prosumers, real-time market information to be used in commercial transactions.

7.1.5 ENERGY STORAGE

In the classic energy system, not much storage is incorporated simply because of technical restraints make it too expensive. As more and more options for storage come on the market, the future grid will expand to encompass new products and services. For example, the battery of the electrical vehicle can act as an energy carrier for the car and also deliver electricity to the end user. This gives the end user the possibility to buy electricity at a low price, store it in their car's battery, and sell the electricity at a higher price later in the day.

7.1.6 ELECTRICAL VEHICLES AND MOBILE INFRASTRUCTURE

Today we use all kinds of fuels for transportation. The energy chain and the mobility chain are separate. But what will happen if the electric car completely replaces the internal combustion engine? Then the two chains will converge. New commercial opportunities extend beyond GHG reduction, especially when car batteries are used as a storage mechanism. For this to happen, however, the price of the electric car must be dramatically reduced and a charging infrastructure must be developed. This new infrastructure will be integrated into the total architecture of the smart grid and, in the end, enable drivers to drive wherever they wish, without fear of not being able to charge their car or sell their electricity back to the grid.

A survey conducted by Enel, Italy's main utility provider, concluded that the majority of its consumers (60%) were concerned most about the cost of energy. One can infer, then, that price is likely to be the most salient variable to manipulate when hoping to change behavior.

With a smart intergrid, if the grid is experiencing peak energy use with the prospect of system overload, sensors and software can automatically direct a homeowner's appliances to delay activity, such as programming a washing machine to rev down one cycle per load or drop the air conditioning requirements by a few degrees. Consumers who agree to these slight adjustments in their electricity use could receive credits on their bills.

Since the true cost of electricity on the grid varies (sometimes significantly) during any 24-hour period, any moment-to-moment information opens the door to "dynamic pricing" opportunities. For example, consumers could program their home to use energy intensive appliances to function automatically when the price of energy drops below a certain level, or to stop activity when it exceeds an upper limit. Real time pricing and net metering policies also allows local energy producers—such as home owners with photovoltaic panels on the roof—the choice of automatically selling energy back to the grid, or potentially dropping off of the grid altogether.

Photo 10: Smart Meter

The evolution of smart grid technology will be crucial in advancing energy efficiency, renewable energy and a cleaner transportation system. Rome needs to capitalize upon these advances in order to reach the next level of energy efficiency. Different service areas have differing priorities and experience has shown that this shapes the development of the smart grid. Smart grids are as much about people, processes and organizations as they are about technology. From an end-user perspective, it starts with microgeneration and appliances in homes, then progresses to smart meters and supplier transactions, then distributed networks, energy and plug-in vehicles.

A number of cutting-edge firms are now working to integrate wireless networks with advanced meter reading (AMR) capabilities. The use of wireless data transfer avoids the costly labor and materials necessary for hard wiring and also promotes functional flexibility. Information about the customer's home energy use can be transmitted rapidly and cheaply over the internet to utilities. Utilities can then communicate new price and market conditions directly to customers. Electricity information is just one type of data that can be integrated on wireless networks. Wireless Home Area Networks (HAN) can integrate multiple sources of home information such as electricity and water use.

ACEA has been utilizing electric meters since 2006 and has installed 1.3 million devices for 1.6 million consumers. They have also developed their own meters, independent of Enel, as they wanted to ensure customers in flats have access to their own individual energy displays.

When smart meters are installed in homes and businesses, consumers will have the capacity to interact and respond to peak pricing signals and other information. In effect, consumers can become active, participating agents in reducing their carbon emissions as they will be able to reduce peak demand for energy when needed. Hence, energy efficiency combined with smart grid investments can provide important flexibilities for the larger energy system within Rome.

At present, consumers in Western European countries waste up to 30% of the energy they pay for by leaving lights on in unoccupied rooms. At one level, this constitutes irrational behavior—no one would happily throw away €100. Yet every year, millions of families do just this through wasteful energy use. The reason that so many people make such apparently irrational decisions is because of poor or flawed information. Quite simply, most consumers have no idea what the hourly or daily cost of energy is. Smart meters make cost implications easily visible to consumers; customers can see their energy use in real time, and thus, change their behavior.

The economic development potential of electricity is enhanced by the integration of cutting edge information and communication technologies across the entire power grid. Established firms like IBM, Cisco and KEMA excel at integrating smart products into large infrastructure systems. Smaller firms, in turn, are specializing in the sensors and devices that make the smart grid possible.

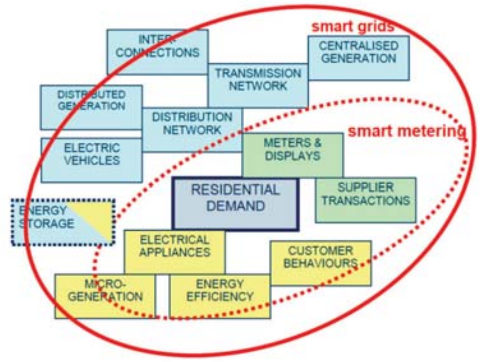
There is upfront capital required to create a network of smart meters in Rome, but the long-term financial savings from reduced energy use is very significant. Capital costs could be covered either through state subsidies or passed on to consumers through energy bills, providing that customers understand that these costs are more than offset by reduced energy use.

7.1.7 OPPORTUNITIES IN ROME

Italy is already a market leader in some aspects of smart grid thinking and was one of the first countries to install smart digital electricity meters, enabling remote meter reading and time-of-day charges.

Italy's smart meter program began in the 1990s when its main energy utility, Enel, conducted a large, residential feasibility study for remote meter management by installing 70,000 meters. By 2006, Enel was remotely managing 28.8 million meters.

Figure 18: Smart Grid System Elements (KEMA)



Enel spent €2.1 billion creating its smart grid. This includes every cost from R&D to IT systems development. This is a significant investment, but Enel estimates that the project achieves an annual savings of €500 million.

As a result, Enel has eliminated estimated billing, enabled remote reading of power consumption, facilitated remote change of contractual parameters and has improved fraud detection and prevention. Its meters have a lifetime of 15 years and a failure rate of less than three-tenths-of-a-percent per year. Since 2006, Enel has provided bidirectional policy phase meters that could be used with distributed generation systems. Another new development is integrated digital metering of gas, water, heating and electricity.

Recently, Enel partnered with Daimler in the "e-mobility Italy initiative" to build a network of 400 electric vehicle charging stations to use with 100 electric vehicles in Rome, Pisa and Milan. The recharging system will use the same type of technology as Enel's 32 million digital smart meters.

IBM points out that the City of Rome has a unique advantage since the local municipality (ACEA) owns the distribution network, provides electricity to the majority of customers in Rome and has already substantially invested in smart meter infrastructure. This offers significant leverage towards the 'second wave' of smart energy use to develop a smart grid.

Advanced as it is, Enel's programme has not yet realized its full potential. Most of the meters currently installed only send information back to the energy supplier, not to the customer, so there is room for further development.

There are already some highly successful examples of smart meters elsewhere in Europe. For example, Vaxjo, Sweden has seen electricity consumption decline by 24% and water usage fall by 43% in those households where smart meters have been installed. Numerous other cities around the world are following suit, including Madrid in Spain, Toronto in Canada and Manchester in England. New York City has gone one step further and trialled smart meters linked to building integrated renewable energy and real-time pricing. This empowers consumers to choose when they use energy-intensive devices, such as washing machines. When the price of energy is low, they can use these appliances. When the price of energy is high, they can sell surplus electricity back to the grid.

However, the impact of smart meters on consumer behavior is still being heavily researched. For example, a study by Oxford University for the London Borough of Camden Council found that poorly designed smart meters can confuse consumers, which often results in them not using the technology. Rome will need to understand the challenges and opportunities so that it can invest in the most successful forms of smart metering. There are significant potential benefits in combining better information to suppliers and consumers in a comprehensive smart grid.

Kema proposes a university campus as a demonstrator smart grid project. Woody Clark, of Clark Strategic Partners, believes that college campuses can become laboratories to test and showcase "agile energy systems."

7.1.8 ISSUES

The primary barrier to implementing a smart grid is the coordination needed at the outset, when commercial and public buy-in will be low. In addition, large financial investment will be initially required in order to establish the networks and linkages.

While there is a huge potential for smart meters to reduce energy consumption, real time information does not automatically deliver expected results. Further work needs to be done to help improve the communication between real time information devices and consumers.

7.1.9 ECONOMICS

From an economic development perspective, the expansion of a smart infrastructure—one that optimizes both energy costs and manages the productive flow of Rome's information and business decisions—will prove to be a vital asset for maintaining a robust economy. As with the other pillars, the expected economies of scale and "learning by doing" will reduce the costs of investment over time.

7.2 BENEFITS

Commercial	Smart grids would increase power quality and reliability, reducing blackouts, while also enabling companies to have greater control of their energy use and, thus, reduce energy bills. This would also facilitate the integratation of renewable energy in buildings (i.e. PV on roofs) into the existing grid network. Furthermore, smart grids stimulate new business opportunities.
Public	Smart grids provide the capacity to integrate more renewable energy into buildings and networks, enabling customers to reduce their own energy bills.
Social	Smart grids provide the capacity to integrate more renewable energy into existing networks, hence reducing carbon emissions. They also provide the ability to manage increasing numbers of electric vehicles, reducing the pollution inside the city.

7.3 PROJECT ELEVEN: SMART GRID DEMONSTRATION

Kema is a global, leading authority in energy consulting, testing and certification, and is active throughout the entire energy value-chain. In a world of increasing demand for energy, KEMA has a major role to play in ensuring the availability, reliability, sustainability and profitability of energy and related products and processes. KEMA combines unique expertise and facilities in order to add value to customers in the field of risk, performance and quality management.

IBM is the world's largest technology company and systems integrator, involved in all areas of the ICT supply-chain including: hardware, software, hosting and consulting. In the 21st century, as Information Technology advances increasingly drive new urban innovations, IBM sees the critical formation of a "virtual city infrastructure" that is instrumented, interconnected, and intelligent.

Kema and IBM have both provided visions for smart grid demonstration projects for approximately 2,000 households (6,000 residents). The projects would be based on a network that manages load and capacity as well as actively matching the supply and demand of energy. It would provide seamless, true integration of renewable energies, like wind and solar power, and would allow "microtrading" of locally-produced energy. Matching supply and demand of energy would require locally-controllable CHPs to balance the fluctuations in renewable energy.

Such a demonstration project should include electric vehicles and the required charging points, heating systems, PV-solar panels, smart meters, smart appliances, micro CHP and heat pumps, as well as user interaction (wall display smart phone applications), broadband connectivity, ICT infrastructure and smart transformer stations.

7.3.1 COST

There are many options for Rome to implement a smart grid: If bearing all investment costs directly, it would cost somewhere near 85-150 million Euros; on the other hand, providing incentive schemes for PV-Solar, CHP, heat pumps and smart appliances is another option to share the costs. If these options are considered, investments would be closer to 25-45 million Euros.

7.4 TRANSPORT

Transport is responsible for 36% of greenhouse gas emissions in Rome and improving traffic conditions is a principal concern of the city, as existing congestion problems are expected to worsen. While Rome's total carbon footprint is not high compared to many other European cities, the share taken by transport—1.7 tonnes per capita—is significantly higher than that of other European capital cities such as London, Paris and Madrid. This comes as no surprise as car transportation takes up a 65% modal share of travel within the city. Most of the journeys are done through private vehicles (65%), while cycling accounts for less than 1%, and public transport accounts for 28%. The City is trying to improve this by building a new underground line and creating more cycleways and park and ride facilities. However, as mentioned before, large infrastructure improvements—especially those involving underground tunneling—meet many obstacles as a result of the historical ruins.

Rome is planning to trade-in approximately half of the city's old vehicles for more efficient, newer ones and it plans to promote biking as an urban means of transportation by investing in infrastructure, increasing bus routes and by installing bicycle racks on busses.

Roman public transport is based mainly on bus services, as there are currently only two underground lines. There are a number of train lines connecting the city center to the hinterland, but the current level of service is not sufficient to achieve a significant modal shift.

There are 2,650,000 vehicles within the city, 72% of which are cars, 21% motorbikes, 6% small trucks and 1% large trucks and busses. Approximately 17.5% of cars, which cover a fifth of the city, are non catalytic converter vehicles, and are banned within Central Rome.

Photo 11: Bike Sharing Program

The city does have a bike sharing initiative, with 200 public bicycles available for hire from 19 parking bays across the city. Each bay is linked via a GPRS network, which updates the capacity and availability of bicycles in real time. Although not well known to many, Rome has the highest number of electrically powered public transport vehicles in Europe, comprised of 87 electric buses, 30 filobuses and 400 methane powered public buses.[45]

The city also has a pilot car sharing scheme, requiring at least three people per car. The service is booked by phone or online and provides some consumer advantages, such as parking and admission in restricted traffic areas.

7.4.1 ACHIEVING TRANSPORT MODAL SHIFT

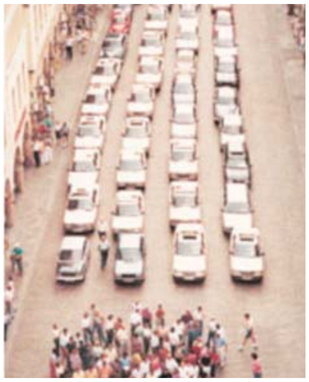
In the short term, achieving a modal shift from high emission transport vehicles to low-carbon public transport and zero carbon methods of cycling and walking is critical for Rome, along with virtually every other urban centre in the developed world.

To date, there have been many successful examples of achieving a modal shift to low-carbon transportation solutions. Copenhagen now registers a 33% modal share from cycling among trips to work. London even achieved a 5% shift from private car use to public transport during a period of strong economic growth—bucking the prevailing trend across the rest of the United Kingdom of increasing private car use.

The benefits of achieving a modal shift from cars to public transport, walking and cycling extend considerably beyond reducing greenhouse gas emissions. Road vehicles take

45 http://www.romaperkyoto.org

Photo 12a, 12b and 12c: Munster, Germany—Illustrating Public Space by Different Transport Modes



up considerable space, a valuable commodity in a densely populated environment like Rome. The image above, staged in Munster, Germany dramatically demonstrates the public space created when people transfer from cars to buses or cycling.

A number of cities around the world have demonstrated the benefits of reclaiming roads as public space. Paris has revitalized itself during the summer holiday period by closing off the right bank of the Seine to traffic and creating the Paris Plage; what is normally an expressway is transformed into a beach. Mayor Delanoe has even reclaimed car parking bays downtown in order to provide cycling parking facilities for the highly popular 'Velib' cycle hire scheme.

Perhaps even more radically, the city of Seoul in South Korea has demolished a four lane highway that used to run through the center of the city in order to uncover the Cheonggyecheon stream and constructed a path along side it. This new pedestrian thoroughfare proved a hit with tourists and Seoul residents alike and now has helped to reduce summer temperatures in the city center by between 0.4 and 0.9 degrees Celsius.

7.4.2 PLUG-IN VEHICLES

The first step in reducing emissions from transport is changing the way people travel and the second is operating vehicles more efficiently. The final stage is encouraging the uptake of improved vehicles and fuel types which emit less carbon, which is again where hydrogen becomes important.

When energy is in high demand, the smart meter and plug-in hybrid vehicle adds more energy storage capacity to the grid. Electric and hydrogen powered fuel cell plug-in vehicles can become "power stations on wheels," with a generating capacity of twenty or more kilowatts. Since the average car, bus and truck are parked much of the time, they can be plugged in during non-use hours, to the home, office or network and provide electricity back to the grid. Thus, electric and plug-in fuel cell vehicles become a way to store massive amounts of renewable energy. First, however, there are a number of different types of vehicles which need to be compared:

- In **hybrid vehicles**, energy that would normally be lost during breaking is used to charge the battery. This, in turn, powers the electric motor that supplements the petrol or diesel engine. They emit 30-40% less carbon than ordinary vehicles of similar size.
- In an **electric vehicle**, the battery is charged directly from the electricity grid and emits 70-90% less carbon per km. (However they currently have an operating range of roughly 50km and, thus, are more well-suited for short journeys).
- **Plug-in hybrid vehicles** use principally the same technology as hybrids, but the batteries are larger and can be charged off grid. These vehicles use 50-80% less fuel than standard hybrids.
- In **hydrogen fuel cell vehicles** electricity is supplied from the chemical reactions inside the fuel cell and the only by-product is water. Hydrogen produced from water and renewable energy results in a zero carbon vehicle. Hydrogen from natural gas provides a 30% carbon saving.[46]
- Vehicle emissions can also be reduced by using **biofuels** in place of petrol or diesel, however the carbon savings vary considerably between types and, at present, the marketplace does not distinguish between them.

Hybrid vehicles are much more energy efficient as they never use all of their battery power and, thus retain their capacity. (Once 90% has been used, the batteries' life is considerably and exponentially reduced). An electric car might be able to store four usable hours of electricity, which is equal to 1 kWh.

[46] London Climate Change Action Plan, Greater London Authority, 2007

In comparison, fuel cell vehicles can go up to 200kWh. It should also be noted that electric vehicle batteries currently need to be replaced every few years, and these environmental costs must also be taken into account.[47]

Hydrogenics has compared two Toyota vehicles, one is a conventional hybrid and the other a hybrid fuel cell car. The conventional hybrid has a marginally larger range capacity. However, its average fuel economy is nine liters for every 100km, compared to that of the fuel cell car, which is 3.4 liters.

Projects and industry partnerships are being formed at all levels to explore this new convergence of smart grid and transportation. In 2008, Daimler and RWE, Germany's second largest power company, launched a project in Berlin that established recharging points for electric Smart and Mercedes cars. Toyota has now joined with EDF, France's largest utility, to build charging points in France and other countries, for its plug-in electric cars. Similarly, Renault-Nissan is readying a plan to provide a network of hundreds of thousands of battery charging points in Israel, Denmark and Portugal to service Renault's all electric Mégane car. By 2030, charging points for plug-in electric vehicles and hydrogen fuel cell vehicles will be installed virtually everywhere—along roads, in homes, commercial buildings, factories, parking lots and garages—providing a seamless distributed infrastructure for sending electricity to and from the main electricity grid.

Photo 13: Hydrogen Fuel Cell Vehicles

7.4.3 THE BENEFITS OF HYDROGEN IN TRANSPORT

Not only does hydrogen transfer large amounts of energy to vehicles quite easily, but the only way to achieve zero emission public transport is through the use of hydrogen, since the energy demands are simply too great for pure battery operation.

[47] MacKay, D (2009) 'Sustainable Energy—without the hot air'

7.4.4 HYDROGEN CELL MINI BUS

Hydrogen offers far greater potential than batteries in transport applications as it has larger capacity and power. Nevertheless, there is still a strong case for combined hydrogen and battery powered vehicles in a hilly landscape like Rome because the battery can be recharged when the vehicles are travelling downhill. And despite concerns, hydrogen is actually safer than gas in vehicles as it does not explode, and if it is released, it rises, rather than sinking to the ground where there is ignition danger.

7.5 OPPORTUNITIES IN ROME

Plug-in cars could be incentivized in the city center. This would significantly reduce the inner city pollution responsible for damaging historical buildings and archaeological heritage. Public-private finance schemes could be used to generate the needed investment. Raising public awareness about the safety, range, and environmental advantages of plug-in vehicles will also be necessary.

The city would also benefit from the design of greater pedestrianized areas within the city center. This would disincentivize the use of private vehicles and reduce noise and pollution. The tourism industry would also benefit from delivering a higher quality environment to Rome's 23 million annual tourists.

7.6 ISSUES

Converting to plug-in vehicles requires the infrastructure to power them, which is costly and has a long lead-in time. A study conducted by Enel highlighted that 66% of plug-in vehicles would be charged at peoples' homes and 34% would use public infrastructure, highlighting the importance of both private and public charging points. Furthermore, even though statistics prove users will rarely need to travel outside of the range of their vehicle, there remains customer range anxiety with battery vehicles. Businesses also tend to perceive vehicles as an increased transport cost. Coordination with local businesses and an overall city-wide outreach and publicity strategy would reduce these types of concerns.

7.7 BENEFITS

Commercial	The introduction of plug-in cars and pedestrian walk ways would increase the air quality and functionality of commercial spaces. Businesses would benefit since citizens and tourists would be more willing to reach the affected areas. Furthermore, as the cost of fossil fuels increases, businesses will save costs from their plug-in transport.
Public	Electric cars, greater cycling facilities and pedestrian walk ways could offer Romans the opportunity of greater personal travel options, without increasing their carbon footprint
Social	Improved air quality from the use of electric cars, greater cycling facilities and pedestrian walkways would also reduce the damage to historical buildings and the archaeological heritage. Reduced pollution and noise could incentivize and improve social spaces.

7.8 ECONOMICS

Most assessments of climate mitigation tend to focus on generating electricity with renewable energy and waste-to-energy technologies. With a commitment to the Third Industrial Revolution that builds on the smart integration of hydrogen fuel cell and other electric vehicles, Rome has a critical opportunity to create synergies between electricity production and transport that will likely lower overall system costs compared to today's "stand alone" transportation and electricity generation systems. This will likely enhance the City's overall competitiveness, especially as it gains experience in the construction and operation of a newly integrated infrastructure.

8 Biosphere Education

The road ahead requires a "systems approach" that adequately addresses the economic, energy, and environmental challenges, and simultaneously, the human and social dimensions. It is important to note that the successful realization of the Third Industrial Revolution vision is not simply a function of innovative engineering, new technologies and physical infrastructure. New social, cultural and behavioral mechanisms will be needed if we are to empower individuals and communities and ensure equitable participation in the transformation to a post-carbon world and a Biosphere Era.

The transition to the Third Industrial Revolution will require a wholesale reconfiguration of the entire economic infrastructure of each country, creating millions of jobs and countless new goods and services. Nations will need to invest in renewable energy technology on a massive scale; convert millions of buildings, transforming them into power plants; embed hydrogen and other storage technology throughout the national infrastructure; transform the automobile from the internal combustion engine to electric plug-in and fuel cell cars, and lay down an intelligent utility network.

The remaking of each nation's infrastructure and the retooling of industries is going to require a massive retraining of workers on a scale matching the vocational and professional training at the onset of the First and Second Industrial Revolutions. The new high tech workforce of the Third Industrial Revolution will need to be skilled in renewable energy technologies, green construction, IT and embedded computing, nanotechnology, sustainable chemistry, fuel-cell development, digital power grid management, hybrid electric and hydrogen-powered transport and hundreds of other technical fields.

Entrepreneurs and managers will need to be educated to take advantage of cutting edge business models, including open source and networked commerce, performance contracting, distributed and collaborative research and development strategies and sustainable low-carbon logistics and supply chain management. The skill levels and managerial styles of the Third Industrial Revolution workforce will be qualitatively different from those of the workforce of the Second Industrial Revolution.

NH Hoteles is a paramount example. Anxious to beat the European Union's 20-20-20 by 2020 goal, NH announced its plan for a: 20% reduction in energy consumption; a 20% reduction in CO_2 emissions; a 20% reduction in water consumption; and a 20% reduction in waste, all by the year 2012. A large portion of its successes thus far can be attributed to its forming the "NH Sustainable Club." By developing financial tools and innovative business methods and then sharing these successes with others, the organization is setting the "industry standard." NH plans to create a similar shared knowledge in Rome by forming a "Supplier Club." (See NH Hoteles' Proposal).

The Third Industrial Revolution Master Plan for Rome envisions a revolution in the way students learn, with the goal of preparing succeeding generations with the knowledge and skills they will need to be productive workers in a sustainable biosphere economy.

In Rome, the very infrastructure of schools is being transformed to provide a living laboratory for a Third Industrial Revolution learning environment. La Sapienza University is reconfiguring its campus buildings into a Third Industrial Revolution infrastructure by introducing renewable energies, hydrogen storage technologies and smart grid networks. The goal is to connect the various universities, high schools and grade schools in a Third Industrial Revolution matrix and spread out across all of Rome. This pioneer web can be linked with business and residential energy cooperatives in the years ahead, metamorphosing in to a fully-operable infrastructure.

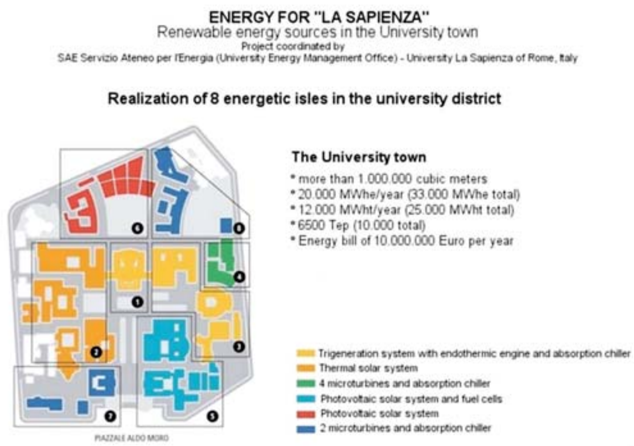


Figure 19: La Sapienza University-Energy Islands

Just as schools in the past decade were equipped with personal computers and Internet connection so that students could create their own information and share it with others in cyberspace, the current generation of students will be equipped with Third Industrial Revolution technologies so they can harvest their own renewable energy and share it across continents in open commons energy spaces.

While preparing students with the professional and technical knowledge and skills they will need to manage a sustainable post-carbon economy is essential, it is not sufficient. Rome will need to place as much attention on developing students' innate empathic drives in order to prepare the next generation to think and act as part of a global family in a shared biosphere.

The issue of what kind of education our youth should be getting is particularly relevant today as humanity attempts to cobble together a sustainable global society in time to avert a potentially catastrophic change in the climate of the Earth.

When we talk about revolutionizing the way our students learn, we need to understand the larger context that sets the framework for fundamental changes in our notions about education. Ultimately, our ideas about education flow from our perceptions about reality and our concepts of nature, especially our assumptions about human nature and the meaning of the human journey. These changes in human consciousness become institutionalized in our educational processes. What we are really teaching, at any given time in history, is the consciousness of an era.

For example, at the dawn of the modern market economy and nation-state era, Enlightenment philosophers—with some exceptions—saw human beings as rational, autonomous agents, driven by utilitarian desires and material interests. Educators then established a modern educational system along the same lines with the goal of bringing out these qualities.

Unfortunately, the educational system—for the most part—is still mired down in these outdated assumptions about human nature inherited from the Enlightenment. The classroom is a microcosm of the factory system, market forces and nation-state governance. Generations of students have been taught to think of "knowledge as power" and to regard learning as an asset one acquires to advance his or her own material self-interest. The education process emphasizes autonomous learning—sharing knowledge is considered cheating—and the mission is to produce efficient and productive workers for the market economy and loyal, patriotic citizens in the political arena.

While these Enlightenment assumptions have provided the intellectual motivation and justification for a vast expansion of wealth for a sizable portion of the human race, they have also left the Earth's ecosystems in shambles, with ominous consequences for the future of our species.

Recall that the convergence of new energy regimes with new communications technology not only ushers in new economic eras, but also fundamentally alters human consciousness. The Third Industrial Revolution is being accompanied by a great transformation from ideological consciousness to biosphere consciousness. By creating energy in our neighborhood communities and sharing electricity peer-to-peer in open commons that span continents, we come to understand our interconnectivity and interdependency in a common biosphere. The shift from ideological consciousness to biosphere consciousness requires a rethinking of the mission of education.

8.1 DISTRIBUTED AND COLLABORATIVE LEARNING

The newly emerging awareness of global ecological interconnectivity is being accompanied by a revolution in the very way students learn. The traditional top-down approach to teaching, the aim of which is to create a competitive, autonomous being, is beginning to give way to a distributed and collaborative educational experience designed to instil a sense of the shared nature of knowledge. Intelligence, in the new way of thinking, is not something one inherits or a resource one accumulates but, rather, the shared experience that is distributed between people.

The shift into the distributed Information and Communication Technology (ICT) revolution and the proliferation of social networks and collaborative forms of engagement on the Internet is taking education beyond the confines of the classroom to a global learning environment in cyberspace. Students are connecting with peers in distant lands in virtual classrooms through Yahoo and Skype technology, turning the educational setting into a global classroom and, by so doing, transforming learning into a distributed and collaborative experience that stretches around the world in real time.

The extension of the central nervous system of the classroom to embrace the whole of civilization exposes young people to their peers in widely different cultures, allowing empathic sensibility to expand and deepen. Education becomes a truly planetary experience, hastening the shift to biosphere consciousness.

We recommend that virtual classroom learning environments be established in the universities, secondary schools and primary schools, connecting Roman students with their peers in cities and regions around the world so that they can become immersed in distributed and collaborative learning environments that span the globe.

The global extension of learning environments in cyberspace is being matched by the local extension of learning environments in school neighborhoods. The walls separating the classroom and community are beginning to break down as learning becomes a distributed exercise involving both formal and informal modes of education in broader more diverse social spaces in the civil society.

In the past twenty years, schools and colleges have introduced service learning programs into the school curriculum—a deeply collaborative learning experience that has altered the educational experience for millions of young people. As part of the requirement for graduation, students are now expected to volunteer in neighborhood non-profit organizations and in community initiatives designed to help those in need, and to improve the well-being of the communities in which they live.

The exposure to diverse people from various walks of life has spurred an empathic surge among many young people. Studies indicate that many students experience a deep maturing of empathic sensibility by being thrust into unfamiliar environments where they are called upon to reach out and assist others. These experiences are often life-changing, affecting their sense of what gives their life meaning.

A growing number of school systems and universities are ratcheting up service learning to pedagogy by embedding it into the rest of the academic curriculum. Subject areas come alive by direct engagement. One learns about sociology, political science, psychology, biology, mathematics, music, the arts, literature and the like, both in the classroom and in direct participation with others through service in the community.

We recommend that the city of Rome implement a service learning program in all secondary schools as part of the requirement for graduation.

Distributed and collaborative education begins with the premise that the combined wisdom of the group, more often than not, is greater than the expertise of any given member and that by learning together the group advances its collective knowledge, as well as the knowledge of each member of the cohort.

Although not yet the norm, an increasing number of classrooms at the university and secondary school levels—and even in the lower grades—are being transformed, at least for small periods of time, into distributed learning environments. It's not uncommon for large classrooms to be divided into smaller work groups, who are then given a collaborative work assignment. They then reconvene in plenary sessions where they share their findings, generally in the form of group reports.

In distributed and collaborative learning environments, the process becomes as important as the product. The old hierarchical model of learning gives way to networked ways of organizing knowledge. Learning becomes less about pounding facts into individual students' brains and more about how to think collaboratively and critically. To be effective, collaborative learning requires mutual respect among all the players in the cohort, a willingness to listen to others' perspectives, being open to criticism and a desire to share knowledge and be responsible for and accountable to the group as a whole.

We recommend that distributed and collaborative learning environments be introduced into the secondary schools and universities in Rome.

Needles to say, distributed and collaborative learning favors interdisciplinary teaching and multicultural studies. Academia is experiencing a transformation from autonomous disciplines with well-defined, walled-off academic borders to collaborative networks whose participants come from various fields, but share knowledge in a distributed manner. The more traditional reductionist approach to the study of phenomena is beginning to give way to the pursuit of “big picture” questions about the nature of reality and the meaning of existence—which require a more interdisciplinary perspective.

Cross disciplinary academic associations, journals and curricula have proliferated in recent years, reflecting the burgeoning interest in the interconnectedness of knowledge. A younger generation of academics are beginning to cross over traditional academic categories in order to create a more integrated field of research. Several hundred interdisciplinary fields like behavioral economics, eco psychology, social history, eco-philosophy, biomedical ethics, social entrepreneurship and holistic health are shaking up the “academy” and portend a paradigm shift in the educational process.

Meanwhile, the globalization of education has brought together people from diverse cultures, each with their own anthropological point of reference. The result is a plethora of fresh new ways of studying phenomena, each conditioned by a different cultural history and narrative.

By approaching a study area from the perspective of a number of academic disciplines and from different cultural perspectives, students learn to be more open minded and able to view phenomenon from more than one viewpoint.

We recommend that interdisciplinary teaching and multicultural studies be introduced into curricula in all Roman universities and secondary schools.

Distributed and collaborative learning, with its emphasis on mindfulness, attunement to others, nonjudgmental interactions, acknowledgment of each person’s unique contributions, and recognition of the importance of deep participation, can’t help but foster greater empathic engagement. In this sense, collaborative learning transforms the classroom into a laboratory for empathic expression which, in turn, enriches the educational process.

The early evaluations of these pioneer educational reform programs are encouraging. Schools report a marked reduction in aggression, violence and other antisocial behavior, a decrease in disciplinary actions, greater cooperation among students, more pro-social behaviour, more focused attention in the classrooms, a greater desire to learn and improvement in critical thinking skills.

If our primary nature is *Homo empathicus*, and the biosphere is the larger indivisible community where we and our fellow creatures dwell, then the mission of Italian education ought to be dedicated, at least in part, to the task of bringing out our core being so that we can optimize our full potential not only as productive workers in the marketplace but, more importantly, as empathic human beings in the biosphere.

Conclusion

The Third Industrial Revolution Master Plan for Rome will radically transform the City that founded Western Civilization into a Third Industrial Revolution economy, making it the first post-carbon city in the world. The Master Plan, which involves billions of Euros of investment over the next 20 years, is a bold and far-reaching initiative to reshape urban civilization in preparation for life in a biosphere era. It is the first comprehensive economic initiative of its kind and puts Rome at the forefront of efforts being pursued across Europe to reach the 20-20-20 by 2020 EU mandate and achieve the long-term goal of realizing the Lisbon Strategy to make the EU the most competitive economy in the world.

The Third Industrial Revolution represents the final stage of European integration—the establishment of a European wide “distributed” communication and energy network that will create a seamless economic infrastructure, allowing Europe to become the largest integrated single market in the world by 2050.

Implementing an urban transformation of this magnitude and scope will require the commitment of the entire Roman citizenry over a sustained period of time that spans two generations. All three sectors—government, the business community and civil society—will need to work closely together to make the vision of a Third Industrial Revolution a reality.

The adventure that Rome is embarking on is a new one in history—a journey out of the old world of narrow material self-interest and geopolitics and into a new world of collaboration and biosphere consciousness. The first Roman Empire was built on the heels of conquest. The Roman biosphere will be built off of humanity’s deep empathic commitment to steward the Earth.

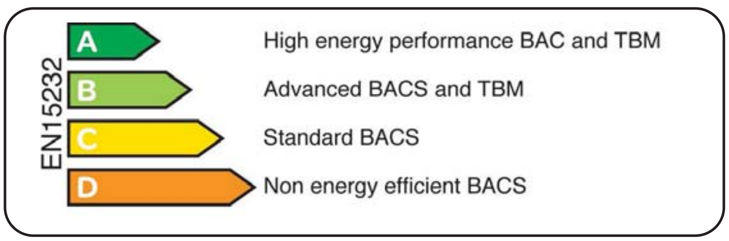
Extended Recommendations and Projects from the Member Companies of the Third Industrial Revolution Global CEO Business Roundtable

BUILDING RETROFIT

1. Overview

The EN UNI 15232 European Standard specifies different **functionalities and a method** to estimate energy saving factors which can be used in conjunction with energy assessment of buildings. It supplements a series of standards which are drafted to calculate the energy efficiency of technical building services e.g. **heating, cooling, ventilation, lighting systems** and takes into account the fact that with building automation control systems (BACS) and technical building management (TBM) the energy consumption of a building can be reduced.

This European Standard should be used for existing buildings and for design of new or renovated buildings.



2. Specific Opportunities in Rome

Considering that 33% of Rome city CO_2 total emission is related to Residential & Buildings (about 8.092 kTon CO_2) a big opportunity of CO_2 reduction can be quick implemented through the implementation of BMS and Home Automation. See EN 15232 savings table attached on chapter 7.

3. Potential/Real Issues

Issues of retrofitting buildings in Rome can depend from the civil works that may be needed to implement the new technology.

4. Solutions to Issues

Compared to those energy improvement initiatives such as insulation, the Home/Building automation installation will require a very limited impact on civil works.

All the installation will be executed inside the apartments/house. That means:

- no civil yard and a very limited impact on traffic jam
- the possibility to renew old & historical buildings
- Moreover most of the residential / office implementations could be done easily in case of house/office renovation.

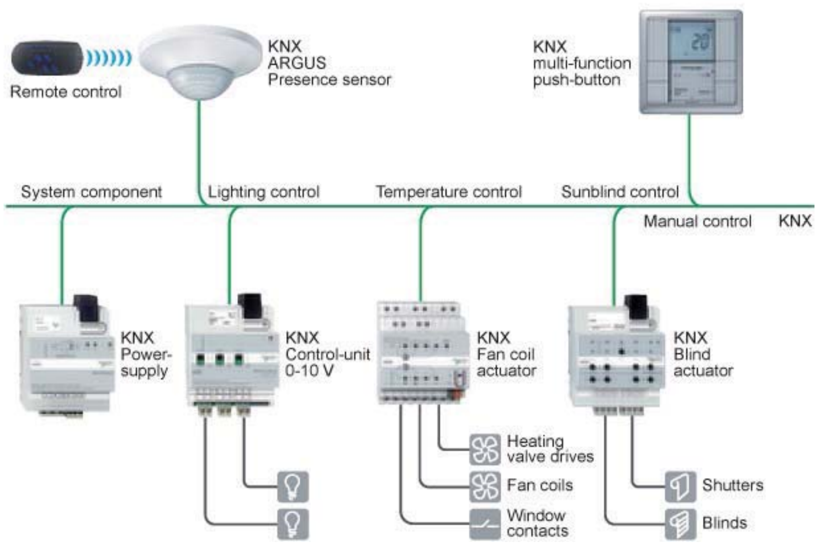
The Italian legislation, such as building certification, may help the energy efficiency improvements.

Schneider Electric

Your Proposal for a Building Retrofit

5. Overview

As reference find below a simple energy optimization achievable though a Home Automation system.



In the above example it is possible to automatically manage building's lighting and air conditioning depending on occupancy, orientation, and natural light. KNX standard is applied in this case.

- Combine a variety of room-level controls for dramatic cost savings.
- The solution is built around KNX detectors and fan and blind actuators, which interact automatically, eliminating activation and deactivation.
- By combining presence and brightness detectors with timers to control lighting, blinds, heating, and air conditioning, you can save dramatically on your energy bills while increasing occupant comfort and safety.
- Lights are switched on only when areas are occupied and depending on natural light. Heating and air conditioning are automatically regulated, switching to standby mode in the event of prolonged absence or if a window is open.
- Blinds are activated according to room temperature.

Benefits for end-users: save up to 50%:

- combining room climate control, lighting, and blinds in a single flexible, automated system is the best way to align energy consumption with room use and occupant behaviour while eliminating waste,

- according to EU standard EN 15232, Class A building management systems must be equipped with room-level controls, which have the greatest impact on energy consumption,
- all-in-one solution for optimised room control,
- reduces energy consumption,

6. Costs

An expected ROI could be in the rang of 3 to 8 years depending on the starting building class (A,B,C,D) and the amount of cost included in the simulation (only high efficiency extra-cost or full cost).

For istance 2,5 – 3 keuro may assumed as difference between a traditional installation compared to a high level home automation system -> in this case an ROI of about 3 years may be assumed.

7. Carbon Saving

Building and Home renovation allow the Rome city to save an important part of the total CO_2. The EN 15232 standard defines, for any kind of application, the savings that may be achieved thanks to the implementation of these systems.

		Definition of classes							
		Residential				Non residential			
		D	C	B	A	D	C	B	A
SHUTTER CONTROL									
0	Manual operation								
1	Motorised operation with manual control								
2	Motorised operation with automatic control								
3	Combined control of lighting, shutters and CVC system (also mentioned above)								
AUTOMATION SYSTEM FOR HOUSEHOLDS AND BUILDINGS									
0	No automation function for households and buildings								
1	Centralised automation system for households and buildings adapted to meet users' needs: e.g. programming, set-point values, etc.								
2	Centralised uatomation system optimised for households and buildings: e.g. regulator setting, set-point values, etc.								

BAC efficiency factors for thermal energy
The BAC efficiency factors in Table 8 and Table 9 of EN 15232 for thermal energy (heating and cooling) are classified depending on the building type and the efficiency class the BAC/TBM system is related to.
The factors for efficiency class C are defined to be 1 as this class represents a standard functionality of BAC and TBM system.

Table 8 — BAC/TBM Efficiency factors $f_{BAC,HC}$ – Non-residential buildings

Non-residential building types	BAC efficiency factors $f_{BAC,HC}$			
	D	C (Reference)	B	A
	Non energy efficient	**Standard**	Advanced	High energy performance
Offices	1,51	1	0,80	0,70
Lecture hall	1,24	1	0,75	0,5 [a]
Education buildings (schools)	1,20	1	0,88	0,80
Hospitals	1,31	1	0,91	0,86
Hotels	1,31	1	0,85	0,68
Restaurants	1,23	1	0,77	0,68
Wholesale and retail trade service buildings	1,56	1	0,73	0,6 [a]
Other types: - sport facilities - storage - industrial buildings - etc.		1		

[a] These values highly depend on heating / cooling demand for ventilation).

Table 9 — BACS/TBM efficiency factors $f_{BAC,HC}$ – Residential buildings

Residential building types	BAC efficiency factors $f_{BAC,HC}$			
	D	C (Reference)	B	A
	Non energy efficient	**Standard**	Advanced	High energy performance
Single family houses Apartment block Other residential buildings or similar residential buildings	1,10	1	0,88	0,81

BAC efficiency factor for electric energy
Electric energy in this context means lighting energy and electric energy required for auxiliary devices but not electric energy for the equipment. The BAC efficiency factors in Table 10 and Table 11 for electric energy are classified depending on the building type and the efficiency class the BAC/TBM system is related to.
The factors for efficiency class C are defined to be 1 as this class represents a standard functionality of BAC and TBM system.

Table 10 — BAC/TBM Efficiency factors $f_{BAC,el}$ – Non-residential buildings

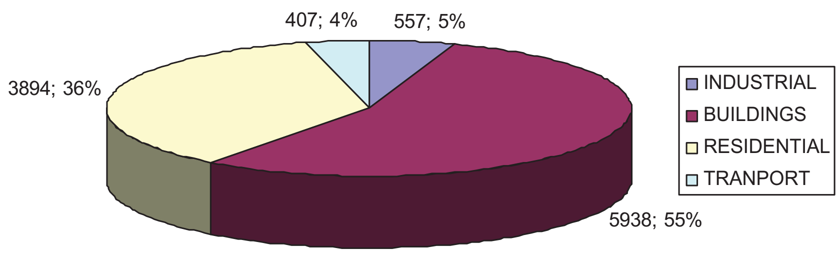
Non-residential building types	BAC efficiency factors $f_{BAC,el}$			
	D	C (Reference)	B	A
	Non energy efficient	Standard	Advanced	High energy performance
Offices	1,10	1	0,93	0,87
Lecture hall	1,06	1	0,94	0,89
Education buildings (schools)	1,07	1	0,93	0,86
Hospitals	1,05	1	0,98	0,96
Hotels	1,07	1	0,95	0,90
Restaurants	1,04	1	0,96	0,92
Wholesale and retail trade service	1,08	1	0,95	0,91
Other types: - sport facilities - storage - industrial buildings - etc.		1		

Table 11 — BACS/TBM efficiency factors $f_{BAC,el}$ – Residential buildings

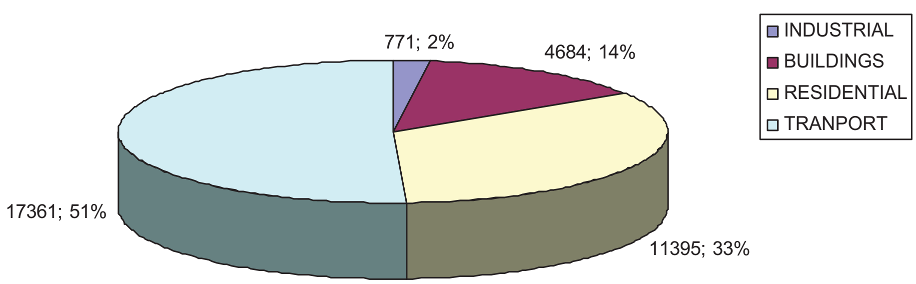
Residential building types	BAC efficiency factors $f_{BAC,e}$			
	D	C (Reference)	B	A
	Non energy efficient	Standard	Advanced	High energy performance
Single family houses Multi family houses Apartment block Other residential buildings or similar residential buildings	1,08	1	0,93	0,92

Now if we consider the consumption datas given during the presentation of Prof. De Santoli in the workshop of December 2009, consumptions can be grouped in two main areas:

ELECTRICAL CONSUMPTION [GWh]



THERMAL CONSUMPTION [GWh]



Taking in consideration thermal consumption, it can be assumed that about **90%** of the thermal consumption is related to heating system in the residential & building segment. That means:

- about 10.255 GWh for residentials
- about 4.215 GWh for buildings

Considering the saving factor indicated in the tables above (Table 8 & 9 of the EN15232), moving **from class C to class A**, savings achievable only for thermal parts, are:

BUILDINGS (offices): 30% => about 1.264 GWh/y equal to **255 kTon CO_2/y**

RESIDENTIAL: 19% => about 1.948 GWh/y equal to **394 kTon CO_2/y**

Total saving about **650 kTon CO_2/y.**

Numbers above are calculating assuming an **emission factor of 0,202 tCO2/MWh** for natural gas.

8. Visuals

See above

Energy Efficiency Lighting for the City of Rome

Outdoor Solutions

A Simple switch for a Sustainable City

1. Overview
2. Specific Opportunity in Rome
3. Potential/Real Issues
4. Solutions to issues
5. Philips proposal for Lighting improvements

PHILIPS

sense and simplicity

1. Overview

Royal Philips Electronics of the Netherlands (NYSE: PHG, AEX: PHI) is a diversified Health and Well-being company, focused on improving people's lives through timely innovations. As a world leader in healthcare, lifestyle and lighting, Philips integrates technologies and design into people-centric solutions, based on fundamental customer insights and the brand promise of "sense and simplicity". Headquartered in the Netherlands, Philips employs approximately 116,000 employees in more than 60 countries worldwide. With sales of EUR 26 billion in 2008, the company is a market leader in cardiac care, acute care and home healthcare, energy efficient lighting solutions and new lighting applications, as well as lifestyle products for personal well-being and pleasure with strong leadership positions in flat TV, male shaving and grooming, portable entertainment and oral healthcare.

Philips Lighting, a founding division of Philips brand operates in all area of lighting, from lamps to lighting components, from interior and exterior fixtures to LED. In 2005 Philips was ensured a leadership position in providing high-power LED by the acquisition of Lumileds, the leading manufacturer of LED modules. The company is today a complete lighting solution provider in all application: homes, offices, outdoor, industry, retail, hospitals, entertainment, healthcare.

The landscape of the lighting industry is changing fast. The energy-efficiency imperative, legislative pressures (such as Kyoto and EUP Directive 2005/32/ECI) and the world of possibilities opened up by the LED revolution are all having a positive influence on our lighting choices. We're spreading the word under our theme of Sustainable Cities. It's our way of helping urban authorities to reduce energy consumption so they can lower CO_2 emissions and improve the quality of life in their towns and cities.

Previous page: Eur lake garden in Rome, LedGine installation

Quality of life - the challenge of unparalleled urbanization

A century ago less than 10% of the world's population lived in cities. By the start of the 21st century that figure had risen to over 50%, and by 2050 it will be over 75%. Faced with this unparalleled expansion, city authorities worldwide recognize the need to re-humanise the urban environment by tackling crime, promoting tourism and fostering local identity and pride.

Sustainability - simple changes, major impact

Philips Lighting has a long-standing commitment to providing lighting solutions that improve our lives and are environmentally sound. It's one of the cornerstones of our sustainability policy, whereby we strive to balance our social, economic and environmental responsibilities. Our outdoor lighting solutions can help you create sustainable cities through:

- Architectural lighting for urban spaces
- Advantages of White Light in the different application areas in an urban environment
- Energy-efficient solution proof points in various application areas
- Existing LED solutions for multiple dedicated application areas

2. Specific Opportunities in Rome

There is a huge saving potential in Outdoor Lighting. By switching to the new energy efficient LEDGINE solution, and using additional dimming solution the energy saving can be further enhanced up to 80%.

This new technology we will introduce in the month of May 2010, is a new step in the LED revolution, as it allows to reach:

- High level of lighting performance
  - High quality and uniformity of light (to have a more comfortable LED and security of the citizens)
  - High energy efficiency (up to 70%)

- Availability to update the system by changing the LED inside the luminaries
  - Led technology is expected to evolve fast in the coming years, with energy efficiency going up. Our LedGine will continuously be upgraded to the best leds, to allow you get the best out of it. And it can also be retrofitted in previous generation.
  - To utilize the increasing energy saving possibilities that LED offers, our system can be upgraded whenever needed. In coming years it will be possible to decrease number of leds and maximize energy reductions.

Eur lake garden in Rome, LedGine installation

3. Potential/Real Issues

The cost of investment in new LED technology is higher than the traditional one, although the TCO is less due to reduction of the energy consumption and maintenance. This represents an issue both for municipality and ESCOs that should invest much money at the beginning of the project.

4. Solutions to Issues

One way to overcome this issue could be that of giving funds to public administration and ESCOs to buy new "green technology" and also activate "green procurement".

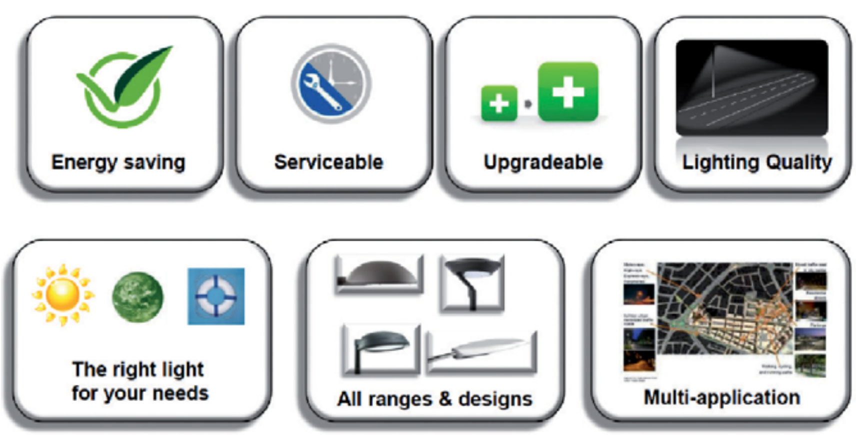
5. Philips Proposal for Lighting Improvements

a. Overview

To start reducing his carbon target we propose to Rome to change some outdoor lighting solution not efficient with new lighting solution LEDGINE.
Philips, Acea and Roma energia has signed an agreement to develop a pilot in one area of Rome: EUR Lake Garden.

The product selected is: CitySpirit Street with LEDGINE.

In order to give municipality a solution that can always be upgradeable and take advantage of the new development of the LED technology, LEDGINE has the following characteristics:



Details of the project: EUR Lake Garden

The project is a renovation of an existing installation (post-top luminaries) around the Lake in the EUR area of Rome.

As a result of the substitution of the 71 lighting point with CITYSPIRIT STREET 24 Leds, Greenline, Neutral White, it has been possible to save 72% of energy.

Energy consumption per lighting point of existing SON100W was 124W. With the new solution energy consumption per light point is only 35W using 24 Leds.

Eur lake garden in Rome, LedGine installation

Carbon Saving pilot project – Eur lake garden

	SON-100W	CITYSPIRIT STREET LEDGINE
# of light points	71	71
Wattage (W)	124	35
Burning hours / year	4.200	4.200
Energy cost savings (EUR) *		3.450
CO_2 emissions savings per year (kg) **		11.147
Energy saving		72%

*0,13 EUR/KWh/**0,42 Kg/KWh

b. Cost

An average cost of a LED solution is about 500,00 euro. Potential cost saving is medium 50%. Payback time is medium 8 years.
These solutions allow to avoid lamp replacement (usually each 2 years) and reduce cost of maintenance.

c. Carbon saving

To estimate which is the potential CO_2 reduction if lighting were to achieve its maximum potential in Rome, following Acea project to change 100.000 Leds within 2020, we suppose that the average power for each lightpoint is 180W and that it is possible to save 50% of energy.

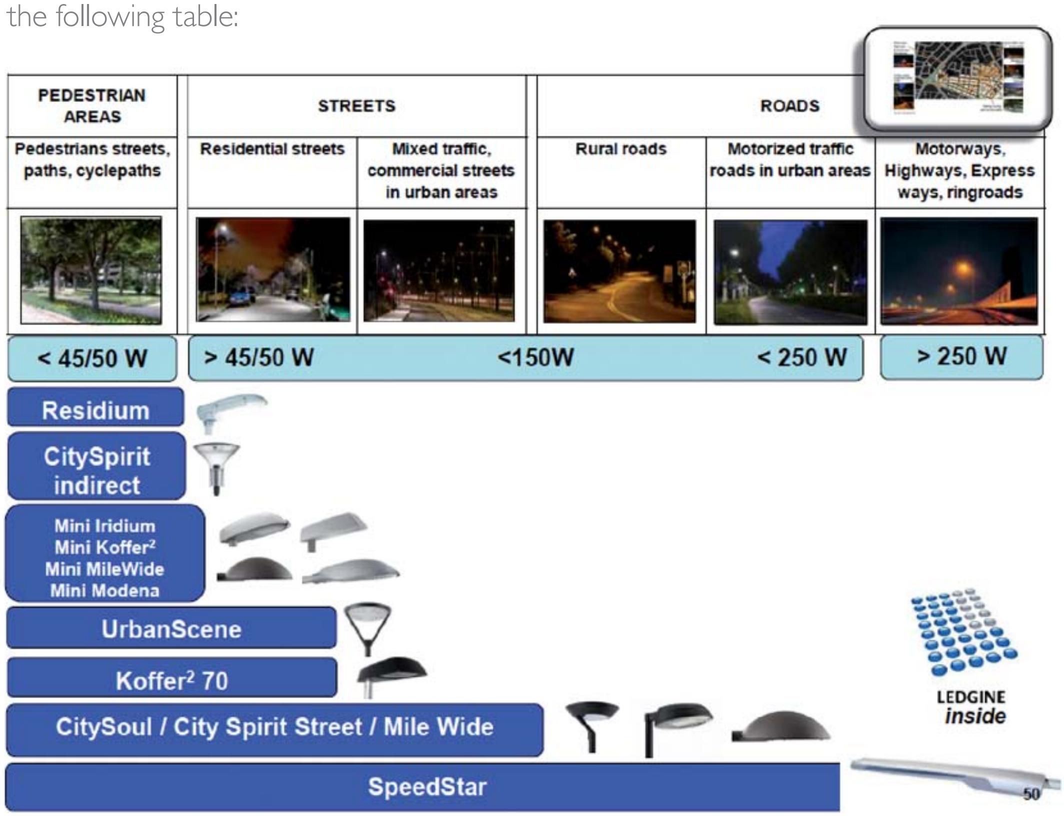
Carbon Saving potential estimated within 2020

	SON or HPL 180W	LedGine
# of light points	100.000	100.000
Wattage (W)	180	90
Burning hours / year	4.200	4.200
Energy cost savings per year(EUR) *		4.914.000
CO_2 emissions savings per year (tonnes) **		15.876
Energy saving estimated		50%

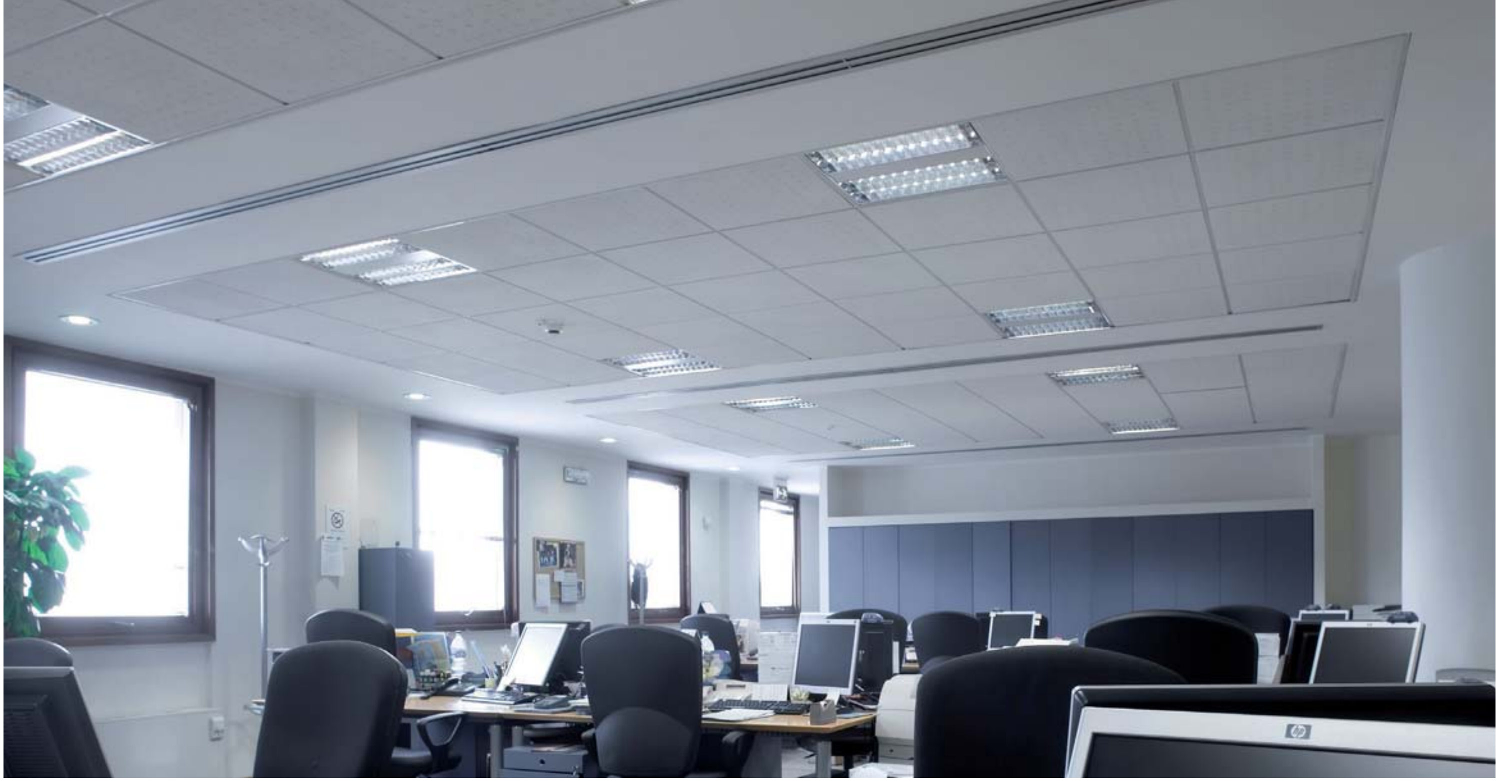
*0,13 EUR/KWh/**0,42 Kg/KWh

d. Visual

Ledgine is available for all application and for different kind of luminaries, as shown in the following table:



CitySpirit Street with LedGine



Energy Efficiency Lighting for the City of Rome

Indoor Solutions

A Simple switch for a Sustainable City

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Good lighting not only enables people to see, it also affects how people feel.
Philips Office Lighting provides
Sustainable lighting solutions that reduce energy costs improve well-being and care for our planet.
We're passionate about lighting that doesn't deplete our planet's precious resources unnecessarily.

Switch on energy savings

Approximately 40% of all the electricity used in buildings comes from lighting, making it one of the most attractive ways to save energy. So we've developed a complete range of solutions that is socially responsible, technologically advanced and pleasing to the eye. Smart and efficient lighting that helps you to sustain your company and the environment.

The EU has set a target to reduce total energy consumption by 20% before 2020. In order to reach this target a number of legislative directives have been developed. One of them is the Energy using Product Directive to reduce the environmental impact of energy-using products. Measures have been put in place to determine the minimal energy efficiency requirements of lighting, which automatically means that some products will be phased out.

Future-proof lighting

Philips is prepared for the change over. Our office lighting solutions provide a complete range of alternatives, all of which comply with the latest legislation. What's more, we're making sure you stay well ahead by equipping all of our luminaries with the highly efficient HF electronic gear.

A move that goes well beyond the legislation, which doesn't require that until 2017. You can see the benefits now by saving up to 25% on energy costs with normal HF gear, up to 75% on energy costs with HF gear and controls.

2. Specific Opportunities in Rome

Approximately 40% of all the electricity used in buildings comes from lighting, making it one of the most attractive ways to save energy.

The municipality of Rome participate the following companies: Acea, Ama, Atac, centrale del latte, DIP.T0_SI.MU, DIPARTIMENTO VII, TRAMBUS, METRO, where a simple change of lamps, A SIMPLE SWITCH, could immediately show how it is simple to save money on the bill.

We propose to substitute all fluorescent tubes with new TL-D Eco and TL5 Eco. With this green solution it is possible to save immediately 10% on energy, without any change of the installation.

3. Potential/Real Issues

Today simple and "eco" solution are possible to implement. The biggest issue is the money municipality has to invest. The second issue is to stimulate "energy efficiency culture".

4. Solutions to Issues

From a financial point of view funds are necessary for "green products", for municipalities and for ESCOs.
From a cultural point of view training are necessary to create a "green & simple" approach to sustainable solutions.

5. Philips Proposal for Lighting Improvements

a. Overview

To start reducing his carbon target we propose to Rome to start with retrofit solution in University.
Schools and colleges, where students spend much of their day in concentrated study, put special demands on lighting. Lighting solutions must properly illuminate desks and vertical surfaces such as blackboards and wall displays. It is possible to save from 10% to 80%.

We will do an audit in **University of La Sapienza / Faculty of Architecture** for indoor & outdoor lighting to propose the right solution.

First action is to substitute all the 2.000 TLD lamps with TLD eco lamps. Second action will be to add control system occuswitch. Simple investment for lamps is only 7.200,00 euros and it is possible to avoid 10.080 tonnes of CO_2.

Details of the project: University of La Sapienza

Carbon Saving pilot project – University La Sapienza

	TRADITIONAL LAMP(T8)	TLD-ECO
# of light points	2.000	2.000
TCO per year (EUR)	32.880	28.260
CO_2 emissions savings per year (kg)		10.080
Payback*		less 1 year

*Payback calculation compared to traditional

b. Cost

We can estimate the cost of the "the energy efficiency of the University" in about 7.200,00 Euro. If we consider that a medium building of a public administration has a similar size, we can assume this value as an average total cost of investment.

c. Carbon saving

Only in the province of Rome are present 735 public building. From our experience we can state that a medium project in a public building (office application) can have 600 luminaires and 3.000 TLD-Eco lamps.
It costs 10.800,00 Euro and can avoid 15.120 kg of CO_2. Potentially, simply changing only the lamps in public building, we save 11.113 tonnes of CO_2.

Carbon Saving potential estimated in Public Administration within 2020

	TLD ECO
# of light points for building	3.000
# of building	735
Total Investment (EUR)	7.938.000
CO_2 emissions savings per year (tonnes)	11.113

d. Visual

We propose to substitute all fluorescent tubes with new TL-D Eco and TL5 Eco. With this green solution it is possible to save immediately 10% on energy, without any change of the installation.

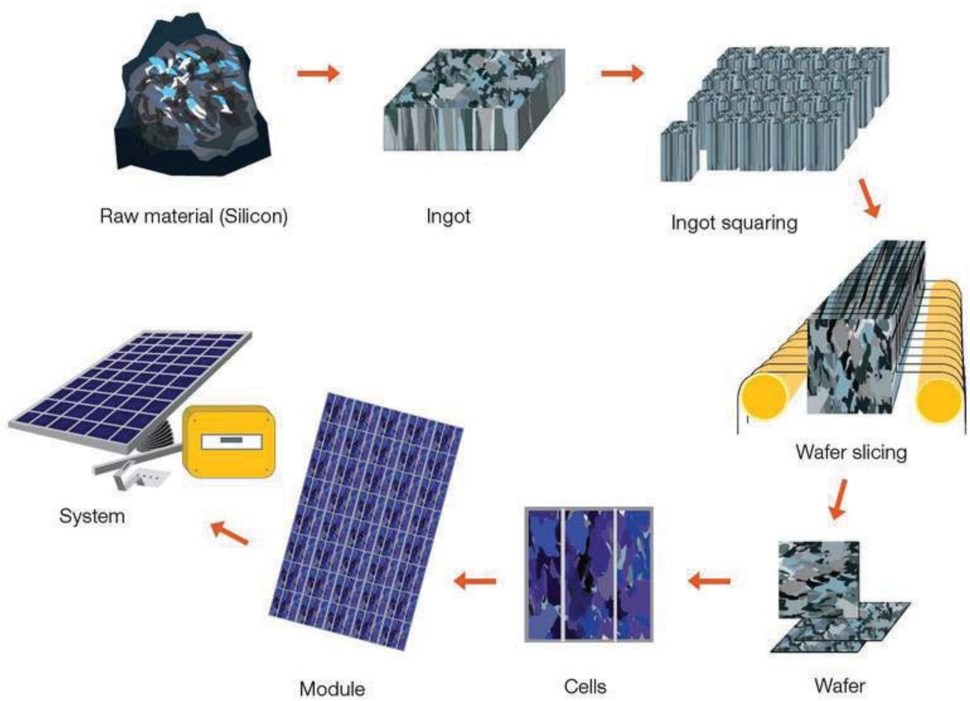
To save more we propose to install a simple control system Occuswith to dimm light. If there is no person in a room of there is already enough natural lighting, the light is switched off or dimmed. With this green solution it is possible to save up to 30%.

If it is necessary to do a new installation in a building it is possible to save up to 70% with a complete green solution.

Assumptions: burning hours = 2500 hours/year ; energy price € 0.14

Installed product type	New Product type(s)	Story + Pay back time	% saving
Recessed 4x18W IC C6	TBS160 4x18W HFSC6 (incl. OccuSwitch)	Improved lighting 4 yr	55%
	EFix TBS 4x14W HF (incl. OccuSwitch)	Improved lighting 5.5 yr	60%
	EFix TBS 3x14W HF (incl. OccuSwitch)	Improved lighting 5 yr	70%

1. Overview

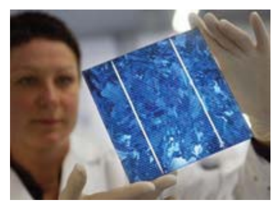


Q-Cells' core business is the development, manufacture and marketing of powerful solar cells made out of monocrystalline and multicrystalline silicon.

Monocrystalline cells

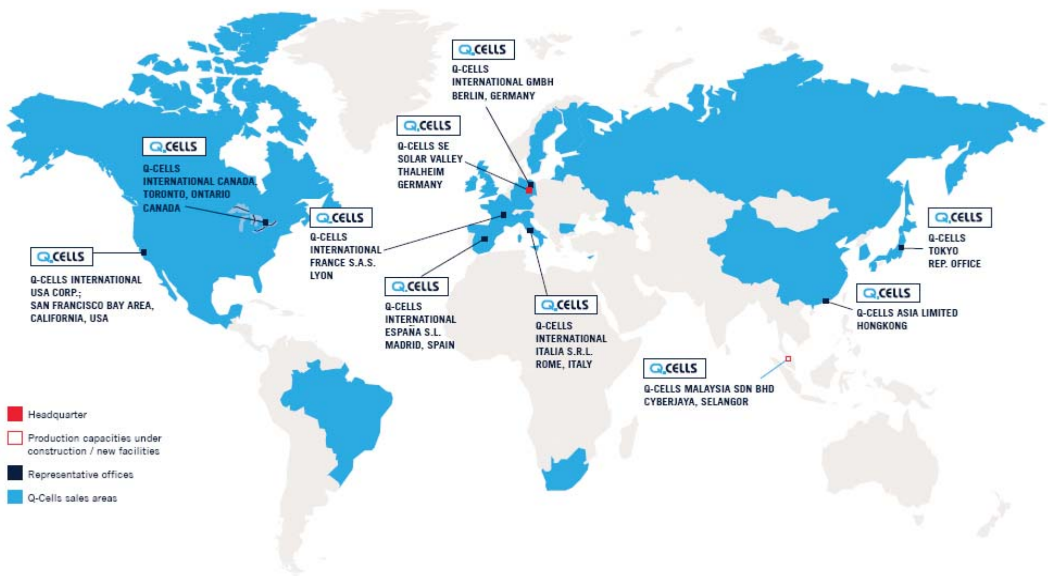
Multicrystalline cells

More than 250 scientists and engineers at Q-Cells are working on technology development to achieve Q-Cells' paramount aim: to drive down the costs of photovoltaics quickly and permanently. Q-Cells' second pillar in production is the manufacture of thin-film technologies based on various technologies.



Thin film cells

In addition, Q-Cells has been building up its project business through its subsidiary Q-Cells International, which specialises in the planning, engineering, construction and maintenance of large-scale solar parks and rooftop arrays. In Italy two local subsidiaries are operating: Q-Cells International Italia srl and Q-Cells Service Italia srl.



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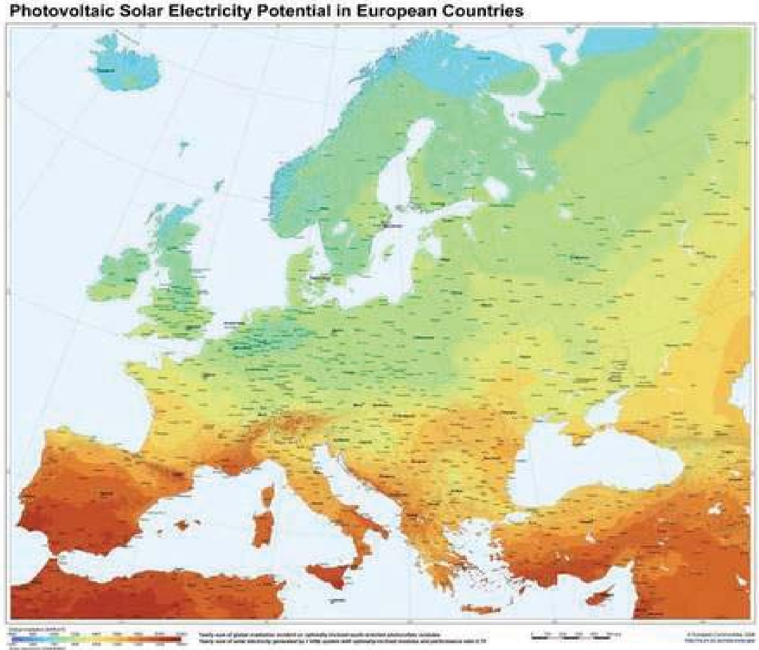
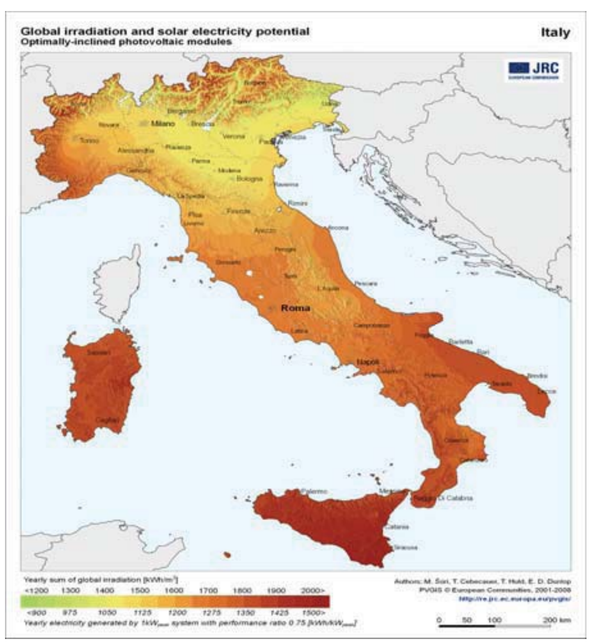
Rome, with his remarkable solar irradiation, attractive feed-in tariffs and relatively high energy prices has a great opportunity in having realized important energy parks.

Photovoltaic Solar Electricity Potential in European Countries





3. Potential/Real Issues

Big issues are the administrative barriers, bureaucratic problems for authorizations and grid connection.

The definition of the location of big energy parks could require deep environmental analysis.

SOME ACTORS

Autorità per l'energia elettrica e il gas

4. Solutions to Issues

The city of Rome, in accordance with the Regione Lazio, should try to reduce, so far it is possible, the legal time to analysis the requirements of building authorizations and define areas outside the city where big energy parks could be installed.

Proposal for an 'Energy Park'

5. Overview

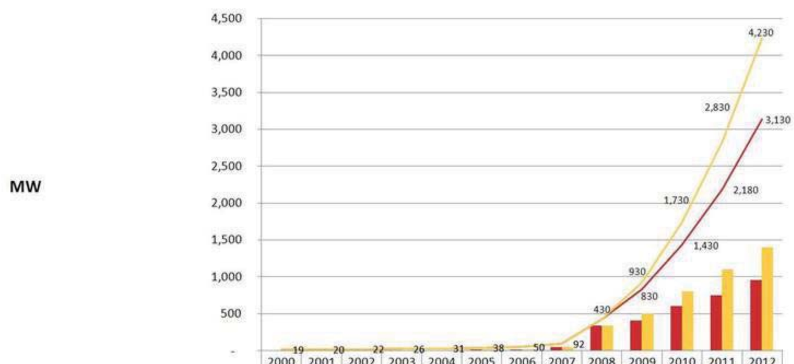
In an agriculture or industry area outside the city of ca. 20 ha an energy park of 10 MWp could be realized by Q-cells, after having all authorizations, in only three months.

6. Costs

In the PV market there is a continuously cost reduction. Q-Cells' strategy is based on technological progress and reducing costs while maximising quality. Cutting costs always takes priority: through economies of scale, reducing material use and the honing of new technologies.

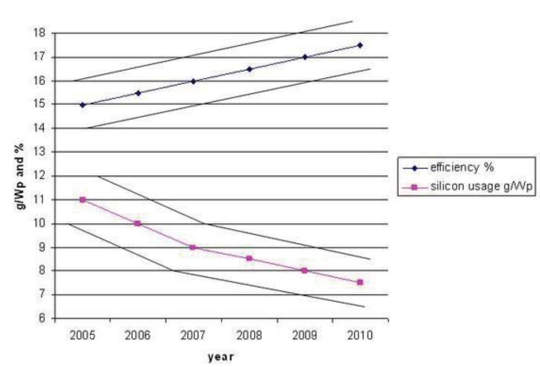
Rome, with his remarkable solar irradiation, attractive feed-in tariffs and relatively high energy prices will reach very soon the grid parity.

Fig 1. Historical PV market development in Italy and EPIA projections until 2013



		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Annual market (MW)	Moderate scenario	1	1	2	4	5	7	13	42	338	400	600	750	950
	Policy-Driven	1	1	2	4	5	7	13	42	338	500	800	1,100	1,400
Projected cumulative PV power installed (MW)	Moderate scenario	19	20	22	26	31	38	50	92	430	830	1,430	2,180	3,130
	Policy Driven scenario	19	20	22	26	31	38	50	92	430	930	1,730	2,830	4,230

Module Efficiency and Silicon Consumption



source: EPIA

Roma Decarbonization Plan Proposal

PositivEnergy Practice LLP
Adrian Smith + Gordon Gill Architecture LLP

Overview

A decarbonization plan is a dynamic and concurrent approach towards maximizing the ecological and economic efficiency of the city. A decarbonization plan focuses on climate change as a thematic integrator, aggregating key performance indicators across a broad spectrum of categories: energy, water, waste, land use, health and mobility in an open source networked virtual city model, the UrbanOS©. This virtual model can live with the city beyond the initial planning effort, intelligent and adaptive to change, continually mining data for new opportunities for improvement, and providing a platform for social marketing, and public consensus building for planned works.

Decarbonization planning enabled by the UrbanOS©:

•Aggregates and benchmarks energy consumption and carbon emissions from a comprehensive set of end uses and readily allows for a statistical comparison of consumers, such as similar buildings, to rank opportunities for resource sharing and carbon abatement

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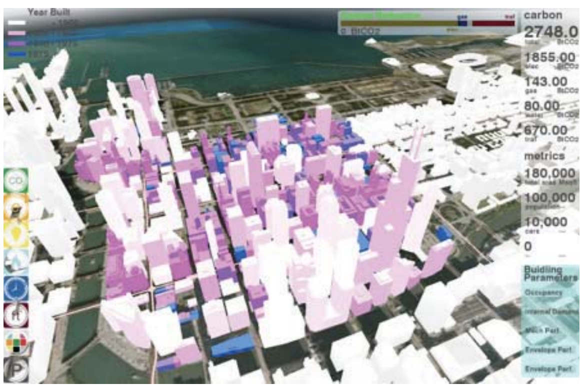
•Tracks and predicts the success of carbon emission reduction initiatives providing diagnostic and decision support for further measures of energy efficiency and greenhouse gas emission reductions

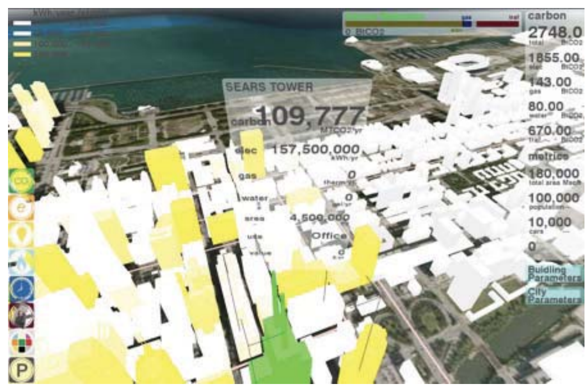
•Maximises carbon abatement value through multi-objective optimisation of specific strategies and policy instruments identifying opportunities and incentives for new development

•Communicates with a number of key stake holders the details and progress of specific initiatives to build political will and broadcast the successes of the city to the world

Objective

Specific to Rome, the UrbanOS© will be utilised by the decarbonization plan to identify opportunities for tapping into the latent potential energy in the historic core. Leveraging these savings will allow new planned development to come on line with little or no impact to the overall utility loads with distributed low carbon energy systems. In essence, the system will serve as virtual market place for future resource consumption and greenhouse gas emission reductions related to the built environment. The plan will serve as the vehicle for both communication and finance. A combination of energy cost savings, central utility investment mitigation, carbon abatement and real estate appreciation may be directed towards investment in planned development.





Target users of the UrbanOS© include:

1. *Residents*
2. *Building owners and property managers*
3. *Business units and organizations*
4. *Utility providers*
5. *Local, national and EU governmental official*

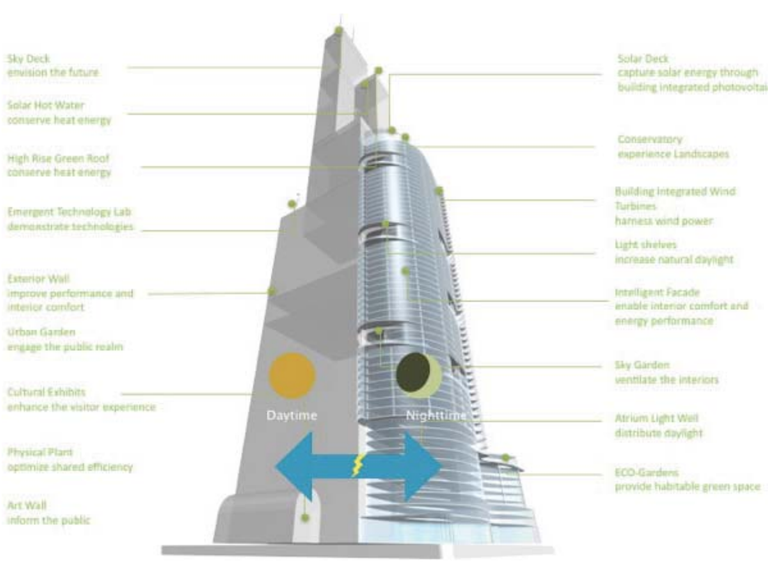
Background

The city is the theme for the 21st century. For the first time in history more people on the planet live within urban centers across our planet. This incredibly powerful trend of population migration has tremendous implications on the city beyond size; the form, efficiency, environmental impact, even the way we use cities is rapidly changing and will have a lasting impact. Urban migration represents a tremendous global opportunity; yet, existing models of urban design and planning are proving to be an anachronism. Energy, water, waste, social and other essential infrastructures are struggling to keep pace with the rate and magnitude of this change in emerging economies; while industrialised, information based economies find their infrastructure in disrepair.

A new approach to urban design is required. Enabled with unprecedented speed and access to vast stores of information, it must be both adaptive and accountable, it must be interconnected and intelligent. In contrast to a traditional approach to planning which culminates in the delivery of a static document, fixed in time, dynamic planning is flexible in light of an ever evolving urban context. Focusing on climate change as a thematic integrator, a decarbonization plan is a dynamic plan facilitated through an open source networked virtual city model, the UrbanOS©. Just as cities provide a physical framework of services to improve the quality of life for residents and businesses, the UrbanOS© is a virtual framework for environmental impact monitoring, data analytics, decision support, social marketing, and public consensus building for planned works. Civil engineering works, starting in the first century BC, provided Rome, the eternal city, the infrastructure to build the complex social, cultural and economic networks that allowed it to thrive. Today and into the future cities will be enabled by an information network that will make them intelligent and responsive, and it will begin here in Rome.

<u>Project Specifics</u>

Due to the global significance of the Historic architecture within the core of Rome, the recommendation for energy reduction is mainly passive within the core. The strategy for growth and building around the city would suggest that the peripheral development be considered for energy storage and generation where new buildings are mandated at low to zero or even positive energy in order to offset the energy consumption of the Historic core. The idea of having a ring of sustainable energy surrounding the core would suggest that energy sharing between new buildings on the periphery and existing buildings in the historic buildings would allow for an overall master plan that weaves new development with the existing city, integrating ancient knowledge such as the understanding of thermal mass with new technologies where appropriate. As a concept, this philosophy is critical; the city as a whole needs to be understood and not developed as old vs. new.



Enabled by the UrbanOS© a decarbonization plan will identify the possibilities for tapping into the latent potential energy in the historic core and to leverage these savings to allow new building on the periphery to come on line with little or no impact to the overall utility loads with distributed low carbon energy systems. In essence, the UrbanOS© will serve as a virtual market place for future resource consumption and greenhouse gas emission reductions related to the built environment. This will require energy reduction strategies within the historic centre and a smart grid system that allows for the transfer of energy and information between buildings and utilities. A combination of energy cost savings, central utility investment mitigation, carbon abatement and real estate appreciation could be directed towards investment in planned development. As an incentive for new development, the reduction of energy in the historic core may be directly linked to FAR bonuses common in many US cities. Developers would be able to increase their new building areas on the periphery provided they contribute to the improvement of public buildings and infrastructure in the historic core.

By quantifying and monetizing the relationship between how we build things and total energy costs, the Rome decarbonization plan will allow leaders and key stakeholders to prioritise initiatives, project future environmental and economic savings, and increase the liveability of the biosphere. New development around the city may be planned in order to develop a decentralized looped system for energy distribution around and into the Historic Core. The seven roads that lead into Rome could serve as the gateways for high performance towers that announce the new philosophy of the City. These sentinels of power need to be designed to meet zero or positive energy and deliver excess energy to the grid and the core. Other structures, such as an iconic stadium, will requisitely be designed to function symbiotically with the surrounding development and infrastructure.

Careful programming of new buildings will also need to be considered to enrich the growth of the city and for a balanced approach of energy consumption. Energy consumption for residential program can be less than that for office and so the re-programming of the existing core in order to elevate property values should be considered as an integral part of planning the new ring. That is to say, where possible, under-utilised existing buildings should be re-programmed as part of the new plan and where possible, changed in order to have a better suited use for a particular building footprint or construction. Existing buildings that are most suitable for residential but are currently used for office should be repositioned and vice-versa.

Scope of Services

1. Project Goals, Objectives and Assumptions

1. Establish Project Scope Goals, Schedules, Objectives and Boundaries.

1.1.1. Organize and conduct a kick-off meeting, with key representatives to meet team members, discuss project goals, objectives and assumptions.

1.1.2. Establish the Projects' Working Group, which should be comprised of key representatives from Comune di Roma, Sapienza Universita Di Roma, members from the PositivEnergy Practice (PEP), Adrian Smith + Gordon Gill Architecture (AS+GG) and other stake holders.

1.1.3. Establish the boundaries for the Study Area, which shall encompass all building structures, future planned structures and associated infrastructure components to be included in this Scope of Work.

1.1.4. Review and adjust Scope of Work and project approach to refine tasks, coordination and sequencing plan, and timeline if appropriate and necessary.

1.2. Site Visits, Data Collection and Document Existing Conditions

1.2.1. Review all relevant data and reports provided.

1.2.2. Conduct site visits when appropriate and review existing conditions, related plans, and recent completed studies.

1.2.3. Conduct a general conditions assessment for the Study Area that will inform the development program, economic analysis, and timeline for energy improvements, water conservation measures, waste reduction strategies and other infrastructure improvements.

1.3. Goal Refinement

1.3.1. In consultation with the Working Group, prepare and refine draft goals and objectives.

1.3.2. Identify and quantify the assumptions needed to prepare the project alternatives.

1.3.3. Conduct a Working Group meeting to review and refine goals, objectives, and assumptions for Client's review.

1.3.4. Establish performance metrics, including Key Performance Indicators (KPIs), to track to ongoing success of the rollout of the Roma Decarbonization Plan).

1.4. Deliverables

1.4.1. Based on review of existing conditions, related plans, and studies, suggest and prepare modifications to the Scope of Work, if necessary.

1.4.2. Obtain missing data as deemed appropriate.

1.4.3. Prepare a preliminary Conditions Assessment Report that documents the findings, as well as any preliminary analysis, conclusions, and recommendations.

1.4.4. Import and visualize appropriate data with a beta rollout of the Roma UrbanOS©.

2. Specific Areas of Focus

The Roma Decarbonization plan will address many aspects of the future design and planning of the city. Some of the specific areas of focus include:

2.1. Building Performance - Responsible for the largest fraction of energy consumption and associated carbon emissions in the developed world, upgrading standards for new and existing buildings is an appreciably cost effective way of reducing carbon emissions. Establishing a localized framework for calculation and monitoring integrated performance of buildings is essential.

2.2. Land Use – Seeking to minimise the aggregate environmental cost of buildings, transit oriented land use patterns which supports density can reduce redundancy in programs such as retail and other amenities. Moreover, unrestrained development can inhibit the effectiveness of policy and investment in public transportation. Proper planning can prevent extensive road investment associated with urban sprawl and decentralization.

2.3. Mobility – Having a direct impact on local air quality and carbon emissions, development of a clean mobility framework is a critical aspect to decarbonization planning. The Roma decarbonization plan takes a building centric approach to mobility, associating commuter emissions with the corresponding structure or development. Energy storage and generation capabilities for future vehicles and mobility vectors and the interface of this motive infrastructure with buildings as a power plant is also considered.

2.4. Smart Infrastructure – Computing has become ubiquitous, as scheduled interactions with programmed databases via desktop machines have given way to continually connected mobile devices for dynamic sharing and collaboration through social networks. The city is therefore emerging as a bifurcation of its previous self, the historic physical layer now joined by a new virtual layer. Beyond twitter and facebook, this virtual layer would allow the city to reach unprecedented levels of environmental efficiency: optimizing energy performance of building systems, identifying routes and modes of transportation and tracking resource flows such as water and waste.

2.5. Energy – The virtual city layer is also an enabler of distributed clean energy generation, as a multitude of decentralized energy sources can be effectively managed and balanced against demand. Buildings are an excellent platform for distributed power through micro-generation and renewable energy. Buildings can provide the necessary electrical, communications and physical infrastructure for deployment. Development of an Energy framework within the Roma decarbonization plan must consider future planning, as energy, water and waste characteristics of the city continually evolve.

2.6. Water – Water treatment and distribution methods can play a significant role in energy consumption and aggregate carbon emissions for the city. Decentralized water treatment at the building or district level is an emerging trend throughout the world, and in many ways is analogous to developments in distributed energy. The Roma decarbonization plan will consider the implications of this trend on infrastructure costs and environmental impact.

2.7. Waste – Inefficient management of resources leads to waste, something that can be reduced through good design. On the supply-side of production, a framework for building design standards that reduce waste in construction can also significantly reduce upfront cost to the developer. With the potential for waste minimized, appropriate measures are proposed to establish demand for reused and recycled products through legislation and marketing.

2.8. Ecosystem Services – The natural infrastructure inherent to healthy ecosystems can provide a full suite of services that may offset engineered infrastructure at little to no cost, while benefiting human livelihood. Services can include water treatment, decomposition of wastes and natural carbon sequestration through vegetative growth while benefits include natural habitat, scenic beauty and increased property value. A decarbonization plan seeks harmony between the built and natural environment, through a pragmatic approach of market-based conservation and stewardship.

2.9. Community Engagement – Participation in the activities of the community enhance shared feelings of citizenship, pride and can build consensus for future development plans. The expansion of social networks with new technologies enhances both the identification and interaction of citizens on multiple levels, including energy and environmental management. A decarbonization plan establishes an approach for community engagement to initiate and continue the plan into the future.

3. Virtual City Model the Roma UrbanOS©

3.1. Develop a beta rollout of the parametric model of the Study Area, to include existing and "future" buildings with the Study Area, as well as available infrastructure site models.

3.2. It is assumed that available CAD, 3D and BIM models will be provided to be used as a base for the development of the Parametric Model.

3.3. PostivEnergy Practice (PEP) will work with the City and others to obtain site specific data and develop the Parametric Model for the future development scenarios and tradeoff studies.

3.4. Based on review of beta rollout conduct a working group meeting to review and suggest and prepare modifications to the system if necessary, and plan for future releases.

4. Identify Opportunities for Energy Improvements and other Carbon Abatement Measures

4.1. Using the UrbanOS© model, generate data for each of the specific sites that can be used in a comparative analysis to prioritize and validate energy improvements and other carbon abatement scenarios. This database will be used to generate maps, diagrams and other output illustrating the potential opportunities. This output will be the deliverable work product.

4.2. Depending on the site, the scenarios should generally identify the structure as:

4.2.1. No Change (assume a no change scenario for each site even though it is not listed).

4.2.2. Potential retrofit of existing buildings and infrastructure (including measures such as energy efficiency, water reduction strategies, waste reduction strategies, improved health and well-being of patrons and staff).

4.2.3. Potential site for building integrated renewable energy production

4.2.4. Potential site for distributed power generation

4.2.5. Potential site for distributed power storage through hydrogen or other means

4.2.6. Potential site for clean vehicle charging infrastructure or mass transit connection

4.3. Depending on the region, the scenarios should generally identify opportunities to:

4.3.1. No Change (assume a no change scenario for each site even though it is not listed).

4.3.2. Potential for electrical energy sharing between structures, micro-grid

4.3.3. Potential for thermal energy sharing between structures, district cooling and heating

4.3.4. Potential for computer infrastructure sharing between structures, virtualized data centers

4.3.5. Potential for district scale renewable and waste to energy systems

4.3.6. Potential for district scale energy storage systems

4.3.7. Potential for decentralized water treatment and recycling systems

5. Prepare Roma Decarbonization Plan (RDP)

5.1. Conduct a Working Group meeting to review and refine the energy improvements and other measures and prepare, attend, and present to the Working Group and Comune di Roma.

5.2. Delivery of data from parametric model, showing alternate scenarios, with associated data, diagrams and maps and other output. This output shall be the deliverable work product.

5.3. Prepare the "draft" Roma Decarbonization Plan (RDP) document, including an Executive Summary of findings that that summarizes the opportunities, constraints, and the comparative analysis and results of the energy improvements and other measures. Deliver "draft" RDP to the City and Working Group.

5.4. Make presentation of the RDP to the city and other key stake holders.

5.5. Include comments of RDP and key stake holders into the "Final" Roma Decarbonization (RDP) document.

5.6. Deliver "Final" Roma Decarbonization Plan (RDP) document and Parametric Model output documents to the City.

6. Future Tasks – to be determined

6.1. Implementation - Upon acceptance of the RDP projects - assist in coordination and implementation

6.2. Monitoring and Reporting - During implementation and upon completion of projects – provide monitoring of performance and individual project's adherence to KPIs. Provide reporting of performance through the UrbanOS©

6.3. Public Outreach - Assist in preparing format for public engagement and understanding of the sustainability measures. Provide interface based on parametric model format.

6.4. Virtual Marketplace - Develop the capabilities of the model as an OTC platform for regional real estate energy, carbon futures exchange and/or an e-commerce marketplace

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The Living Stadium

1. OVERVIEW

IaN+, established in 1997, is structured around a core of three professionals with different training and experiences. These professionals include Architect Carmelo Baglivo and Architect Luca Galofaro, who specialize in architectural design and theory, and Engineer Stefania Manna. IaN+ has participated in many national and international design competitions, earning mention and winning several prizes. In 2006, IaN+ was awarded the Gold Medal of Italian Architecture for their work on the Triennale of Milan. Other projects IaN+ has worked on include building a research facility for the University of Rome, Tor Vergata, and contributing to several editions of the Biennale of Architecture in Venice, London, Beijing and Valencia.

On behalf of the Catalan Government, IaN+is currently investigating the relationship between sport and regional development in a project known as Sportcity. The results of this research will be released at several international conferences, as well as the HiperCatalunya exhibition for the MACBA in Barcelona.

IaN+ is currently in the construction phase of the following projects:

- City of Rome’s urban regeneration project, including a public square, park and two public buildings in Falcognana;
- "Hospital of the Sea" in Naples, consisting of the main hall building, a connecting building, and the surrounding urban areas;
- Multi-floor, underground car park in Verona

2. OPPORTUNITY FOR ROME

Designing a new stadium presents an opportunity for the general development of the City of Rome. Social sustainability is defined as development and growth with a net impact of zero. The existing stadiums in Italy are outdated models, inefficiently using land in a manner that only maximizes available space at certain times and wastes energy. The misalignment between stadium capabilities and the City of Rome’s needs results in traffic congestion during commuting hours and unused space during the rest of the day.

Looking at the example of the transformation of the Domitian stadium in Rome to the Piazza Navona, we think of the stadium as a space used to capacity, inhabited and used daily by the residents of the city. The stadium should become a public square, an open public space in the suburbs of the city. Constructing homes, plazas, museums, shopping malls, and universities would successfully make use of the land in the community.

3. Social Sustainability

Social sustainability methodology suggests the need to use sports infrastructure to maximize utility and benefit the community. Instead of viewing the structure as merely a stadium, we must view it as a valuable public facility for the City. The idea is to use the stadium for needs other than hosting sporting events. Before and after matches, the stadium could be used as a multi-purpose space.

The stadium can be divided into parts, which would open the interior to the urban grid and result in improved conditions within the surrounding landscape. The area around the stadium could be transformed into public park, with public sports facilities.

This proposal is inspired by:

- The transformation of the Domitian Stadiuminto the Piazza Navona in Rome;
- The post-games strategy of transforming Atlanta's Olympic Stadium into Turner Field;
- The dismantling and recycling of the circus-style design behind Albertville's Théâtre des ceremonies;
- Downgrading the seating capacity in London Stadium;
- And Chicago's 2016 Summer Olympic holdover stadium.

The design of the stadium will be the opposite of Beijing's de-civilizing monolith. The exterior will host vertical gardens or information screens, in order to mitigate the impact of its structure on the surrounding area. Rather than remaining a stadium in a city already saturated with athletic and outdoor cultural venues, this new stadium will be adaptively reused after the games for multi-purpose needs or low-rise affordable/low-income housing. It will be truncated into pieces, with the excised modular units clustered around the stadium. This newly formed neighborhood will then be filled with further developments until it reaches a certain capacity. Additionally, the stadium will be carved into segments to open the interior to the urban grid and link it to the City's Olmsted-designed Emerald Necklace of parks and large green boulevards.This open space could be turned into a park, piazza, or any number of community locales.

The stadium will become a public, open space, and the steps, parking lot and field will become part of an urban park. The buildings will host all sports-related functions. Proposed structures for the area include a museum, hotel, shopping center, and The Sports University residences—a center for high-performance athletes from all around the world. The stadium exterior should have the distinctive quality of FAT's architecture, the lushness of a vertical garden, or the interactivity of a vastmultimedia screen. Whatever the decision for the stadium's exterior, the design process will have to take into account future function and the design of the interior.

A stadium village

The structure must operate 365 days a year, and14-24 hours a day. For this reason, a live stadium would be a viable option. The stadium will have a capacity of 60,000 spectators. The size of the parking lot in our proposal is balanced, devoting 6 m^2 per person, or 1 car for every 4 seats. The lot could either be single or multi-leveled.

5 Implementation of a new architectural concept

5.1 Mobility

Currently, the Olympic Stadium in Rome is located near the historic center, and inundated by local traffic. The new stadium will be located in one of the quadrants located by the Urban Ring Road. As a result, the primary objective of the project should be to direct the stadium users towards the use of "sustainable transport" which can be done through various incentives.

One solution that is already widely used by other companies such as Ikea, is the use of private shuttles to transport people to their destination through pick-up points located in the city.

5.2 Relationship with the urban fabric

The extravagant spaces of huge brownfield redevelopment projects are pushing investors and designers to use these areas as intensifiers of the project, useful in consolidating the urban functions during the night-time and holidays. A return to the city seems to emerge from this future scenario. In order to prevent compatibility problems between various city components, this must happen in conjunction with an innovative concept of accessibility. Since the stadium is primarily accessible by private transport means, if the City were to depart from these structures, attention would need to be given to the public transport network to prevent congestion. From here, the realization of a place of urban aggregation should generate exciting, new attractions.

Keeping in line with the principles of sustainability, one might rethink the concepts behind the development of large facilities (stadiums, sports arenas) —which is already happening in the rest of Europe— intended only for individual activities and, therefore, of minimal usefulness to citizens. In the Rotterdam and Amsterdam Arenas and the stadiums in England, stadiums function not only as a venue for football games, but for other leisure activities (shops, restaurants, cinemas. ..) available to the general populace 7 days a week.

Zero emission solutions for stadiums

There are many opportunities for the stadium as a structure to cut down CO2 through integration of solutions.

The building envelope and roofing structures are the first potential link in sustainability. They accommodate and integrate systems for the exploitation of solar energy rather than solutions for the reduction of thermal loads, allowing for reduced fuel consumption and emissions. The benefits of the zero-emissions solutions would ideally extend beyond the perimeter of the structure to involve the surrounding urban fabric.

It is also necessary to introduce and disseminate cutting-edge elements, such as the use of hydrogen energy carriers with high symbolic value and suitable matching with energy production from solar sources.

THE STADIUM : WE MUST VIEW IT AS A REAL PUBLIC SPACE WITHIN THE CITY

THE LIVING STADIUM

IaN+

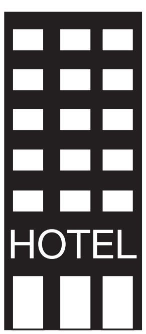
3rd Industrial revolution
theory frame work by Jeremy Rifkin

1_HOUSING

Rather than remaining a stadium in a city already saturated with athletic and outdoor cultural venues, this new stadium will be adaptively reused after the games as low-rise affordable/low income housing or for mixed uses. The stadium as a space inhabited and used daily by the residents of the city.

4_THE SPORT MUSEUM

The stadium will become a public and open space, the steps, parking lot and the field will become part of an urban park. The buildings will host all functions directly related to sports, like a sports museum.



2_HOTEL

The idea is that the stadium be used beside the sport events which it will host there. The stadium, before and after the matches, will be used as a multiple purpose facility space.

3_SHOPPING MALL

Just as the stadium of Domitian in Rome was transfored into the present Piazza Navona, we think of the stadium as a space inhabited and used daily by the residents of the city, as a public square, an open public space in the suburbs of the city.

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Workshop for a *Third Industrial Revolution* Energy Plan for the City of *Rome*

3rd Industrial Revolution – theory framework by Jeremy Rifkin

Buildings are the number one cause of Global Warming.
It is the Architects role to introduce technologies and concepts that reduce the buildings impact an carbon dioxide exhaust and balance energy consumption with sustainable design and renewable energy production.

Pillar one.

Wind Energy

Wind Energy may be collected even in urban scenarios with the use of small scale vertical wind turbines. Products available today have greatly improved in noise reduction and visual penetration.

Rainwater collection

Collecting and storing rainwater for the use in eg. WCs.

Geothermal Energy

Geothermal Energy is most commonly used for heating, but may be used for cooling as well.

District Cooling and Heating

A nearby factory might provide unused energy to heat or cool nearby buildings.

Photovoltaic Cells

PV cells convert sunlight to electric energy when installed on the roof or on facades.

Pillar two.
Building as Power Plants

Grey Water re-use

Biologically filtered waste water may be used to water plants.

ETFE skin

ETFE reduces the solar radiation impact and reduces construction resources eg. structure due to its weight significantly compared to glass.

Photo Voltaic integrated in façade

Green Roof/Façade

Plants on the roof of a building reduce heat reflection in urban areas, increase comfort and produce oxygen.

Pillar three.

Hydrogen Energy Storage

Whenever the above renewable energies generate a surplus this energy is best stored using hydrogen technologies. It may then me converted back to electrical power whenever needed.

Pillar four.

Smart Grid

A surplus of generated energy might be sold to other buildings. When connected to a smart grid the overall peak usage of energy might be compensated by reducing - insignificantly to the user - the amount of energy consumed by a machine or device.

Social and Cleaning Robots

Social Robots encounter the user and help to communicate the buildings technologies, visualize data information and the performance of a building.

Sensors to monitor environment

Nature could be monitored in order to get locally information on the environment.

-

Technologies & Concepts

Enric Ruiz-Geli

CLOUD9

Climatic Architecture

3rd industrial revolution
theory frame work by Jeremy Rifkin

Pillar One

1
WIND POWER
BY GREENURBANENERGY
Energy production
Mill size: 4.2m x 2.75m
height: 5.5m
weight: 350kg
Rated Power: 4kW
Rated Wind Speed: 12m/s
Noise Level at 3 Meter Distance:
27dB – 37dB

2
PHOTOVOLTAIC LIGHTS
BY IGUZZINI
Technology: poli-cristalline silicius
LED: TOP LED RGB OSRAM 4X 0.4W
Total Wattage: 5W
Battery technology: lithium-ion
CPU w/ custom made operating System
Weight: 800 gramm
Dimensions: 34,5cm

3
GEOTERMIA
By Tecnalia
Geothermal heat is absorbed through heat pump which satisfies 0.07% of global primary energy consumption

4
DISTRICT COOLING AND HEATING
ENGINEERING BY Grupo JG
Heating / Cooling energy demands can be reduced by 35% when a network to factories is established that produce heat as a side product.

❹ GEOTHERMAL

❺ WIND POWER

Pillar Two - Building as Power Plants

2
ETFE SKIN W ENERGY EFFICIENCY
BY VECTOR FOILTEC
BY CLOUD 9
Reduction of solar gain: through the use of the fog system the coefficient of thermal conductivity is lowered by 8% to 29%.

4
PV INTEGRATED IN FAÇADE
BY TECNALIA ENERGIA

Technology: poli-cristalline silicius
Costs: 2 Euros per Watt
Lifespan: about 30 years

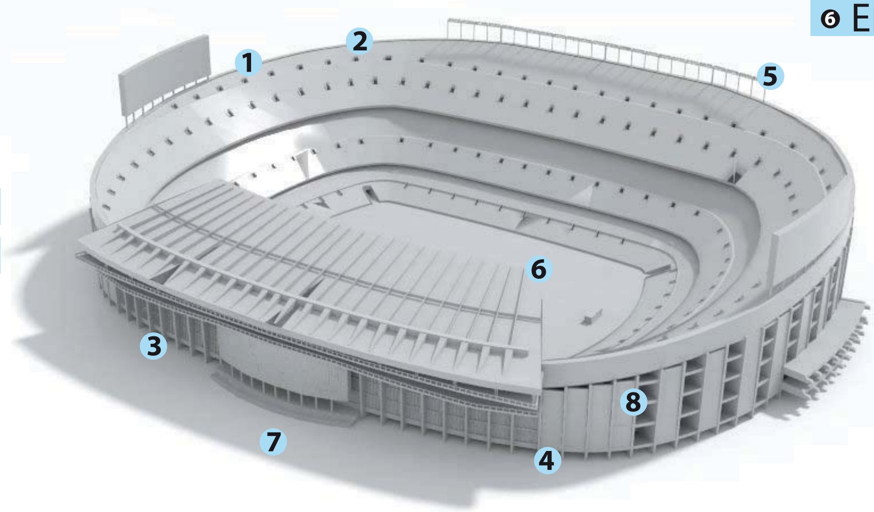
3b
GREEN ROOF
BY BURES (www.buresinnova.com)
Energy consumption reduction:
A green roof for a room of 120 m³ can decrease indoor temperatures by 5,1°C and provide a cooling potential of 3.02 kWh per day.

3a
VERTICAL GREEN GARDEN
BY CLOUD 9 and BURES
CO^2 consumption:
15kg of CO^2 per m² per year
Air Quality: Pollutants are caught by plants and then transmitted to substrate by the plants metabolism.

❶ ETFE©

❷ SOLAR PANELS

❽ VERTICAL GREEN



Pillar Three

HYDROGEN STORAGE
BY HYDROGENICS
Intermittent Energy is converted to Hydrogen.
Hydrogen as an energy carrier can reduce the release of pollutants or greenhouse gases at the point of end users.

ELECTRIC CAR
WITH HYDROGEN STORAGE
by TECNALIA
name: H2CAR
type: prototype

❸ HYDROGEN

❻ ELECTRONIC METERS

Pillar Four - Smart Grid

IP ADRESSES
BY SIEMENS, SCHNEIDER
An electronic device added to energy producing and consuming units can obtain information on how to decrease peak energy usages and when to sell energy at times demands/prices are high.

MONITORING NATURE
SENSORS BY ANDREU CATALA, UPC
PLACED IN THE TREES
Data like movement, climate conditions, sun orientation and humidity are collected to increase energy performance of buildings.

SOCIAL ROBOTICS
by UPC,
person in charge: Andreu Catala
cost: 20.000 euros
In addition to IP devices and monitoring of nature social robots may inform users about status and performance of buildings.

CLEANING ROBOTICS
by FATRONIK,

Robots are introduced to perform regular inspection of used technologies and to clean for example the solar panels

❼ SOCIAL ROBOTS

Hydrogenics

HYDROGEN FUELING STATION

1. Overview

Hydrogenics is a Canadian company that provides advanced Hydrogen solutions for customers worldwide. Hydrogenics' Toronto division provides fuel cell products as well as renewable hydrogen systems for community power and renewable energy connection. Hydrogenics' Belgium division provides advanced electrolysers systems and complete hydrogen fueling stations. Hydrogenics' Germany provides OEM fuel cell system integration support as well as providing hydrogen fueling solutions. Hydrogenics is the largest manufacturer of electrolysers in the world today and has installed over thirty-five (35) hydrogen fueling stations in countries such the United States, Canada, Brazil, France, Germany, Holland, Spain, and Sweden. The company is publically owned and listed on the Nasdaq (US) and Toronto (Cdn) stock exchanges with a 35 M US market cap.

With over 165 employees world-wide, Hydrogenics has offices in Russia, China, India, California, Canada, Belgium and Germany. The company's manufacturing facilities in Toronto, Belgium and Germany are ISO-certified and produce equipment to CE (ATEX directive 94/9/EC), GOST/Rostechnadzor, NRTL/UL/CSA, SAE J2601 (Fueling Station Protocol) and guidelines ISO TC197, WG11 for the safe use of H2 generating equipment. Our equipment is in use and considered the industrial standard for companies such as Air Liquide and Linde who purchase our equipment to supply safe and reliable high purity hydrogen for their customers in locations around the world.

2. Specific Opportunities in Rome
    a. The first zero-emission hydrogen fuel cell bus fleet operating in Italy using Italian Bus Manufacturers such as Tecnobus, Rampini, etc…
    b. Solar power to zero emission hydrogen fueling stations for key center of Rome transit circuits.
3. Potential/Real Issues
    a. From experience in previous proposals there is a unique technical challenge in the supply of hydrogen infrastructure in Italy/Rome – which is the seismic code compliance and engineering calculations to show that what is delivered meets this code for discreet areas in Italy. (From our experience with providing fueling station solutions in many other cities (including San Francisco) we see no other real issues – we provide full code compliance to all applicable regional, country, EU specific requirements for all equipment and work with a local civil works agency to supervise and install the station. We then provide training and monitoring of the station following commissioning.
4. Solutions to Issues

a. Regional and country specific issues are resolved with the use of 3rd party engineering firms who provide complete engineering calculations on our equipment and certify that the equipment meets seismic code compliance.

OUR PROPOSAL

5. Example stations which could be copied as demo projects in Rome for consideration:

   It is our understanding that ATAC Rome is currently rebuilding a bus terminal designed to house and service Rome's large fleet of minibuses. This new bus terminal could be retrofitted to include an electrolyzer hydrogen filling station to fuel a fleet of ten (10) minibuses. Rome currently has the largest fleet in the world of minibuses serving the tight city center. These minibuses are manufactured by the Italian company called Tecnobus. Tecnobus together with Hydrogenics have delivered several hydrogen fuel cell buses to Germany and Spain which are in regular daily service.

6. Costs

   Approx budget = 1,000,000 Euros for a complete hydrogen electrolyzer station (HyStat 60) which would be capable of fueling over ten (10) Tecnobus sized buses per day… we would work with your team to specify the type of station(s) that suit the number of buses that Rome is looking to run on zero-emission hydrogen.

7. Carbon Savings

   As a general example: A hydrogen electrolyzer fuelling station producing 120 kg of hydrogen per day using renewable electricity will save approximately 1400 kg of CO_2 per day when used in a 30 person hydrogen fuel cell cit bus.

HYDROGEN FUELLING STATIONS and VEHICLES

Preliminary Brief Description

Table of Contents

Introduction:

Following the successful proceedings of the Rome Workshop in December 2009 on the Third Industrial Revolution energy plan for the City of Rome, the following group of companies and institutions, organized under the supervision of **Eng. Alexander Vrachnos**, member of the board of the ***Hellenic Hydrogen Association***, outlined a roadmap to build a network of hydrogen fuelling stations to develop hydrogen-fuelled vehicles. This proposal functions under the assumption that hydrogen will be produced from renewable energy sources, adhering to the principles of the Third Industrial Revolution.

1) ***Overview:***

The design and construction of a large-scale hydrogen project requires the cooperation of several companies, research institutions, universities and experts, in order to be efficient & successful. We propose the following companies for this project, keeping in mind that upon final formulation of the project's goals and requirements, more participants could enter the group.

a. **Alexander S. Vrachnos. B.S. , MSc**

Chemical and Metallurgical Engineer, founding member and member of the board of the ***Hellenic Hydrogen Association,*** has been involved in waste management, renewable energy, green development and hydrogen projects. Holding the position of the President for three years, of Tram SA, owner and operator of the Tram of Athens, he has served the last two years as President of the "Green Transport Committee" established at the Hellenic Ministry of Transport. Friend and participating member of the vision of the 3rd Industrial Revolution.

b. **Sapienza University - Rome, Italy**

The knowledge and experience in all scientific fields of the present Rome project as well as its excellent knowledge and understanding of the City of Rome and its people, will make it an important participant in the Group.

c. **<u>TROPICAL S.A., Athens, Greece</u>**

TROPICAL S.A. is a Greek company located in Athens, consisting of two major departments, Vehicle Air Conditioning and Hydrogen + Fuel Cell and Renewable Energy Sources; having in its portfolio more than 100 products with its own technology and the knowledge of most of them. Forty (40) of these products are associated with A/C units for vehicles and sixty (60) are associated with H_2 + F.C. technologies & R.E.S. Moreover, it has been **certified from TUV HELLAS** (Member of TUV NORD GmbH, Germany) for the **Design and Production of Fuel Cell Systems** with Certificate Reg. No: 04 100 20021692-E9**. TROPICAL is an Industry member of the E.U., JTI** (Joint Technology Initiative**) on Hydrogen and Fuel Cells.**

TROPICAL is manufacturing PEM Hydrogen Fuel Cell Power Systems ranging from 100Watt to 20kW (stationary & portable), Reformate Hydrogen (from Natural Gas, Methanol, Ethanol, Biogases) PEM Fuel Cell Power Systems ranging from 1kW to 20kW, Electric & Hydrogen fuel cell vehicles (bicycles, scooters, boats, cars & minibuses) & Metal Hydride Hydrogen Storage Tanks.

Tropical S.A. has participated over the last 10 years in numerous scientific hydrogen technology projects in cooperation with Universities and Research Centers. Presently is participating in several projects, the following are a few examples:

- "Green Future Home" (Electrolyzer Unit and Management Control System) - Design & development of a hybrid management system which includes photovoltaics, wind generators, water electrolyzer for hydrogen production, metal hydride storage tanks, fuel cell stack for power production and a "smart" parametric controller with recorded data on last 10 years weather data for the area.

- Nanotubes & Nanoscrolls – Hydrogen in Nanostructured Carbon – based materials for light hydrogen storage tanks designed for the automotive industry as well as for portable applications.
- Hybrid Poly-generation (All-In-One) Unit for Islands – Design & development of a hybrid system which includes photovoltaics, wind generators, desalination unit for producing drinkable water, water electrolyzer for hydrogen production, metal hydride storage tanks, fuel cell stack for power production and fuel cell GreenCityCar.
- Design & development of a Hydrogen MiniBus for operation at the inner centre of Athens.

TROPICAL S.A. developed and presented in 2006 the 2-seated and 4-seated GREENCARS which are the first European small two & four seated hydrogen operating fuel cell cars. The construction of these city cars has been made with the "Modular" method—the construction of the steady modular-chassis, which includes the chassis, the front and rear axles, the metal hydride tank, the fuel cell-engine and the body. Both cars have an increased range, up to 200km with zero emissions. Moreover, in 2008, it completed the development of a Hydrogen Fuel Cell Scooter and fuel cell boat.

d. <u>Center for Renewable Energy Sources (CRES), Athens, Greece</u>

CRES was founded in 1987 by Presidential Decree. It is a public entity supervised by the Ministry of Development, and has financial and administrative independence. CRES has a staff of 120 scientists and engineers, consisting of the following basic Divisions:

- R.E.S.
- Energy Efficiency
- Energy Policy & Planning
- Program Development
- Financial, Legal & Administrative Services

- Quality Assurance

CRES' ROLE & MISSION

CRES operates in two main fields of activity:

- **As a Research and Technological Centre for RES / RUE (Rational Use of Energy) / ES (Energy Saving)**, by developing applied research for the new energy technologies and by technically supporting the market for the penetration and the implementation of these technologies.
- **The National Energy Centre** works on energy planning and policy for RES and ES and on developing the necessary infrastructure to support the implementation of RES and ES investment projects.

CRES has extensive experience in ***Hydrogen Technologies*** with a well developed Laboratory and pilot scale installations, working for many years.

e. National Center for Scientific Research "Demokritos", Athens, Greece

The National Center for Scientific Research "Demokritos" was founded in the late 1950s as an independent Public Research Center, initially called "Demokritos" Nuclear Research Center. It has been involved in hydrogen safety Research for many years and will be responsible for the safety part of the project.

f. Agricultural University of Athens, (AUA), Athens, Greece

For more than twenty-five years, the Section of Farm Structures and Agricultural Mechanization of the Dept. of Natural Resources and Agricultural Engineering of AUA have been active in the field of renewable energies and hydrogen technologies. In the framework of these efforts, the Section has been involved in several renewable energy activities and large amount of experience has been gained. Particular attention has been given to research and application of autonomous renewable energy systems and also hybrid renewable energy systems to supply electricity for water pumping, water desalination or hydrogen production in rural and remote regions. Some of the projects over the years are:

- PV Enlargement and Hydrogen Production through electrolysis
- Hybrid renewable energy systems (PV and hydrogen) in Donoussa and La Graciosa islands as prototype systems for applying desalination and electricity to small villages by using local renewable energy sources.
- Local integration of renewable energy technologies for water and fuel supply in the Frangocastelo area (south of Crete).
- Design and development of a polygeneration system, producing electric energy, drinkable water and hydrogen for use in vehicles and homes.

g. <u>Erde srl, Pisano, Italy</u>

ERDE s.r.l. is a company operating in projection, construction and sale of On Site gas generators, with relevant accessories for special applications. It can supply: hydrogen and oxygen generators using electrolytic dissociation process of water molecules.

ERDE s.r.l. has participated in several projects, many of which dealt with hybrid systems that produce hydrogen through water electrolysis and renewable energy sources.

h. <u>Bredamenarinibus spa, Bologna, Italy</u>

BredaMenarinibus is one of the traditional and historic Italian companies in the bus industry. During its 90 years of activity, more than 30,000 buses have passed through the gates of their plant. These buses transport millions of passengers and contribute to the development of public transport in Italy. Now the company’s plant covers a surface area of 155,000 sq. m. where the production activities, as well as the assembly, are carried out.

Many BredaMenarinibus models are state of the art designs and engineering, and represent an example of the best Italian industrial tradition in the sector. In its many years of activity, BredaMenarinibus, thanks to its engineering know how, was able to provide technical solutions to complex customer requirements. Breda Menarini is also in discussion wit Tropical to develop hybrid hydrogen-electric mini–buses.

2) ***Specific Opportunities in Rome:***

In the context of sustainable development, the Third Industrial Revolution, and most importantly, the historic and cultural identity of the city, Rome is certainly suited to be the leader in the development of hydrogen technologies and their applications.

Hydrogen is a means of storing energy that can be applied in any place, since the sun, wind and water are present almost everywhere on the planet.
Rome can take advantage of these resources, and be amongst the first to follow the hydrogen way.

3) ***Potential Real Issues:***

In order to implement hydrogen projects in Rome and more specifically the network of fuelling stations, certain important factors must be studied.

The locations of the fuelling stations are very important in order to successfully serve the fleet of vehicles chosen, and be in a position to receive electricity from renewable energy sources. There is also the option of producing hydrogen elsewhere and transporting it to the stations by means of trucks or pipelines, but this is not the most desired way of doing it.

A second parameter will be to select the fleet of vehicles to initially use. This will be based upon their size and fuel cell technologies. Criteria such as trips per day, total distance covered, terrain, traffic conditions and daily hours of operation must all be taken into account. It must be decided if the vehicles will be only hydrogen fuelled, hydrogen-electric hybrids, hydrogen-natural gas or a mix of all three.

Rome City vehicles, Sapienza University vehicles and vehicles from other public institutions have to participate in developing the first fleet of hydrogen powered vehicles. There is also the possibility of the auto industry financing the use of private vehicles.

One more important parameter to be investigated is the renewable energy systems that will be used and the way they will be located in order not to interfere with the city's historic architecture.

4) *Solutions to Issues:*

The above mentioned group of companies and institutions will cooperate closely with the City of Rome and Sapienza University. Rome City planners, traffic engineers, public transportation officials, sociologists and scientists from other fields of study, will have to be consulted in order to determine the location of the first fuelling stations to be built. The first stage in the development of a coherent and well researched network of stations to be constructed in the years to come.

It is this team's opinion that the city should start with a fleet of hybrid hydrogen-electric vehicles. This will ensure that the demand for hydrogen and the costs of producing and storing it will be low. The team believes that a few small hybrid hydrogen–electric buses should be included as well municipal vehicles of various types and sizes.

5. Overview

LOCATION:

One idea is for the two hydrogen fueling stations to be located at the main entrances of Rome and in areas that are not densely populated. Moreover, since the power for the water electrolyzers will be produced from photovoltaics and wind generators, the power network must be stable and as close as possible to the fuelling stations in order to minimize energy loss. Another idea is to locate the fueling stations close to bus terminals, since we have proposed that two hydrogen minibuses be in our fleet of vehicles.

CAPACITY:

The capacity of the hydrogen fuelling stations is relevant to the hydrogen vehicle fleet that Rome will have. We are proposing that two hydrogen–hybrid minibuses as well as ten hydrogen–hybrid two and four seated passenger or service vehicles be used in this project. For the minibuses we have calculated a minimum operating time of two hours per filling, and for the cars, a minimum operating time of five hours per filling. Based on this use, we have calculated that each fueling station should produce daily about 1000Nm^3 of H_2.

SIZE:

The area that will be needed for each fueling station will be about 500-1000 m^2, which includes the hydrogen tanks, the safety compartment, the electrolyzer compartment, the control room, as well as other office facilities. The station will be able to refuel two vehicles at a time.

To summarize, our proposal will deliver the following to the City of Rome:

1. Two complete hydrogen fuelling stations with 500Nm^3 capacity per station
2. Two hydrogen-hybrid minibuses, each one carrying about 25 passengers
3. Five two-seated hydrogen-hybrid passenger or service cars

4. Five four-seated hydrogen-hybrid passenger or service cars

6. Costs

On the proposed project there are three main basic costs, expressed in Euros, which are:

a. FUELLING STATIONS – includes cost of the following components and not only the cost of labor required to build the system :

Water Electrolyzers

High Pressure Hydrogen Tanks

High Pressure Compressors

Filling & Dispenser Units

Safety & Fire House

b. H_2 – HYBRID VEHICLES which include :

Hydrogen-hybrid minibuses x 2

2-seated hydrogen-hybrid cars x 5

4-seated hydrogen-hybrid cars x 5

The **total cost** of delivering two hydrogen stations as well as the hydrogen-hybrid vehicles to the City of Rome is **approximately €2.600.000.** We have not included in our calculations any country taxes or transportation costs.

c. SITE & BUILDING

For the land needed as well as for the buildings needed, a cost estimate can not be given. When the site is chosen and construction requirements are finalized, cost estimates can be made.

The payback time and the potential cost savings are quite difficult to estimate at this time since in the total cost, site and building cost have not being included. On the other hand, taking into consideration examples of other best practices, we can state that the payback period may be around 10 to 12 years and the cost savings can be promising. Payback and cost savings certainly depends on a number of assumptions, but it is too early to state anything realistic at this moment.

7. Carbon Saving

Each fuelling station will be delivering around 1,000Nm^3 of pure hydrogen per day. This means that about 1,050 kg of CO_2 will be saved per day, compared to the hydrocarbon fuels that would be otherwise utilized. Since the hydrogen is being produced entirely from R.E.S. there are no emissions of CO_2 in the atmosphere. Moreover, we would like to note that the above CO_2 savings do not include the savings of CO_2 derived from the electricity produced by charging the hydrogen – hybrid vehicles batteries at night from electricity produced by R.E.S.

8. Visual

Hydrogen – Hybrid Vehicles (from Tropical S.A.)	
	
Hybrid (Hydrogen – Batteries) Minibus in collaboration with Bredamenarini Spa	4-seated Hybrid (Hydrogen – Batteries) car being manufactured by Tropical S.A. and sales have been achieved
	
2-seated Hybrid (Hydrogen – Batteries) car in collaboration with AEE	Hybrid Scooter (Hydrogen – Batteries) being manufactured by Tropical S.A. and sales have been achieved

C.R.E.S. Fuelling Station (Athens, Greece)

The wind generator is producing electricity which is then provided to an electrolyzer for producing hydrogen at low pressure.

The hydrogen compressor is lifting up the pressure to 250bars which is stored in high pressure hydrogen tanks.

ROUND – UP

As mentioned in the introduction, as well as in parts of the above description of this project, many parameters have to be discussed in order to be in a position to present more concrete results with respect to the location, type, design, capacity and size of the fuelling stations. The first two stations will be the beginning of a larger network of stations to be developed at a later date. As is usually the case, the cost of the first two stations will be higher than the cost of the ones that will follow.

The Hellenic Hydrogen Association is looking forward to participating in this innovative and pioneering project on a real city-wide scale, which we are certain will bring Rome to the forefront of the Third Industrial Revolution, promising a sustainable future for the generations to come.

Alexander Vrachnos
Project group coordinator

Distributed Energy Model

Introduction

Cities provide the infrastructure upon which societies construct elaborate economic, cultural, and (historically) defensive structures. Civil engineering has played a major role in the construction and operation of these platforms, beginning with earth and stone works to provide defense against enemies and protection against weather. In the 21st century, Information Technology advances will drive new urban innovations, allowing cities to gather, analyze, and act upon detailed operational data. This detailed view and analysis will enable cities to make more accurate decisions. IBM's view of Smarter cities[1] is that this process and the arising "virtual city infrastructure" will have an impact equal to that of the preceding infrastructure innovations.

Virtual city infrastructure is loosely defined as those components which permit such data collection and aggregation, analytics, and decision support. This infrastructure includes deployed sensors, both distributed and centralized processing capability, transmission bandwidth, and accompanying software models and presentation logic to support human decision makers. This virtual infrastructure must respect sustainability principles in its own construction, and also improve a city's operational sustainability.

IBM's view of Smarter cities emerged from the recognition of specific trends and changes, and placing these within the context illustrated in a 2008 study known as the Instrumented Planet[2]. The central observations of this study were that in many aspects (though not all) the Earth is already instrumented, that pervasive networks are available to collect real-world sensor data, and that cheap computing is available to analyze such data. Furthermore, this study indicated that significant benefits could be achieved by using that data to connect physical events to advanced analytic capabilities, with resultant improvements in intelligent, integrated city control and management systems. We refer to such systems in general as Smarter Planet systems, of which Smarter cities are a major sub-set. As a result of the Instrumented Planet work, IBM has defined its view of a Smarter Planet system through three IT characteristics as follows.

Instrumented, meaning that this instrumentation enables the capture or integration of real-world data through the use of sensors, kiosks, meters, PDAs, appliances, cameras, smart phones, implanted medical devices, the web and other similar data acquisition systems. Note that today, some of the systems in a city will be instrumented in some way, but in many cases may not be used.

Interconnected, meaning that data is integrated throughout an end-to-end process, system, organization, industry, or value chain. In addition, such data may be interconnected across multiple processes, systems, organizations, industries, or value-chains. Interconnection may also bring together data that exists in an unstructured way or "en-masse" and not associated with a system in particular. For example, Web 2.0 interconnectivity across social networks, search engine queries, and other such logical constructs offer meaningful information, but exist across a mesh of physically distributed systems.

Intelligence, meaning that the analysis of this interconnected data must yield new insights which drive actions to improve process outcomes, or system, organization, industry value chains. Such outcomes must fundamentally change the end-user experience or eco-system, i.e., they must demonstrate tangible value-add. The best examples will also have intelligence that is 'real-time,' forward-looking, or predictive.

The convergence of cities' structural, demographic, economic, and environmental needs with the insights of the Instrumented Planet study is thus the foundation for the work on Smarter cities.

The Instrumented Planet

Today, a broad range of urban resources, including electrical power, effluent emission, fresh water usage and road capacity are subject to increasing pressure. Through more efficient use of natural and manmade resources, it is possible to reduce these pressures. Efficiencies may be achieved by accurate measurement of resource lifecycles through data captured from the wide range of available sensors. By processing this data with increasingly powerful mathematical models, it becomes possible to more accurately monitor and manage the lifecycle of a resource. The Instrumented Planet[3] is a concept that uses the idea of connecting sensor-provided data streams to mathematical models and thence to business processes as a means to enable transparency in the use and control of resources according to a specific set of policies. Figure 1 illustrates the flow of information and decision-making in the Instrumented Planet model.

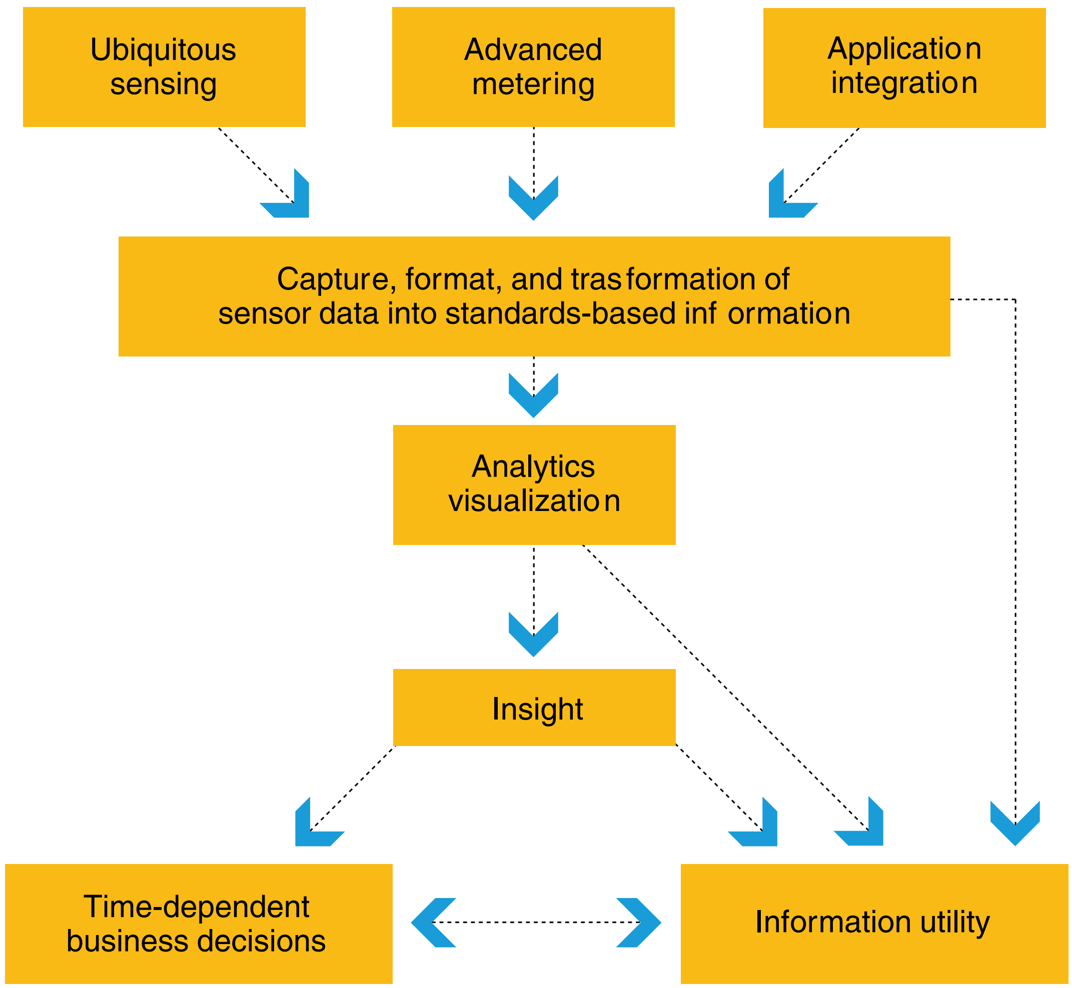


Figure 1 **The conceptual flow of data and information in an instrumented world system, beginning with real-world data and ending with insight that drives decision making. The information utility concept (bottom right) indicates that multiple clients may exist for the various insights that the system can produce.**

Significant customized coding will be required to manage entire resource lifecycles, from sensor data capture, through modeling and optimization. Experience shows that as cities look to manage a specific resource, such as Greenhouse Gas (GHG) emissions, traffic, or water, the need to integrate such resource management becomes more acute. For example, although most water in California is used for agriculture, pumping that water uses some 20% of the state's electrical power[4]. This interdependence of energy, water, and the food supply, for example, requires that these resources be managed simultaneously - not in isolated silos.

The interdependence of such resource systems becomes clearer as demand approaches the capacity limit of the resource, since every aspect of managing the resource lifecycle is now critical. It is thus important in situations where one or more resources is being optimized, to provide an open framework to enable rapid service and model integration and to support the mathematical representation of interdependencies based on either heuristics or scientific models. Doing so permits diverse parties with complementary skills and interests to research, model, and provide suggestions around non-intuitive resource dependencies. Many such interactions are not easily envisioned, and can be most easily accommodated by open frameworks.

Finally we cannot consider applying such principles to cities without centrally considering the people who live, work, and visit there. In dealing with critical public infrastructures, systems engineering principles teach us the importance of including people in the resource management process, as models, particularly interacting models of this type, cannot be relied upon to make sensible decisions under all conditions. Even more importantly, the people of a city have a key role in defining the policies under which the city is governed. The people are also the intrinsic force animating the city's activities and, through their interactions with the city's intelligence, individually drive these operations and collectively indicate how they desire resources to be allocated.

Notwithstanding these challenges of complex resource interdependencies and of the essential role that people play in a Smarter city, we see the Instrumented Planet approach as a powerful new method for both improving and transforming the operations of Smarter cities. We note however that this approach - where data are transformed into models, which in turn allow cities to make integrated decisions about which roads to make available under specific conditions, or where to pump water or to generate renewable energy - is an emerging and rapidly evolving application domain which will require investment in integrating Information Technology, mathematics, business and social processes. These transformations will at least be comparable to those employed during the 1980s and 1990s in the development of Enterprise Resource Planning and Supply Chain Management for individual enterprises and value chains of enterprises.

Roles for Information Technology in Smarter cities

Although the concepts of Smarter cities are still emerging and many have yet to be demonstrated, we see several key roles for Information Technology in the development and operation of Smarter cities. Such models are complementary, and adopting cities will undoubtedly demonstrate multiple attributes to varying degrees, according to maturity of their technological and societal adoption.

In the *Sustainable City*, Information Technology can apply hierarchical control systems to shape various forms of consumption and emission, and to drive city operations toward defined Key Performance Indicators. Additionally, IT can enable behavioral changes in resource consumption using market-based and social incentive-based methods for managing constrained resources[5].

In the *Integrated City*, Information Technology can provide city management with an "enterprise-wide view" of the manner in which city resources (e.g. power, water, and road availability, among others) are being used and can also enable cross-resource optimization of city services. Information Technology also can enable a tighter integration of various kinds of incident management. While cities are usually capable of delivering services, they have lagged behind commercial organizations in operational integration and may sometimes have inefficient flows of operational information due to functional division into operational silos. Integrated IT can break down such silos to provide new benefits and improved services.

In some ways, the city is evolving from an aggregation of people and activities into an "organism" with an increasingly interconnected data or "nervous" system. Information will increasingly be at the core of how the city is run, and how it responds minute-by-minute to events within and around it. Cities are also evolving from their historical role as aggregators of skills, materials, and services for the production of goods, into aggregators of market demand, both broad and niche[6]. This evolution also demands a transformation of the "information chain" that drives the city's economy.

These changes, and the correspondingly greater involvement of Information Technology in the operation of the city's services and economy, will potentially bring great benefits for how effectively and sustainably the city operates. But the realization of these benefits requires considerable care.

Many sustainable city experiments currently being created appear to envisage a centralized, command and control model, managed by some single optimization function that allows the city's policies to automatically drive the operation of the city's services. In practice, what is required is a "system of systems" model, where the "smartness" of the city comes from the interaction and interdependence of various distributed systems. The central challenge will be to create the context in which individual systems that control the city's services are aware of other systems that relate to them and in which they can "co-evolve" (for example, linking energy and crowd management systems to provide additional lighting where crowds may be congregating, or reduce lighting in other areas).

For this to happen in turn, many technological challenges need to be overcome. Examples of the more complex challenges include the following.

A cooperative framework is needed to enable city systems to interoperate while maintaining semantic integrity, so that the results of that interoperation can be trusted. While each component in the city's "system of systems" will manage its own temporal and spatial scales of operation, its own data types and definitions, reporting frequencies and workflows, and so on, a common standard semantic model, tailored to the individual systems is required. Further, these frameworks will need to enable rapid development of solutions to new issues as these emerge, by combining different application modules in new ways.

Security services must ensure the integrity of data received from sensors and system operation. Individuals intent on disrupting operations may try to disable systems by faking sensor readings or interrupting their outputs – much like the recently publicized risks of attacks on the US energy grid. Sensor networks are not inherently secure, so technologies must be developed to remedy this, as the operation of entire cities becomes increasingly dependent upon their integrity.

Privacy levels must meet the legitimate expectations of citizens and enterprises. Protection must be ensured against the inappropriate use of data about personal and business activities, collected as a consequence of managing resource consumption. Data will be supplied from multiple sources, and combinations of such data may pose additional privacy challenges. The city's "system of systems" will need to address privacy at multiple levels, effectively tagging each data item with controls on where and how it may be used, either on its own or in aggregate. Privacy has not, to date, had to be protected on this scale or across so many emergent, multi-level uses.

Smarter cities are not simply aggregators of information systems, but rather, are complex organisms requiring a structured approach to the integration, operation, and long-term management of such systems. Successful implementation allows the city to achieve a "collective intelligence," enabling powerful new services, while preserving the critical freedoms of its citizens.

The Distributed Energy Project

In the Smarter city framework, as referred several times, The energy supply is one of the key systems of the Smarter city framework that is specially under pressure nowadays. It is not only calling for more reliability, affordability and security of supply. It is in the bright spot of environmental sustainability.

Rome, like all major urban areas, is currently facing a big challenge towards a sustainable energy model. Carbon neutral energy sources are considered, developed and deployed in growing scale and there is general consensus that the traditional centralized energy model will be gradually replaced by Distributed Energy Resources were the single buildings can become micro-generation sites.

Distributed generation in big cities means mainly solar PV roofs but while the latitude of Rome helps this technology to already have acceptable efficiency, the historical relevance of most of the buildings brings additional architectural constrains. Proper sites for solar panels will unlikely be identified 1:1 with the residential and commercial buildings they need to serve. This simple consideration gives immediate evidence of the relevance an efficient electrical grid will have in the success of any distributed energy model. A Smart Grid will be required to give proper connection among dispersed producers and consumers. And a grid that becomes smart is a system of the Smarter city framework that can provide broader services to the community on top of the electrical supply.

Referring to "Smart Grids" we envisage a system that adopts various technologies to enhance power delivery and use through intelligent two-way communication. Power generators, suppliers and end-users are all part of the equation. With increased communication and information, a Smart Grid system can monitor activities in real time, exchange data about supply and demand and adjust power use to changing load requirements.

A Smart Grid uses a combination of technologies - devices, software, and advanced analytical tools - to give all parties more information

- End-users can choose to modify their energy usage behavior for lower costs, "greener" use patterns
- Generators can optimize output of their resource portfolios (including renewable energy resources)
- Grid operators can improve reliability
- Distribution utilities can enhance service quality and control costs for improved customer satisfaction

Among sensors and actuator devices the electrical smart meter is a key enabling technology toward Smart Grids as it represents the contact point between the final user and the distributor.

The city of Rome in this scenario has a unique advantage towards the implementation of an efficient energy system. The local municipality (ACEA) that owns the distribution network and provides electricity supply to the vast majority of customers in Rome has already undertaken a massive roll-out of Smart Meters that represents today a major asset to leverage towards a "second wave" of smart energy usage.

A central aspect of managing a city is resource management and electricity is a main resource that needs to be provided at a city level. A fundamental aspect of managing resources is to match supply and demand. A Smarter city must proactively manage its supply and demand. To do so cost - effectively, and possibly in an environmentally preferable way, city operations need to perform supply side management to handle the supply of resources and demand side management to control the demand for these resources.

The demand for electricity varies by time of day, day of week, and seasonally, and is of course significantly impacted by weather conditions. Demand management is critical in optimizing energy use, and it requires developing a reasonable forecast of energy load by time of day for a period of a year. Once there is an estimate of the anticipated load, another aspect of demand management is to condition and shave peaks using demand response techniques. The key here is to use information (including price) signals to modify behavior associated with energy consumption.

Basic economic theory provides a price-based mechanism to influence demand. Typically, demand goes down with an increase in price, suggesting a negative slope for the curve that connects demand to price. On the other hand, the supply of electricity goes up with an increase in price. Introducing real, variable electricity prices has the following effect on demand (see Figure 2).

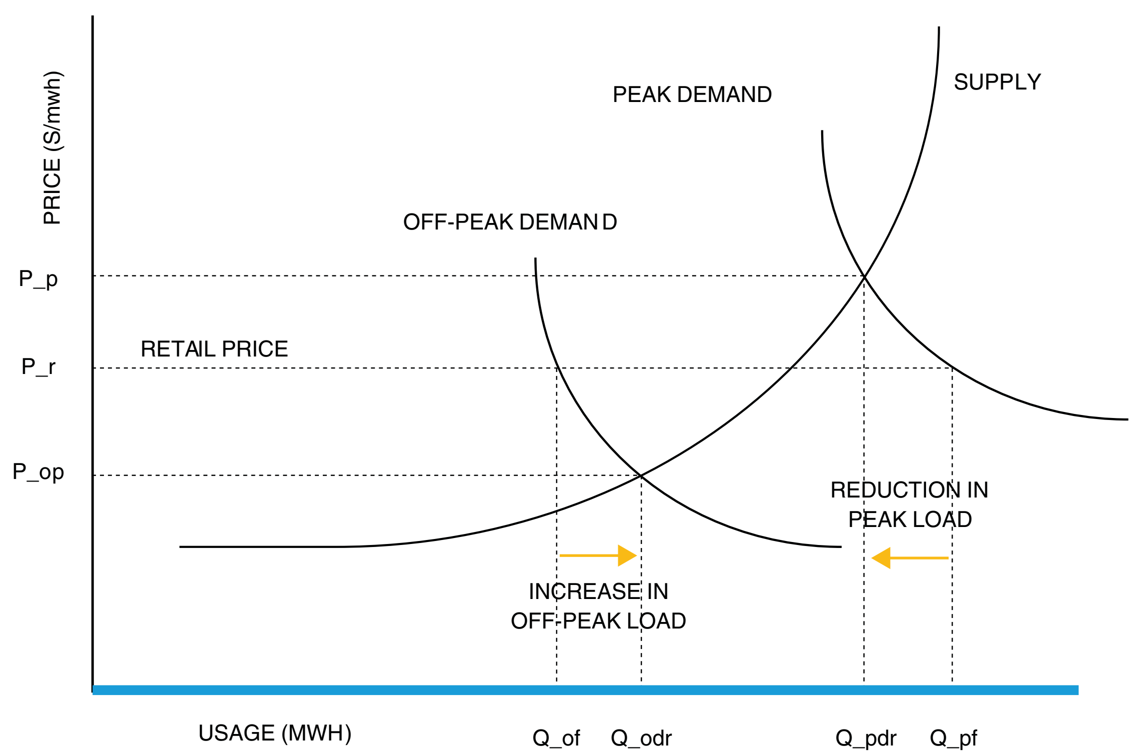


Figure 2 **A schematic of demand response to price. The Peak and Off-Peak Demand curves represent aggregated demand from the customers served during the current trading period and the Supply curve represents the utility's offer price. The experiment shows the shift of energy demand from Peak to Off-Peak periods.**

This figure illustrates demand movements in peak and off-peak periods. If we impose a fixed retail price (P_r) the demand in peak periods is Q_{pf}. However with variable prices the demand equilibrates at the intersection of supply and demand and yields a demand Q_{pdr} ($< Q_{pf}$) leading to price of P_p at a total cost at peak with demand response $C_{pdr} = P_p \times Q_{pdr}$ as compared to the original cost at peak with fixed retail price of $C_{pf} = P_r \times Q_{pf}$. The question is whether $C_{pdr} < C_{pf}$. Similarly at non-peak hours the cost with fixed retail price is $C_{of} = P_{op} \times Q_{of}$ and the cost after demand response is $C_{odr} = P_{op} \times Q_{odr}$.

Estimating the efficacy of demand response models requires the ability to quantify the price elasticity of demand. This is defined as the percent decrease in demand for a one percent increase in price, and in turn allows us to estimate the peak shift/reduction to a price signal. This calls for a software platform that is integrated with building management systems, which facilitates the control of information signals, and which records the responses at the apartment or appliance level. Statistical analysis of the response data provides an estimate of the price elasticity and hence of the demand response.

Supply procurement planning is another aspect of optimal energy management, focusing on purchasing the optimal portfolio of energy blocks for a given time horizon. Doing so takes as input a load forecast (which in turn is informed by weather/climate forecasts), as well as the electricity price forecast. Cities typically own many office buildings and other facilities, for which they need to manage energy costs. Based on a load forecast for the facilities, the city can design an energy portfolio to minimize the cost of meeting its electricity demand.

Based on the previous considerations we suggest a Smart Distributed Energy model project for the city of Rome that builds an end-to-end smart energy system including distributed renewable generation, optimized grid management and end-user energy efficiency programs for a pilot area of Rome population.

This project can demonstrate an innovative way to optimize green generation while keeping the electrical grid healthy. In times of stress electrical demand can be managed through a combination of intelligent technology and financial incentives. A virtual marketplace can be created where both consumers and providers participate in setting the incremental price of electricity. The marketplace allows consumers to trade flexibility in usage for lower costs. Intelligent devices (such as thermostats) in consumers' homes are tied to the system, which can lower their usage based on individual preferences during times when demand for power outstrips supply. The project also can demon¬strate how intelligent appliances can sense and respond to impend¬ing grid failure.
Demonstrating a new, transactive methodology for managing energy constraints based on price signals

- Gives customers an active role in maintaining the health of the grid
- Empowers utility customers with information and the ability to fine-tune power usage and save money
- Helps avoid power restrictions and cascading power outages
- Makes both consumers and providers participants in an open energy marketplace

The project scope would cover two mayor areas:

- Integrate multiple commercial and residential assets
  - Distributed Generation (DG)
    - ✓ Aggregated DG across several commercial sites
    - ✓ Individual dispatchable DG
  - Demand Response (DR)
    - ✓ Residential and Commercial Demand Response assets
    - ✓ Direct load control
    - ✓ Residential customer signals to encourage usage change

- Build a Shadow Real-Time Market
  - Handled outside the normal utility energy bill; cost of energy from the market is not paid by Residential Customers but managed as a virtual account, in the end just providing direct evidence of the value of consumption
  - Both DR and DG assets bid into market
- Base clearing price is calculated from a virtual wholesale market price, adjusted based on real-time market demand and constraints

The ultimate goal for the Distributed Energy Project is to improve global electric system efficiency while empowering consumers in their energy usage choices under limited resources.

A number of management approaches can be adopted to relief pressure on limited resources. These include increasing the cost of the resource to some level which drives users to reduce their utilization; allocation of resources based on some algorithm which attempts to assign resources based on some objective such as efficiency; and most drastically, rationing of resources through mandates. Although all of these approaches work to varying degrees, the second approach typically manages the issue most gracefully and with minimal disruption.

In this case, as the requirement for efficiency increases, the information about the use of the resource increases. For example, in the case of the improved efficiency of electrical power in a home, information about individual appliance usage becomes available to allow this improved efficiency. Unless all homes in a given area adopt the methods by which usage is made more efficient, the maximum efficiency of the system is not achieved. Clearly this requires many of the devices that consume considerable power in a home to be instrumented and controllable.

This leads to some interesting dilemmas which are intimately connected to individual's privacy and freedom of action. It thus also becomes important to provide approaches that allow the individual and the community to deal with this efficiency while preserving this privacy and reasonable freedom of action. At least two approaches can be used to provide this optimized utilization while maintaining the necessary degree of freedom and privacy.

Economic Incentives act by providing explicit and timely information to consumers about the financial costs of their energy consumption choices. This is achieved via automated systems that provide individuals, companies, governments, or other organizations a choice of maximum efficiency with some degradation of convenience. For example, in the case of the utilization of electricity, the utility could send a specific request for power utilization to industry, government and individuals. The result of this request at a data center, for example, would be to prioritize computational workloads according to agreements with customers, and reduce activity based on the service level agreements that the data center has with its customers. For certain customers the availability of a service may be of paramount importance, in which case they will pay for the necessary power. Clearly making the data center a "node on the network" requires new agreements to be implemented between the data center owner and their customers – essentially reflecting the economic value for the utility and for the data center owner and customers. In such a situation, it is likely that new business models for managing demand will evolve. Similarly for the consumer, it will be possible for them to choose maximum convenience – which will cost them more than maximum savings.

Social Incentives act by invoking social norms or shared goals of a community. For example, providing consumers with explicit and timely information about individual consumption and how it relates to achieving individual or communal goals may prompt behavioral changes. In such cases, aggregate and individual ratings are made visible by a cluster of some numbers which makes it impossible to identify an individual entity, also makes it difficult to hide large deviations from the mean. The intent is not to be punitive, but rather to make the information available. This could be connected to a more global social network focused on resource efficiency, allowing participants to advise and aid each other with ideas to reduce resource usage and to identify problems in infrastructure, suppliers, and other participants in the resource lifecycle.

A project with similar characteristics and goals has already been tested on a very limited scale in the Olympic Peninsula Project - a research consortium in US - with positive outcomes and interesting results. The new challenge Rome would aim to address is transform the US experience in a catalyst project, in line with European Smart Grid Technology platform recommendations, extended to a significant area of the town (eg 3 urban areas with different urban characteristics summing up to 40.000 inhabitants). The Rome experience would include other specific areas of attention:

- Architectonic impact and solutions for solar generation technology on historical buildings
- Identification of loads worth to be remotely controlled in the specific Mediterranean area
- Readiness of local citizens to proactively sustain energy efficiency behaviors

The outlined project would be coordinated by the proper institution inside City of Rome but its success will clearly depend on the right partnership ecosystem - no single entity could accomplish this effort alone; each partner contributes its piece of the project, leading to a robust, diverse, and comprehensive test of smart grid technology

- Two-way communication from generation to consumer helps optimize the electric system, do more with existing resources
- Better managed energy demands can help defer costly investments
- Increased automation for utilities to deliver improved services with the same resources for greater cost-effectiveness and value to their customers
- Potential reduction in greenhouse gases (GHG) and carbon footprints through better integration of renewable resources
- Non-participants can learn from the Project, accelerate adoption of the best technologies, avoid costly mistakes
- Promotion of interoperability

Summary

In urban environments, a myriad of sensors and pervasive networks provide surprising volumes of data that bring information about the activities underway in a city. The central concept of IBM's Smarter city initiative is to take advantage of this multitude of information flows to improve a city in various ways - to learn from yesterday, to make the best of today, and to prepare for tomorrow. This applies particularly to how the physical infrastructure of the city supports the needs of the citizens for safety, employment, energy, comfort, mobility, and community. Creating the Smarter city implies capturing and accelerating these flows of information both vertically, within the operation of a given infrastructure system, and also horizontally, among the many different infrastructure systems and using this information to manage the operations with a specific objective, such as minimal energy usage or maximum citizen comfort, in mind.

While the original sensing and networking elements may have been deployed for reasons of automation, or convenience, or to provide a new service, this ability to derive high value information from them enables us to address concerns that are becoming acute in countries around the world.

The integrating and transformative power of Information Technology enables the leverage of these information flows to achieve improved efficiency in the utilization of existing infrastructures that would be enormously expensive and disruptive to achieve by extending the infrastructure itself. Likewise they enable new thinking about how to manage public infrastructure services – making them dynamically responsive to the citizen's activities. Not least, these approaches can lead to reductions in the consumption of energy and water and hence to the attainment of a city's sustainability goals; many of these reductions will come from closely tailoring consumption to actual need and from offering city manager's ways to promote more sustainable behaviors.

The city of Rome is well positioned to experience an advanced energy model thanks to the already available asset of smart electricity metering deployed to all town citizens. Introducing significant distributed energy generation and extending sensors presence to include home appliances, the suggested project would define a virtual dynamic pricing model to enhance network management and optimal energy usage.

While our work is rooted in technology, it is closely bound to many social implications and must therefore respect the right and interests of the citizens as well as being aligned with the work of architects, urban planners, and city governments[7].

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[6] Pacific Northwest National Laboratory, "Department of Energy putting power in the hands of consumers through technology", see http://www.pnl.gov/topstory.asp?id=285

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HOTELS IN ROME: A SUSTAINABLE MODEL

Wake Up To a Better World

I. THE IMPORTANCE OF MEASURING ENVIRONMENTAL VARIABLES:

In order to implement improvement measures in our hotels and know their potential, we first must know where we are. Thus, it is very important to make continuous measures of environmental variables in the hotels.
In this way, we can detect the fields with the greatest potential for improvement measures to be taken individualized, depending on the particular needs of each hotel.

NH Hoteles has developed an online **Control System**, the **Datamart**.
This tool enables to centralize the control of the consumptions, design actions to optimize the use, identify more efficient Ienergy sources for the chain or control systems in hotels that optimize the use of these non-renewable energy sources. This will centralize the collection of data by developing a data entry interface, customized for each hotel, based on the type of supplies consumed, that is checked by the Environmental Department of NH Hoteles. This **optimizes the processes** of collection, homogenization and aggregation of existing information.

Up to date and thanks to the efficiency measures that we are carrying out in our hotels in **Rome,** we achieved the following savings from 2007 – 2009:

- **15,5%** reduction in water consumption
- **20%** reduction in energy consumption
- **22%** reduction in CO2 emissions
- **26%** reduction in waste generation

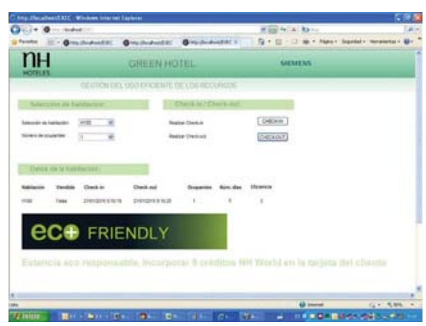
II. PROJECTS TO BE IMPLEMENTED

- **Energy efficiency**

RELAMPING PROJECT: This project aims to replace **all** lamps by low consumption ones in the public areas of the hotels. Therefore, for each of the lamps and fixtures specific models were chosen and were tested beforehand in order to check the quality and brightness provided by the bulbs to get sure to chose the best option available in the market. With this measure we get significant savings in energy consumption in our hotels.

CENTRALIZED CONTROL SYSTEM: the centralized control systems for all operations and distribution of air conditioning and sanitary hot water, optimizes the orders of air conditioning in rooms, convention rooms and public areas. With this system you can set the temperature levels of comfort as the room is occupied or not. The environmental benefits of this system are mainly derived, directly or indirectly from energy savings.

Currently there are **intelligent rooms** in test phase, in which we have developed a system of real-time monitoring, of the water, lighting and energy consumption of our guests**.**
The objective of this project is to provide a better service; adapting lighting and air-conditioning to the guests preferences; the guest can control and save energy, without loosing comfort. We can define specific energy efficiency programs based on consumption patterns obtained from the guests and the hotels' employees, since we know the guest consumption, schedule and maintenance carried out in the NH standard rooms.



People Focus Business sense Environmentally friendly Innovation
DEPARTAMENTO DE MEDIO AMBIENTE E INGENIERIA

With these new intelligent rooms, we aim both to establish the pattern of actual water and energy consumption of the guests and to reward those with a more eco-responsible attitude. When checking out, each guest will be able to check whether his consumption is above or below the hotel average. This is an additional measure taken by NH Hoteles to make its guests aware of the rational use of natural resources and to make them accomplices in its stake for the environment. The guest will be rewarded for its "eco-behavior" with credits in the World NH loyalty card.

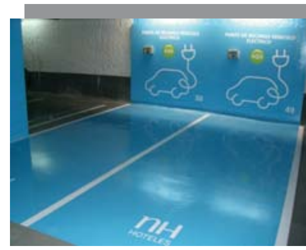
PROMOTION OF RENEWABLE ENERGIES: NH Hoteles is strongly committed to the use of alternative energies. For all projects of new openings we are studying its viability. In Italy we have focused primarily on **thermal solar energy,** already implemented in 15% of our Italian hotels. Our goal is to increase this figure and to promote the use of **photovoltaic solar energy**, as we did in the hotel **Vittorio Veneto** in Rome, which is about 10% of the total energy consumption.

- **Waste Reduction:**

NH Hoteles is working to develop a sustainable activity to minimize the impact of our activities on the environment and to protect the available resources.

- **Materials** of low environmental impact:
    - The wood and paper used in our installations come from sustainable forests with FSC certification
    - Amenities and accessories made of "bio" materials and of low environmental impact

- **Equipment** adapted to the needs offered by the hotel. Eco-design and efficiency for kitchen and catering elements.
- **Segregation** and integration of waste recycling systems in all cities where we operate.
- **Ecomeetings:** NH Hoteles has re-designed some of the traditional products and services in our rooms and convention rooms, offering our guests with no additional cost a more sustainable alternative for meetings.



- REDUCTION OF EMISSIONS:

In the context of our Environmental Plan 2008-2012, NH has detected a great potential in the electric vehicle industry. That is why we are including free recharging points in some of the most emblematic NH hotels.

- **Reduction of water consumption:**

In all our hotels water saving devices are installed at toilets, showers and taps, as well as dual flush systems in many toilets

III. MEASURES FOR A CONTINUED IMPROVEMENT:

Within this framework and going along with the vision of continuous improvement, the line to develop in future would be to create a **Supplier Club in Rome,** in its constant effort to innovate and promote dialogue and communication with stakeholders, in this concrete case, our suppliers. This would be an innovating and pioneering initiative.

The purpose of it is to work with the most sustainable suppliers, searching for innovative solutions and the development of **new products and services**, characterized by the Eco- efficiency. Therefore, the NH Sustainable Club was created as a **joint innovation lab**. It is an initiative that begins in the design and operational performance and it continues to **improve the global performance.**

Appendix

ACEEE
American Council for an Energy-Efficient Economy
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To: Livio de Santoli
Roma Energia

From: John A. "Skip" Laitner
Director, Economic and Social Analysis Program

Re: Overview of Methodology on 3rd Industrial Revolution Investment Scale

Date: April 30, 2010

This memo provides the critical assumptions and working methodology we propose to use in estimating the scale of the potential investment that will be necessary to reduce energy and greenhouse gas emissions in Rome as shown in Figure 1 (copied below) of the report, "Rome Climate Change Master Plan." More specifically, we are explaining the methodology that underpins the statement: "Moving Rome from a business-as-usual case of a small increase in overall greenhouse gas emissions, to a transition that greatly reduces total greenhouse gas emissions will require on the order of 10 billion Euros of incremental investment that can be directed toward this purpose."

The investment figure we cited was in the spirit of providing a broad narrative that might inform Roma Energia and the City of Rome about the potential scale of investment that might be needed to bring down the region's total greenhouse gas emissions to 20 percent below the 1990 level by 2020 – using some combination of energy efficiency, renewable energy, clean energy technologies, and other non-energy related processes.

In effect, we propose a three-step process in generating the various estimates to be provided in the draft report: (1) build an emissions projection through the year 2030; (2) find a potential path that would provide at least a 20 percent reduction from 1990 levels by 2020; and then, (3) estimate the potential investment needed to move onto an emissions reduction path. I describe those more fully below in the hope of getting some immediate feedback from you before we lock into a final methodology and set of estimates.

Total Greenhouse Gas Emissions Projection for Rome through 2030

To give us a starting point in total greenhouse gas (GHG) emissions (including both energy and non-energy related emissions) we used a variety of 2005 to 2008 data that was provided us following our successful executive seminar and discussions in December 2009. We grew the 2008 level out to 2030 by relying on the IEA World Energy Outlook 2009, following the data for the European Union from 2008 to 2030. Finally, we anticipated what we might refer to as a normal rate of reduction in the GHG emissions per constant dollar of Gross Domestic Product. This last change generally followed the national rate of reduction of carbon dioxide emissions associated with energy consumption as projected by the IEA through 2030 (IEA 2009). With that we have the following table of key values for the years 2010 and 2030:

Key Rome Data	2010 (est)	2030 (est)	Annual Growth
Population (1,000s)	2,828	2,944	0.2%
GDP (millions of 2008 Euros)	124,389	167,534	1.5%
Estimated Primary Energy (PJ)	201	210	0.2%
Estimated GHG Emissions $MMTCO_2e$	14.5	15.1	0.2%

The 20 Percent Energy Reduction by 2020

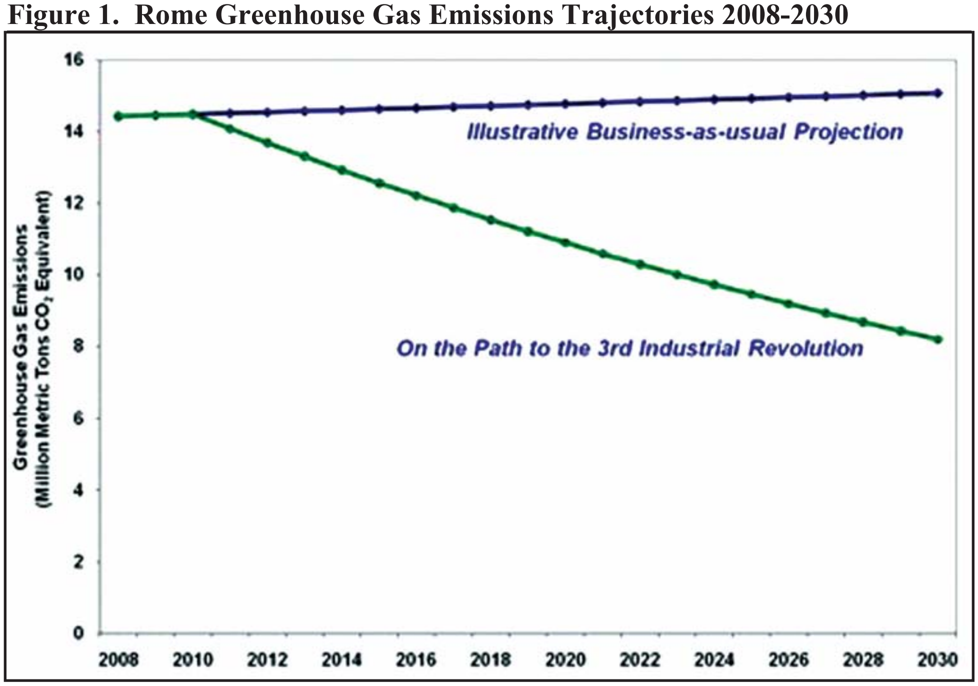
The estimate of the 20 percent energy and related emissions reductions (from a 1990 benchmark) was a straightforward calculation. It generally followed a number of previous estimates of what might be possible economy-wide (see Elliot et al 2007, Laitner et al 2007, AEF 2009, McKinsey 2009, and IEA 2009). This resulted in the following values for the years 2020 and 2030.

Rome Energy/GHG	2020 (est)	2030 (est)	Annual Growth*
Baseline Energy (PJ)	205	223	0.2%
TIR Energy (PJ)	175	152	-1.4%
Baseline GHG Emissions ($MMTCO_2e$)	14.8	15.1	0.2%
TIR Emissions ($MMTCO_2e$)	10.9	8.2	-2.8%

* Growth is from the assumed 2010 values shown in the first table above.

If this trajectory for the Third Industrial Revolution is followed, then total primary energy demand for Rome (including transportation and all non-electricity fuels) in 2030 would be reduced by about 27 percent. Total greenhouse gas emissions would be reduced by about 46 percent in 2030. Depending on how the emissions reductions are actually achieved and how we want to assign the credit, it appears that efficiency improvements would provide about half of the reductions. Clean energy technologies, smart infrastructure, and other improvements in agricultural and industrial processes would provide the balance of the reductions. Figure 1 below highlight s a typical emissions trajectory based on the data and tables previously discussed.

Figure 1. Rome Greenhouse Gas Emissions Trajectories 2008-2030



Estimating the Investment Potential

From published sources within the publications of the European Union and the OECD we were able to estimate that ongoing annual investments necessary to maintain normal economic activity throughout Italy is now about 21 percent of regional GDP. By applying that ratio to the projected GDP for Rome, we estimated that normal investment in the province would rise from about 26 billion Euros in 2010 to about 40 billion Euros in 2030 (as measured in constant 2008 Euros). This, of course, includes a huge number of uncertainties, but it allows a benchmark against which to compare or understand the magnitude of the investment that might otherwise be required to reduce greenhouse gas emissions.

The total investment required to reduce total greenhouse gas emissions is assumed to be a function of changes in energy use and the carbon intensity of the remaining energy that is used. In effect, energy is also responsible for picking up the non-CO_2 emissions. The basic calculation depends on the starting average price for all primary energy used 2010, multiplied by an estimated payback period needed to reduce either energy use or the CO_2 intensity that might be associated with energy use. From the data you provided, and comparing it to other IEA data published in 2009, we determined that the average price of all energy in Rome was $27 per gigajoule. If the equivalent starting payback value for an investment in emissions reduction is three years in 2010, then the investment to reduced GHG through either a reduced energy use or through a reduced CO_2 intensity for the energy that is used is $81 dollars per GJ (also in constant 2008 Euros). If that average payback eventually grows to 9 years by 2030, then the investment required also grows to $243 per GJ (again in constant Euros).

The payback of 9 years is a weighted value that assumes efficiency would deliver about 60 percent of the reductions by 2030 and would require an average payback of about 5 years, while clean energy technologies, the purchase of emissions offsets, and the improvement of non- CO_2 intensities, responsible for the remaining 40 percent reductions which might require an average payback equivalent of 15 years. The weighted average payback then becomes about 9 years. We triangulated around these values relying on a variety of sources to inform our estimate (including Lazard 2008, Elliott et al. 2007, AEF 2009, McKinsey 2009, and IEA 2009).[1]

From these data we estimated that the annual investment would have to grow from 420 million Euros in 2011 to 500 million in 2030 (also in constant 2008 dollars). That is an investment level that represents about 1 percent of total required annual investment in Rome over the period 2010 through 2030. Let me again highlight several caveats in providing this estimate. First, the estimate does not assume any so-called “learning,” where costs decline because of improved processes; nor does it include economies of scale with expanded ramp up of program efforts, nor does it take into account innovations in technology and or any dynamic market response (see Knight and Laitner 2009, for example). At the same time, it does not include program costs and diminishing returns. Finally, other assumptions would, of course, change these values.

I hope this provides a credible documentation of our assumptions and our overall methodology. While we cannot provide a precise estimate of any future values, we think they results reasonably describe the magnitude of potential emissions reductions for Rome, and the magnitude of investments necessary to achieve those emissions reductions. In developing estimates of the eventual investments necessary to transition the City of Rome into the Third Industrial Revolution it is our intent to inform you and others within the City of Rome about the scale of

[1] This was a technique we adapted for the Semiconductor Industry Association in May 2009, for example (see Laitner et al. 2009) as well as for the City of San Antonio (Rifkin et al 2009).

investment that might be needed; rest assured, however, it is not at all to prescribe what should be done within Rome, or to suggest what precise mix of technology and/or program solutions should be pursued. I would be happy to discuss this further as you may have additional questions.

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EUROPEAN PARLIAMENT

2004 *2009*

12.2.2007 0016/2007

WRITTEN DECLARATION

pursuant to Rule 116 of the Rules of Procedure

by Zita Gurmai, Anders Wijkman, Vittorio Prodi, Umberto Guidoni and Claude Turmes

on establishing a green hydrogen economy and a third industrial revolution in Europe through a partnership with committed regions and cities, SMEs and civil society organisations

Lapse date: 14.5.2007

DC\651204EN.doc PE 385.621v01-00

0016/2007

Written declaration on establishing a green hydrogen economy and a third industrial revolution in Europe through a partnership with committed regions and cities, SMEs and civil society organisations

The European Parliament,

– having regard to Rule 116 of its Rules of Procedure,

A. whereas global warming and costs of fossil fuels are increasing and having regard to the debate launched by the European Parliament and the Commission on the future of energy policy and climate change,

B. whereas a post-fossil fuel and post-nuclear energy vision should be the next important project of the European Union,

C. whereas the five key factors for energy independence are: maximising energy efficiency, reducing global-warming gas emissions, optimising the commercial introduction of renewable energies, establishing hydrogen fuel-cell technology to store renewable energies and creating smart power grids to distribute energy,

1. Calls upon the EU Institutions to:

   - pursue a 20% increase in energy efficiency by 2020,
   - reduce greenhouse gas emissions by 30% by 2020 (compared to 1990 levels),
   - produce 33% of electricity and 25% of overall energy from renewable energy sources by 2020,
   - institute hydrogen fuel cell storage technology, and other storage technologies, for portable, stationary and transport uses and establish a decentralised bottom-up hydrogen infrastructure by 2025 in all EU Member States,
   - make power grids smart and independent by 2025 so that regions, cities, SMEs and citizens can produce and share energy in accordance with the same open-access principles as apply to the internet now;

2. Instructs its President to forward this declaration, together with the names of the signatories, to the Commission and the Member States.

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