Risø energy report 10 : Energy for smart cities in an urbanised world

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The concept of a smart city is a new approach to what cities should do to become more liveable, economically successful, and environmentally responsible. The illustration shows how a city can be converted to an energy-efficient, consumer-focused and technology-driven smart city:

- Turn the buildings and houses to smart buildings and smart houses
- Organise distributed generation within the city limits
- Organise sustainable transport systems
- Build storage and conversion facilities
- Add the Smart Grid and exploit ICT
Information and communication technology (ICT) allow greater energy efficiency and flexibility in end-use. A smart Grid interlinks demand and supply of energy. This includes:

- Micro CHP
- Waste to energy plant
- Growth of algae for biofuel
- Small wind turbines
- Solar thermal
- Smart building
- Building integrated PV
- Urban farming
- Solar street lighting
- Solar traffic signs and parking machines
- Electric vehicles
  - Electric buses
  - Electric trams
  - Electrical ferries
- Local energy storage for heat & power
- Fast lanes for walking & cycling

These technologies work in tandem to create a sustainable and efficient energy system.
By 2050 more than 6 billion people will live in urban areas, most of them in developing and less-developed countries. The number of megacities (with more than 10 million people) is expected to increase from three in 1975 to 29 by 2025. These cities contribute to climate change, and in turn are affected by its consequences. At the same time, urbanization generally leads to increased demand for energy-consuming services such as housing and transport. This trend is further stimulated by increasing average income levels.

For these and other reasons we need a new approach to what cities should do to become more liveable, economically successful, and environmentally responsible: smart cities, that is, energy-efficient, consumer-focused and technology-driven.

This mindset will create opportunities in relation to the development of new efficient urban infrastructures, including cities optimized for economic activity, energy consumption and environmental impacts.

Urban density and the spatial organisation of cities are important parameters for energy consumption especially for transport but also for residential and commercial buildings. The dynamics of urban expansion show that density of cities generally decrease as income goes up. However, analysis shows that lower density is not only affecting energy for transport, but it tends also to pave the way for generally more sustainable cities.

In the context of energy a smart city is a sustainable city focused on low energy use, renewable energy and small carbon footprints. However, only new and emerging cities can become true smart cities. An example is Masdar City in Abu Dhabi, planned as a smart city since its foundation in 2008.

Existing cities, in contrast, will have to adopt compromises between their existing forms and the full potential of true smart cities. In Denmark for example, Copenhagen, founded in 1167, is aiming to become a sustainable and smart city with a strong focus on the energy sector, climate change, and the broader environment.

Energy in smart cities should be highly distributed and self-supplying to a large extent, so as to minimize the need for huge investments in high-capacity transmission lines from distant power plants.

A range of renewable energy technologies modified for installation in cities can meet these requirements. This includes small wind turbines, micro-CHP and heat pumps. Both solar thermal heating (and cooling) and photovoltaics (PV) are modular technologies that can be integrated in residential, public and commercial buildings. The production and use of urban biomass should also be promoted.

Energy networks in smart cities must themselves be smart, with integrated information and communication technologies (ICT) to enable greater energy efficiency and flexibility in energy use. Full integration of energy networks and the smooth running of an energy system supplied mostly from fluctuating renewable energy will require policies and technologies to manage demand response.

The buildings within a smart city are themselves smart, with internal systems featuring a high degree of interoperability thanks to ICT and connections to the smart grid.

People and goods in a smart city will be transported by vehicles running either on electricity produced from renewable energy or on fuel produced from biomass. Public transport should basically be driven by electric technology. Non-fuel-consuming transport such as walking and cycling should be encouraged.

A challenge will be to motivate consumers in smart cities to achieve sustainable development by using available technologies in smart ways. Motivation may be economic, but may also take the form of information, education, regulation, reorganization, or improved services. Smart technical solutions already exist; now they must be made available to consumers and backed up by suitable economic incentives.

Many energy- and ICT-technologies for smart cities are already available, but still needs further R&D to fulfill the needs of the future smart cities. This could be achieved through establishment of broad networks and collaboration between the business sector, research, local governments and other partners. Further, the market pull for these smart solutions will grow during the coming decades in order to reduce the global CO₂ emission, ensure security of supply and give access to modern energy for the poor people in the world’s developing countries.

The Danish research system will in cooperation with the Danish energy- and IT industry be able to undertake the necessary basic research, development, demonstration, market maturation and commercialization.
1. The smart city concept offers a new, sustainable framework for a combination of policy and planning efforts combined with technological innovation with regard to energy supply and the way it is consumed in transport, housing, services and industry.

2. To exploit the full potentials of the smart city concept further research and development of technologies and systems for smart cities should be given high priority.

3. Smart technologies and systems should be tested and implemented individually or collectively on scales from new developments of single-family houses to entire part of towns in order to improve performance and bring down the costs.

4. New cities and new part of towns should be planned and built as smart cities, and the concept should be used as much as possible in future urban planning to address climate change and turn tomorrow’s cities into good habitats with healthy economic growth.

5. By urban development of existing cities the smart city concepts should be implemented in order to utilize and test parts of the smart city concept wherever economical feasible.

6. Large scale test and demonstration projects in new cities as well as in existing cities will strengthen the basis for planning and developing future smart cities, both for large cities and mega cities.

7. The existing and emerging sustainable energy technologies need to be re-engineered for optimal performance in smart cities, a task that Danish energy- and IT industry together with the Danish research system should be encouraged to undertake based on their outstanding competences within these areas.

8. The same is true with regard to the development of smart buildings as active components in smart cities.

9. Smart transportation systems are a prerequisite for development of true smart cities, as economical growth is dependent of high mobility. Hence, individually and coherent transport demonstration projects are strongly needed.

10. The ongoing Danish research, development and demonstration of smart grids should be extended with projects aimed at smart cities.

11. R&D as well as information- and legislation initiatives should be initiated in order to motivate and make it attractive for the consumers to exploit the numerous opportunities in the smart city concept.

12. There is a need for new political framework conditions in order to increase research and development in technologies and systems for smart cities, in order to stimulate green growth in the industries involved and exploit the prosperous opportunities for export of knowledge as well as products.

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