Sustainable Energy Solutions for Smart City

by Ichin Cheng, Director & Co-Founder of Sustainable Innovation Lab and
Professor Martin Charter, Director of The Centre for Sustainable Design (CfSD), UCA
Corresponding author. Email: ichinc@the-si-lab.com, mcharter@ucreative.ac.uk

Abstract
A clean energy transition is now happening. Global renewable energy capacity have now overtaken coal as the world's largest source of installed power after a record-breaking year in which half a million solar panels were installed every day. In the coming years, energy supply and demand will go through a major shift and cities are at the heart the clean energy transition**.** Cities are major hot beds of environmental, social and economic problems but can also be catalysts for the development of new sustainable solutions. Cities are important and in the future are predicted to become even more important. In Europe, a handful of small cities and islands are achieving 100% renewable energy. The key to cities transition to a green and low carbon economy is significant innovation, especially systemic innovation taking account of technical, social, economic and ecological considerations.

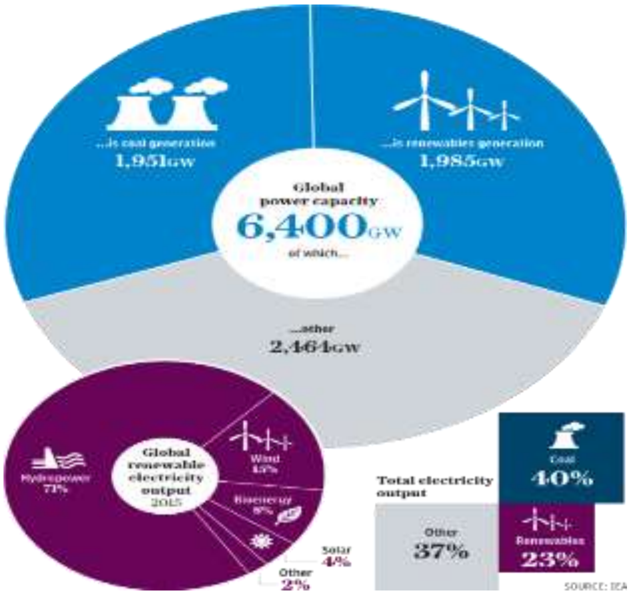
Key words: sustainable innovation, clean energy, smart city, low carbon

1. Introduction: Clean Energy Transition

After the Paris Climate Agreement, the world's clean energy transition is underway. For the first time, the global renewable energy production capacity has overtaken coal as the world's largest source of energy (Figure 1) after a record-breaking year in which half a million solar panels were installed every day.(IEA,2016) This milestone indicates that a clean energy transition is now happening and this trend will continue in next years to come.

Two-thirds of global greenhouse gas (GHG) emissions are currently generated by the energy sector (IEA 2013: 15). The main source of energy-related GHG emissions is fossil fuels, which still account for over 80 percent of global energy consumption (IEA 2013). However IEA report shows 28 % t of global electricity generation is expected to come from clean energy by 2021, in comparison to 23 & in 2015. (IEA 2015)

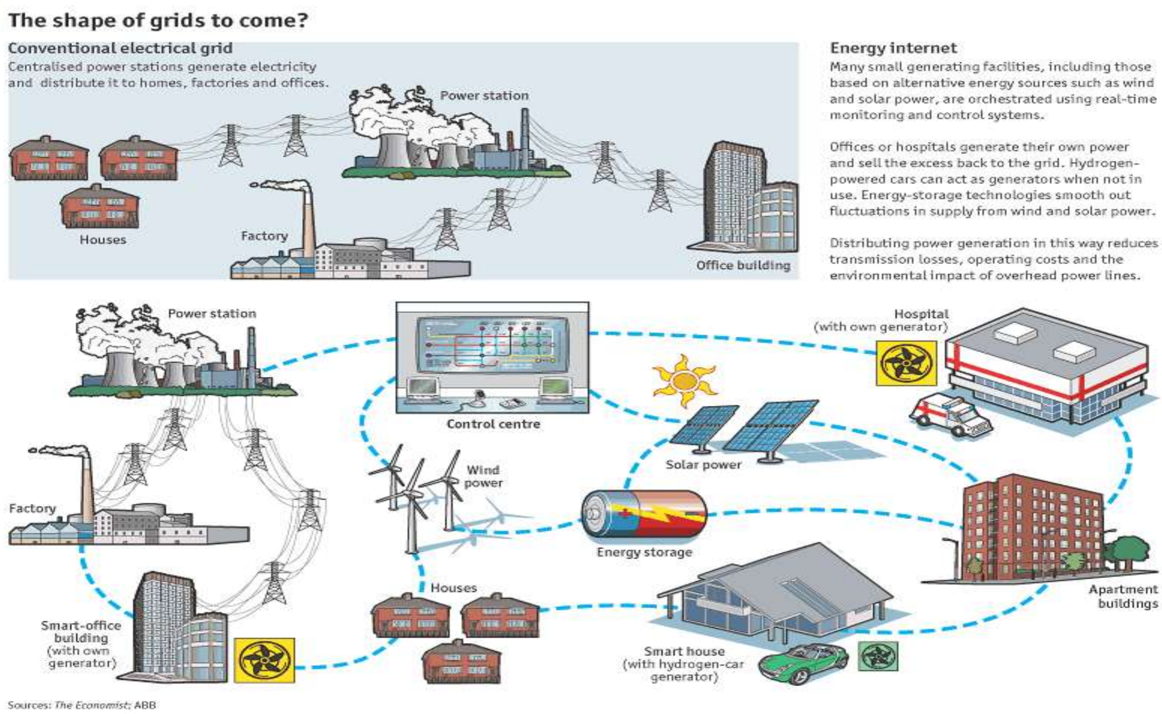
Figure 1: Renewables overtake coal in power



In coming years, energy supply and demand will go through a major shift:

- From coal and fossil fuels to renewable energy and energy efficiency
- From centralised and big energy systems to de-centalised energy systems, the so-called ‘energy internet’ (Figure 2)
- From macro to micro energy systems
- From micro grid and smart grid technology
- From supply-side management to demand-side management by better using smarter technology and improving battery storage technology

Figure 2: Energy internet



2. The Main Drivers of Clean Energy Revolution

2.1 Societies demand cleaner energy

Carbon-based energy sources, including coal, oil, gas, not only are significant causes of pollution and social cost that must be curtailed if the ecosystem is to be saved, but also are based on rapidly depleting resources. Carbon dioxide in the atmosphere is now at its highest level in 650,000 years and increasing by approximately 2 ppm per year. Humanity must undertake a massive move to clean and carbon-neutral energy

Avoiding catastrophic climate change impacts is the main driver for a decarbonised energy system globally. Doubling the share of renewables by 2030 could deliver around half of the emissions reductions needed and, in combination with energy efficiency, keep the rise in average global temperatures within 2 degrees Celsius, the widely recognised target to prevent catastrophic climate change.

Another driver is the avoidance of the negative health impacts from fossil fuel based energy. Around 18 000 people die each day as a result of air pollution. In fact, the number of deaths attributed to air pollution each year – 6.5 million deaths – is, according to the World Health Organization (WHO), much greater than the number from HIV/AIDS, tuberculosis and road injuries combined.

Energy production and use, mostly from unregulated, poorly regulated or inefficient fuel combustion, are the single most important man-made sources of air pollutant emissions: 85% of particulate matter and almost all of the sulphur oxides and nitrogen oxides. These three pollutants are responsible for the most widespread impacts of air pollution.(IEA, 2016)

2 Divesting fossil fuels and invest in clean energy

There are major efforts being driven from civil society and investor communities. In 2014, starting from 350 organisations and US Universities, then spreading to rest of the world on '**Divesting fossil fuels'** movement played a final push of climate change campaigns among NGOs.. By September 2015 Institutions worth $2.6 trillion have now pulled investments out of fossil fuels. A coalition of 2,000 individuals and 400 institutions are shifting assets from coal, oil and gas companies to tackle climate change. UNFCC Climate Chief Christiana Figureue has called for the shift of investment from fossil fuels to meet the $1trillionper annum need for clean energy investment.

> Estimates show that fossil fuel subsidies average USD 400–600 billion annually worldwide while renewable energy (RE) subsidies amount to USD 66 billion in 2010 but are now predicted to significantly rise to USD 250 billion annually by 2035.The International Energy Agency (IEA) estimates that if fossil fuel subsidies are fully eliminated by 2020, global primary energy demand will decrease by 5 percent and CO2 emissions by 5.8 percent. (IEA,2015)

In late 2015,before COP21 in Paris, the world's largest insurance company, Allianz (Allianz managed about €1.8tn ($1.9tn) assets in US, Germany, France, Italy, Britain and the Asia-Pacific region) announced it would decrease investments in companies using coal and boost funding in those focused on wind power in 2015. At the same time, US White House teamed up with Apple, Google, and Microsoft announced USD 140 billion investment in renewable energy. US presidential candidate Hillary Clinton has also committed to a 700% increase in renewable energy investment if she becomes president.

The cost of renewable energy plummets as deployment increases.
Solar photovoltaic (PV) prices have fallen by 80% since 2008 and are expected to keep dropping.

The cost of onshore wind electricity has fallen 18% since 2009, with turbine costs falling nearly 30% since 2008, making it the cheapest source of new electricity in a wide and growing range of markets.

3. Cities are at the heart the clean energy transition

The energy landscape is shaped by major cities. With more than half of global population and about 80% of the world's GDP in 2013, cities account for about two-thirds of primary energy demand and 70% of total energy-related carbon dioxide (CO2) emissions. There is no doubt that a movement to more sustainable cities are central to this energy transition. Our cities can be the cornerstone of the clean energy transition to green economy, supporting resilient societies and inclusive communities with universal access to public services and economic opportunity.

Cities are major hot beds of environmental, social and economic problems but can also be catalysts for the development of new sustainable solutions. Cities are important and in the future are predicted to become even more important: 70% of the global population will be located in cities by 2050 compared to 50% at present (UN World Urbanisation Prospects); at present, 60% of global GDP is from 600 cities (McKinley's); and, as indicated above, cities currently account for 70% of greenhouse gas emissions (UN Habitat). The expanding city populations will mean growing environmental impacts and challenges, as well as, potential opportunities related to the development of more sustainable solutions for energy, water and food production/storage/distribution, transportation, housing and waste (or resource) management. (M Charter, 2014)

Cities drive economic growth but can also drive sustainable change. Ambitious action in urban areas can be instrumental in achieving long term sustainability of the global energy system – including the carbon emission reductions required to meet the climate goals.

In European Union under the EU's 2030 climate policy, a new binding target of 27% of renewables from the total EU energy consumption has been set for 2030 in 2015. Tougher binding renewable energy targets have also been established:.

- a 40% cut in greenhouse gas emissions compared to 1990 levels
- at least a 27% share of renewable energy consumption
- at least 27% energy savings compared with the business-as-usual scenario

The EU has set itself a long-term goal of reducing greenhouse gas emissions by 80-95% when compared to 1990 levels by 2050. A2050 roadmap strategy is in place that includes milestones to achieve this that targets 40% emissions cuts by 2030 and 60% by 2040
Under overall EU binding target and Climate and Energy Package, the EC launched the Covenant of Mayors (CoM) to endorse and support the efforts deployed by local authorities in the implementation of sustainable energy policies. The CoM is the European movement involving local and regional authorities; voluntarily committing to meet and exceed the EU 20 % CO2 reduction objective by 2020 by increasing energy efficiency and through the use of renewable energy sources (RES).[clxxxii] Currently, CoM brings together 7000 local and regional authorities committed to implementing EU climate and energy objectives in their territories. Other initiatives have been launched involving leadership cities and regional government's organizations e.g. C40, R20 or ICLEI.

For example, Güssing, a in South Burgenland, Austria, a town of around 27,000 inhabitants, is the first community in the EU to deliver 100% of its energy demand (electricity, heating/cooling, fuels) – from renewable resources produced within the region.
In 2016, a new 100% renewable energy campaign-- solution project which also provides funding and best practice to communities and cities who aiming for 100% renewable energy across Northern American.

100% renewable energy movement also starts in big city.
In 2015, more than 1000 global mayors signed a declaration that supports a transition to 100% Renewable Energy at the Climate Summit for Local Leaders in Paris COP21. In Europe, a handful of small cities and island have already achieves 100% renewable energy.
In April 2016, Los Angeles City Council members Paul Krekorian and Mike Bonin co-authored legislation for a fast route to 100% clean electricity for California's largest city — and the nation's second-largest city. In 2016, Costa Rica has already powered its electricity grid for over 100 days entirely from renewable energy.
Växjö, a town in Sweden, decided to be fossil fuel free in 1996. The municipality developed a partnership with local firms, industries and transport companies to achieve this goal. They created a policy commitment "Fossil Fuel Free Växjö" to stop using fossil fuels and reduce carbon dioxide (CO^2) emissions in heating, energy, transport, businesses and homes. Växjö's success story is based on the district heating network using heat from a combined heat and power plant, powered by waste wood biomass. Rather than importing energy, the city taps into its local resources, with half of its territory being covered by forest, supplying its citizens with cheap and renewable heat.

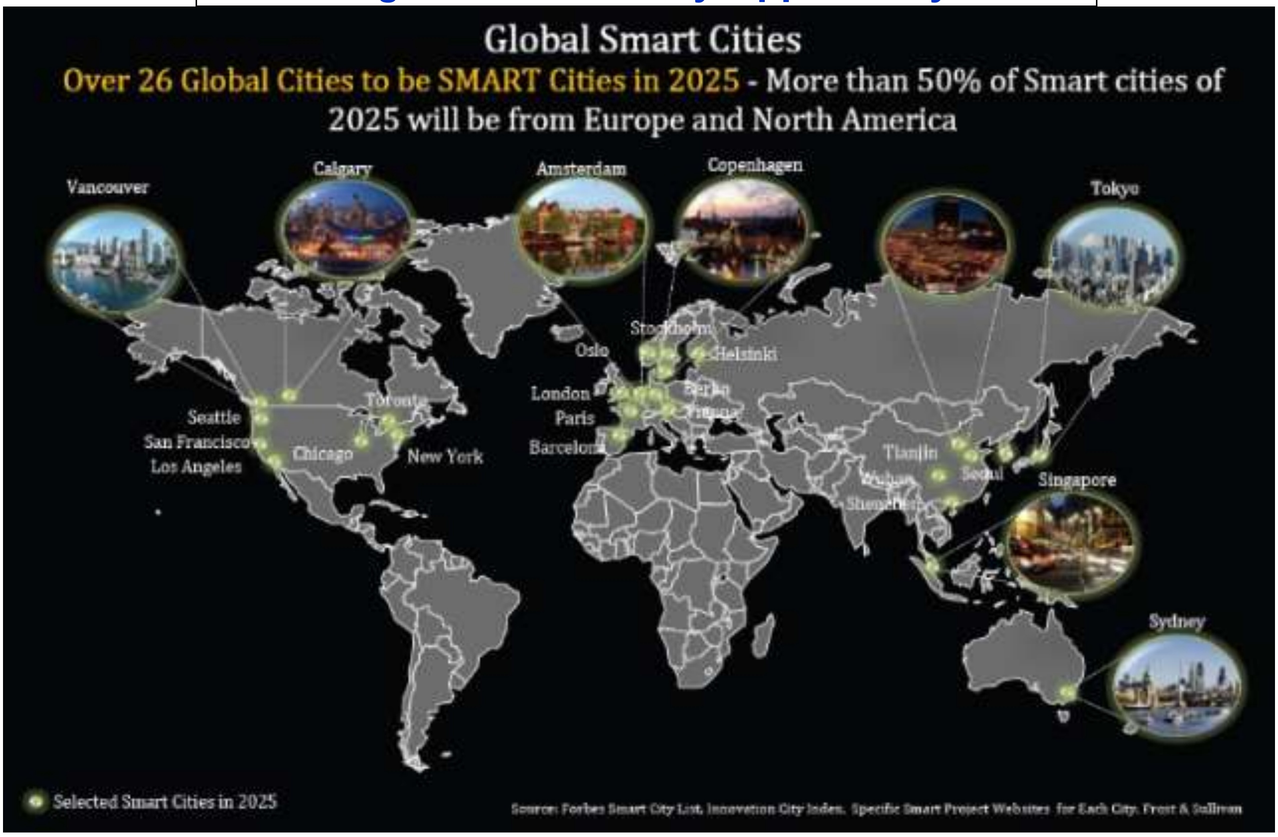
Bornhom island is an island in Denmark that has already achieved 75% renewable energy production. The island is also the location for EC EcoGrid project, the winner of the prestigious EU Sustainable Energy Award 2016 (EUSEW16).The EcoGrid EU offers Smart Grids dissemination and deployment using the distributed electricity grid (DSO). The aim is to contribute to the European 20-20-20 goals by showing that it is possible to operate a distributed power systems with more that 50 % RES using Smart Communication and Smart Market solutions. EcoGrid EU is a large scale demonstration of a complete power system including following:

1) A distributed grid with up to 60 kV; 28,000 costumers; 55 MW peak load; 268 GWh electricity consumption; and 500 GWh heat demand.
2) All distributed RES, including wind power (30 MW), photovoltaic (2 MW), biomass (16 MW), biogas (2 MW), five CHP units and electric vehicles with a total penetration of more that 50 % of the electricity consumption.

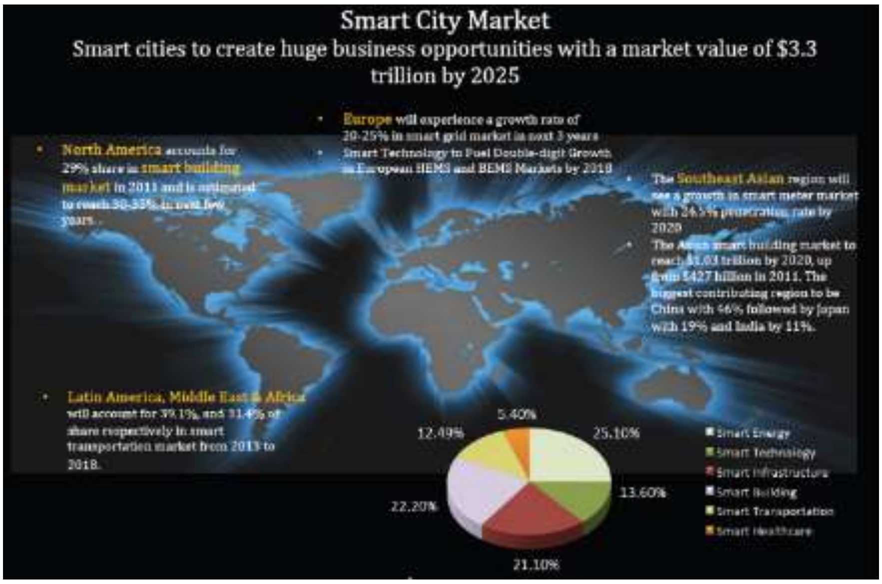
3) Full market participation utilizes all parts of the existing power market, and developing a new near real time market delivery of ancillary services both from RES and DR. Smart House appliances, Smart Meters, E-mobility using electric vehicles are an integrated part of the total concept. Storage of energy demonstrated using heat pumps, district heat systems for Wind to Heat appliances. The batteries of the electric vehicle will be utilized for direct electricity storage.[16]

4. City transition to smarter, cleaner and move innovative

Figure 3: Smart City Opportunity



[16] http://www.eu-ecogrid.net/ecogrid-eu/the-bornholm-test-site, EcoGrid EU is the winner of the prestigious EU Sustainable Energy Award 2016 (EUSEW16).



Cities are also getting smarter. There has been a growing discussion over smart cities and significant interest being expressed in the concept.(Figure 3) Research shows, that ’Smart City’ market is likely to be worth a cumulative USD 3.3 trillion by 2025.[17](Frost & Sullivan, 2014)

However, are smart cities purely large scale strategic experiments created by a small number of transnational corporations rather than being real catalysts for smarter, more sustainable urban regeneration?

At present much of the smart city development is being driven by a few key players such as IBM, Cisco, Schneider and Siemens in cooperation with a number of major cities. For example, Songdo in Korea, is a smart city that has been built from scratch in partnership with companies including Cisco. To develop smarter, more sustainable cities will require partnerships between a range of stakeholders including government, business, finance and civil society. Smart city, smart grid and and ‘big data’ discussions should dovetail and a key part of the focus should be on how we establish secure and effective systems to collect, analyse and present environmental, social and economic data to enable improved decision-making. The ‘Internet of Things’ (the network of physical objects accessed through the Internet) linking up data from vehicles, buildings, smart meters, lighting systems, etc will expand the available pool of ‘big data’. For example, in a number of cities e.g. Barcelona, major networks of sensors have been installed throughout the city to monitor, for example, recycling rates and levels of air pollution.

Smart cities are a techno-centric concept and a key issue will be how we move beyond technological discussions to explore how civil society and citizens can engage and involve themselves in the process of making cities smarter, more sustainable and importantly, livable. The key to the transition to a green and low carbon economy is significant innovation, especially systemic innovation that integrates technical, social, economic and ecological factors. The share of renewables needs to grow not only in power generation but also in transport, heating and cooling. (FigureFigure 4.1)The transition requires massive changes in the energy system, and the 2 Degree Scenario (2DS) highlights targeted measures needed to deploy low-carbon technologies so as to achieve a cost-effective transition. Urban energy systems provide significant opportunities for increased efficiency in delivering transport and building services. (Figure 5)

In the 2DS, final energy demand in the urban buildings and transport sectors in 2050 is reduced by 60% compared with the 6 Degree Scenario (6DS). These energy savings can be realised

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[17] Strategic Opportunity Analysis of the Global Smart City Market, : Frost & Sullivan,2014, http://www.egr.msu.edu/~aesc310-web/resources/SmartCities/Smart%20City%20Market%20Report%202.pdf

through the avoided "need" for a portion of energy end-use services (e.g. reduced length and frequency of trips in compact cities) and more energy-efficient options to meet the same level of service demand, as in the case of the modal shift from personal cars to public transport, walking and cycling. Energy savings and lower-carbon fuels in urban buildings and transport can lead to direct and indirect (i.e. avoided generation of electricity and heat) carbon emission reductions of about 8 Gt by 2050 in the 2DS (relative to the level achieved in the 6DS) – which is equivalent to almost two-thirds of the total emissions reduction for these two sectors and to about 40% of the total for all end-use sectors. Key to a significant portion of this urban sustainable energy potential is increased electrification in end uses (electricity is the largest urban energy carrier in the 2DS by 2050), such as through heat pumps and electric vehicles, coupled with a decarbonised power sector. (IEA, 2016)

Figure 4 Transition Cities *

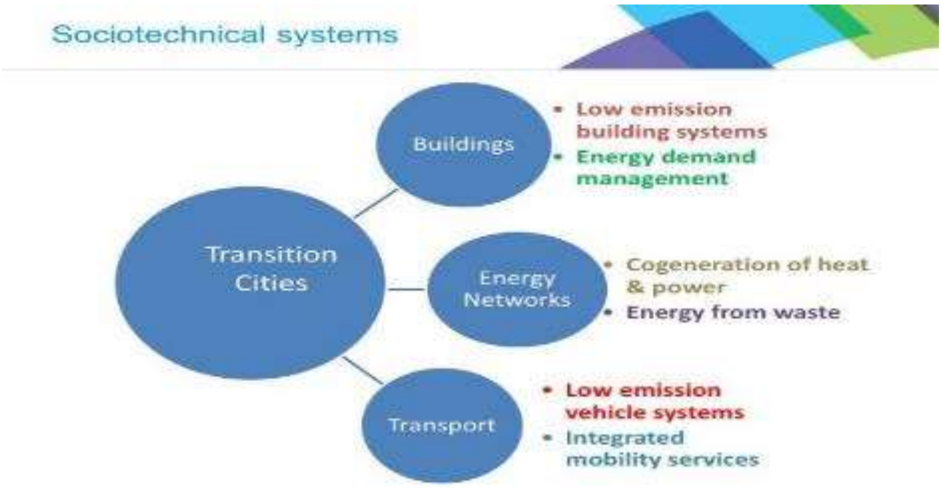
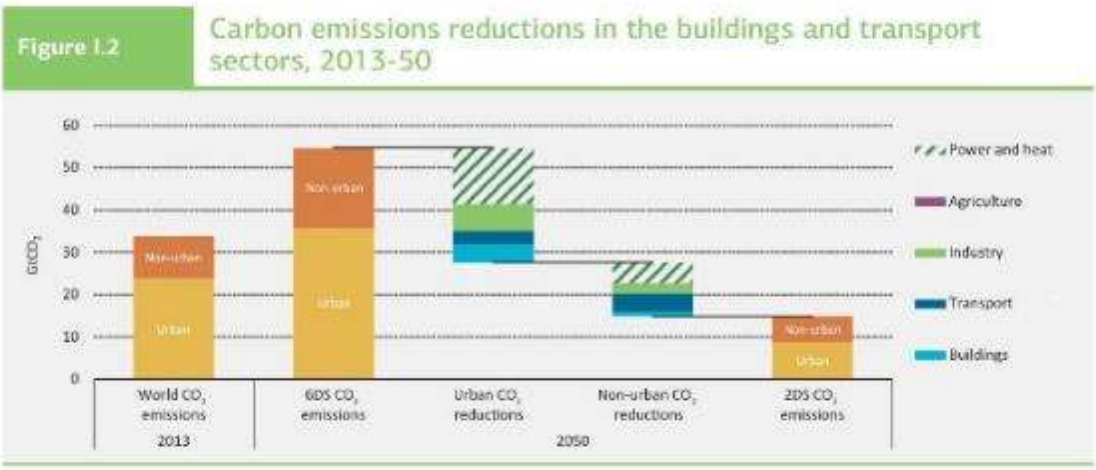


Figure 5 Urban buildings and transport play an important role for sustainable energy transition



Source: IEA, 2016

4.1 Innovation in the building sector

There are some great examples of new technologies and innovations emerging for better demand side management, including zero energy or energy positive new building design.

In UK, the Pines Calyx claims to have developed abeyond zero carbon building/energy positive building. This system was designed to enable the building to move beyond 'carbon neutral', enabling the Pines Calyx to become the first conference venue in Europe to have a negative carbon footprint in operation.(Figure 6)

Heralded as Australia's "first carbon-positive prefab home," the Carbon Positive House is a solar panel-topped house that produces more energy than it consumes. Designed by ArchiBlox, the airtight 800-square-foot house takes in significant amounts of natural light through a double-glazed facade and is topped by a green roof and vertical garden walls for insulation and shade. The interior is decked out in sustainably sourced, energy efficient and non-toxic materials and fixtures.(Figure 7)

Figure 6 The Pines Calyx

Figure 7 Heralded

The Heliotrope is a stunning energy-plus solar home in Freiburg, Germany that rotates 180 degrees to follow the sun's path and maximize solar panel efficiency. A 6.6 kWH rooftop solar array helps the home achieve plus-energy status, while solar thermal tubing heats the home's water and radiators. Designed by architect Ralph Disch, the rotating home can generate up to five times the energy than it consumes. [18]

About 80% of the buildings in use today could still be in use 40 years from now. So to reduce the immense energy consumed by buildings, it is imperative to do something with the existing ones.

By optimizing and combining existing technologies in new ways, an ordinary office building from the 1980s at Kjørbo in Sandvika could produce more energy than it uses. This is the first time a building will be renovated in this way in Norway, and the method can be easily applied to other office buildings.[19]

Innovation is also happen on new type of smart grid and energy management. Today's virtual power plants already transmit their electricity from software-bundled, distributed power generating facilities to the energy markets. But a cost-effective, mass-market solution for RE integrating production, consumption and storage units does not yet exist. In late 2015, Siemens and RWE are tackling this challenge with the RWE Smartpool project, in which they are jointly building the next generation of an IT system for connecting a large number of distributed energy resources. In doing so, they are bundling distributed energy resources on a future-oriented technology platform.[20]

4.2 Innovation in mobility

Cities are the main drivers of global mobility demand as a result of direct passenger transport activity within and among urban areas, as well as indirectly through freight activity needed to

[18] http://inhabitat.com/8-homes-that-generate-more-energy-than-they-consume/

[19] http://www.powerhouse.no/en/aktuelt/great-potential-for-energy-positive-office-buildings/

[20] http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2015/energymanagement/pr2015110068emen.htm&content[]=EM

meet the demand for goods of city residents. Urban transport activities accounted for about 40% of total transport energy use and total well-to-wheel greenhouse gas emissions in 2013. (IEA,2016)

Some European cities provide public transportation combined with electrical vehicles. For example, in Geneva, Switzerland capital use many ways to encourages people use public transportation for tourists and Zermatt is car free since 1966. The German city of Hamburg has announced plans to become car-free in the city center within the next two decades.
The Netherlands built the world's first solar road – an energy-harvesting bike path paved with glass-coated solar panels in 2014. The French government has announced that it wants to pave 1,000 Km (621 miles) of road with solar panels over the next five years. Once the project is completed, the new roadways will be able to supply electricity to 5 million people, or about 8% of the French population.
Different future public transportation and non-fossil based mobility systems have been explored recently.(see Figure8)Some of new clean transportation system could be operating within 5-10 years.
Electric cars are the main force to drive the innovation. 2015 saw the global threshold of 1 million electric cars on the road exceeded, closing at 1.26 million. This is a symbolic achievement highlighting significant efforts deployed jointly by governments and industry over the past ten years. In 2014, only about half of today's electric car stock existed.

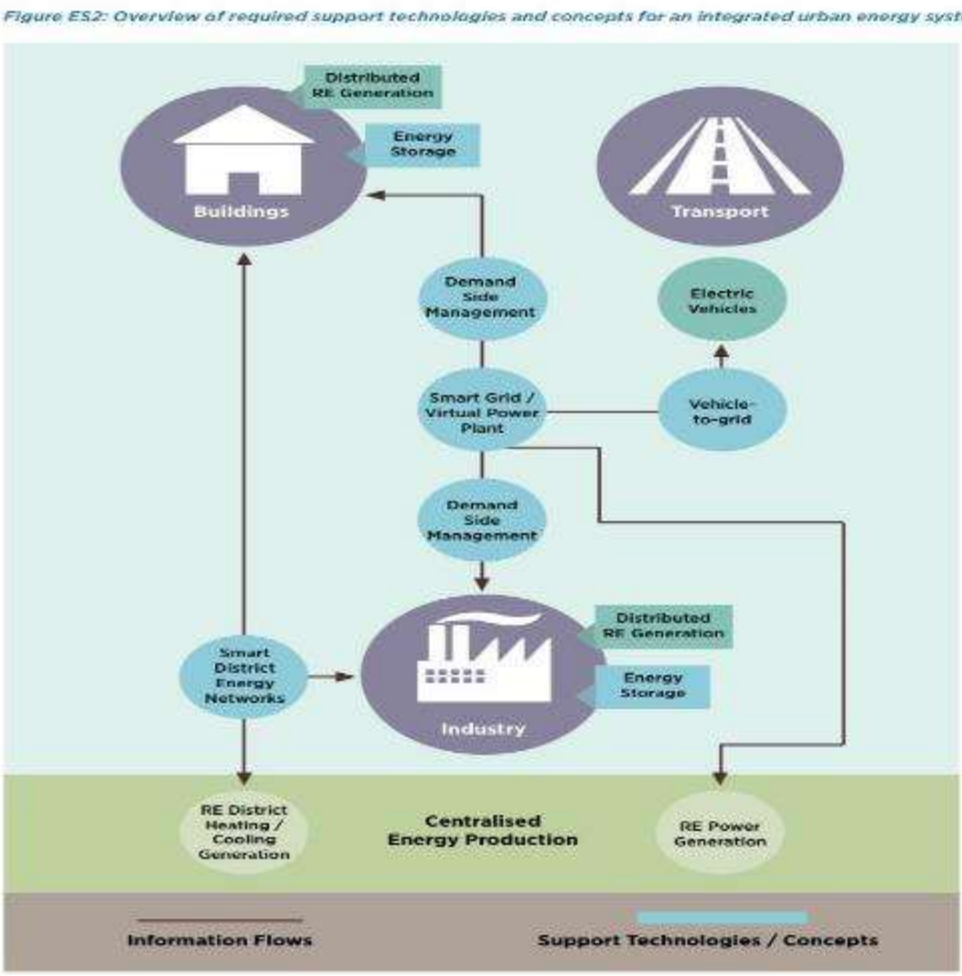
Figure 8 Future city concept

In 2015, the UK started the world first trial in-road wireless charging tech for electric vehicles .Highways England has announced that it plans to carry out off-road (test track) trials with a view to carrying out subsequent on-road trials of the technology in 2015.(Figure 9)

Figure 9 wireless charging tech for electric vehicles Figure 10 Tesla glass solar roof tiles and EV charging system

Entrepreneur Elon Musk, CEO, Tesla is driving a path to technological innovation in clean mobility, renewable energy and building by providing integrated urban clean energy system. (Figure 10 & Figure 11) Musk hit global news with his new solar roof - -glass solar roof tiles and electric vehicle (EV) charging system illustrating the benefits of combining his electric car and battery producers with the solar installer SolarCity Corp. The entrepreneur has launched solar-powered roof tiles that eliminate the need for traditional panels and a longer-lasting home battery, which Tesla calls the Powerwall, aimed at realizing his vision of selling a fossil fuel free lifestyle to consumers. Powerwall is a home battery that charges using electricity generated from solar panels, or when utility rates are low, and powers the home in the evening.

Figure 11 Overview of required support technologies for an integrated urban energy system



4.3 Systemic Innovation

Energy from waste is part of the energy network (see Figure 4) of city's low carbon transition process. Cities are large producers of waste. Depending on the city context, availability of infrastructure and the regulatory framework, waste can take different routes: it can be sorted, recycled and reused, combusted for recovery of energy, or landfilled. There is potential to use more waste for energy .

The sustainable use of energy in cities involves creative thinking, and finding synergies not available during the fossil fuel era. This means going beyond the energy sector, and including other important areas of operation In UK , a Bio Bean, a start-up company was set up by24 year old Arthur Kay when he was studying architecture at UCL in 2012. He was tasked with a project looking at closed loop waste-to-energy systems for buildings and he happened to choose a coffee shop. He then discovered the oil content in coffee and the sheer amount of waste produced e.g. 200,000 tones a year in London. He puts 3 different technologies together and start to produce bio oil from coffee waste. According to Bio Bean, every ton of waste coffee could power the car drive from London to Beijing and return, save 6.8 tone CO2.
More radical thinking could also help solve waste, water, energy problems in cities. For example, algae power cell that harnesses electrical energy from the photosynthesis and respiration of algae has been developed by researchers from Concordia University in Quebec, Canada. The power cell uses cyanobacteria, blue-green algae that are able to survive across a broad range of conditions and locations found on Earth.

In US, a California scientist Dr Jonathan Trent is leading Global OMEGA Initiative-- "**O**ffshore Membrane **E**nclosures for **G**rowing **A**lgae". OMEGA began as a NASA and California Energy Agency fund $10.8 million 'Advanced Life Support' research project to grow algae for biofuels and evolved into an ecosystem of technologies that generate sustainable energy, turn wastewater into drinking water, and provide food without using land.
OMEGA combines and optimizes new and emerging technologies for energy production, wastewater purification, and aquaculture. In protected ocean bays, OMEGA's floating platforms are covered with water-cooled solar panels that produce electricity and heat. The electricity runs pumps that circulate nitrogen- and phosphorus-rich wastewater through a network of clear, flexible, plastic tubes to grow oil-rich algae, which are harvested and processed into biofuels. In addition to making all-important liquid biofuels, the algae capture CO2 that would otherwise be in the atmosphere as a greenhouse gas. And they remove nutrients and contaminants from the wastewater as a first step in a unique OMEGA process that turns wastewater into drinkable water—at a fraction of the cost of standard desalination technologies[21]. (Figure 12)

Figure 12 OMEGA project: an integrated waste-water treatment, food, energy system

[21] http://omegaglobal.org/

Figure 13 Future city vision 2020

1. Conclusion: City action on sustainable energy transition

The world is a very different place, in many senses, compared to 5-10 years ago. Change is the constant and predicting the future is an increasingly difficult exercise. However, it is likely that cities will become significantly more important and powerful globally. Cites that generate their power from 100% renewable energy are starting from a vision to become a potential reality.

But will cities become smarter, more sustainable and liveable? As we see more urbanisation, what will this process mean outside of cities, in regions, in provinces, in towns and rural areas? The process is likely to mean that knowledge, finance and other resources may get more concentrated in major cities. Cities may increasingly be designed to be the 'hubs of innovation'

The Paris Agreement was a milestone for implementation. For the first time, non-state actors were invited to be an intrinsic part of the process. Not only were public energy stakeholders included in the process but non-governmental organisations (NGOs), the private sector and regional and local entities. Cities were among the front runners, with their strong role in the lead-up to COP21 through the Lima-Paris Action Agenda as well their support for the Paris Pledge for Action. The need to accelerate low-carbon technology innovation has also received significant attention in international fora, with the newly created Mission Innovation and the Breakthrough Energy Coalition aimed at catalysing investments in transformational technologies to accelerate decarbonisation. (IEA, 2016)

Many cities need to start build up their clean future from big and board vision. (Figure 13) leaders want to be winners and may have a vision or may need help in constructing it, but will need courage to make decisions that enable radical change, if they want to be re-elected. The city of Palo Alto has set audacious CO2 reduction goals and is establishing an open, ‘green’ learning and innovation culture to enable this. For example, the city is has recently re-engineered bureaucratic processes to cut the authorization period for solar photovoltaic permits from notionally 1 year to 1 day. Change will require new thinking and re-thinking. This is illustrated by the City of Copenhagen move to a culture of saying ‘yes’ rather than ‘no’.

Developing countries’ urbanization processes hold the key of the future of our planet.
The way new cities in emerging economies are going to be built is crucial, especially in Asia (e.g. China and India. For example, in China, there are more than 140 cities with more than 1 million people and 103 cities with 1-3 million populations today. 10 mega cities have more than 10 million people in 2012 and by 2020, more than 60% Chinese people will live in cities
To avoid a lock-in with unsustainable energy systems, investments must grow immediately and must almost double to USD 500 billion annually between now and 2020, IRENA’s analysis shows.

There are five actions for a sustainable energy future in the cities and communities across the world:

1. Strengthen the policy commitment to renewable energy. Commitment from the top- down and commitment from bottom-up
2. Mobilise investments in renewable energy.
3. Build institutional, technical and human capacity to support renewable energy deployment
4. Harness the cross-cutting impact of renewable energy on sustainable development
5. Enhance regional engagement and international cooperation on renewable energy development.(IRENA, 201

References

- IEA, World Energy Outlook Special Report 2016: Energy and Air Pollution, 2016
- IEA, World Energy Outlook, 2015,2016
- IEA, Energy Technology Perspectives 2016: Towards Sustainable Urban Energy Systems
- Martin Charter 2014, Cities as Drivers for Sustainable Innovation, Sustainable Innovation Conference 2014
- IRENA report, 2015
- Strategic Opportunity Analysis of the Global Smart City Market, : Frost & Sullivan,2014, http://www.egr.msu.edu/~aesc310-web/resources/SmartCities/Smart%20City%20Market%20Report%202.pdf
- Strategic Opportunity Analysis of the Global Smart City Market, : Frost & Sullivan,2014, http://www.egr.msu.edu/~aesc310-web/resources/SmartCities/Smart%20City%20Market%20Report%202.pdf
- http://www.covenantofmayors.eu/index_en.html
- EC ECO GRID, http://www.eu-ecogrid.net/images/Documents/EcoGrid%20EU%20-%20Guide%20to%20the%20large-scale%20project.pdf