Integrating the many sources of renewable energy into urban electricity networks:

the point of view of an operator about smart grids

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The unending search for energy

- Sea is the new frontier to get the energy we need. The solutions to solve our energy problems partly lie in the sea.
- The 20th century was the century of oil. The 21st will probably be the one of hybrids: hybrid energy sources, hybrid roles of utility subscribers - being either energy consumer or producer.
- However, it is not sufficient to reinvent sources of energy to ensure sustainable growth and cities. We must also reinvent electricity networks.
- We are entering into a new energy transition. Will we manage successfully all these hybrids and these new grids?

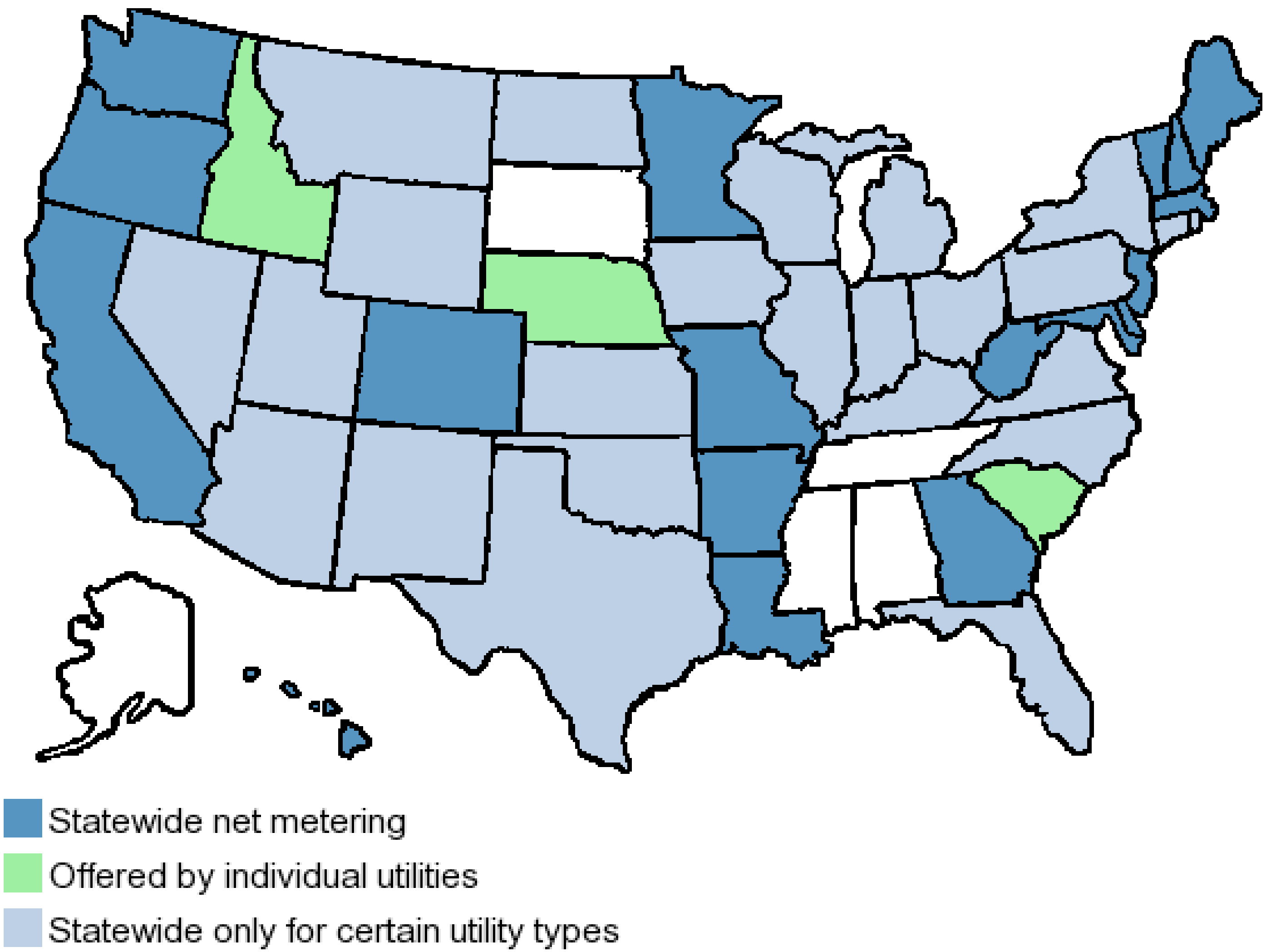
Bringing electricity grids from the 20th to the 21rst century

- Most of the major PECC countries have launched smart grids' projects:
  - US: the most dynamic and advanced market for smart grids (e.g. the Southern California Edison's smart metering program);
  - South Korea: it has been testing smart grids since 2009.
    - ➜ The Jeju island pilot's project includes 168 companies and 6,000 households;
    - ➜ Kepco, the national electricity utility of South Korea, is planning to invest in smart grids > 6 billion $ before 2030;
  - Australia, in the frame of its clean energy initiative;
  - Canada: on-going project to implement 4.5 million smart meters.
- Project of smart meters and/or smart grids are emerging elsewhere:
  - EU: obligation to equip 100 % of subscribers with smart meters in 2022 ;
  - India: aiming at making national grid larger (to serve all people) and smarter at the same time.

State Net Metering Programs in the United States

Net metering programs credit customers for electricity exports to the grid.

Customers only pay the provider for the difference between the electricity they consumed and the one they produced.



Source: Pew Center on Climate Change (2010)

Part I – Change in energy, change in power grid

What are the shortcomings of classical grids ?

- Line losses amount to 7% to 16% of the power produced.
- Current grids do not support the massive deployment of many decentralized sources of power production.
- Existing transmission grids are not designed to accomodate renewable energy sources (intermittent and low production capacity) and the needs of an evermore technoglogy advanced society.
  - The American grid was designed more than half a century ago.
  - The increase of intermittent energy sources (over 20% to 30% of the energy mix) makes the grid more **unstable**. Wind turbine systems in particular cause disruptions when they stop operating because of too-heavy winds and disconnect from the grid.
- Power failures. This global phenomenon is mainly due to saturation of networks undersized in relation to demand.
  - Many American and Asian cities are suffering outages;
  - The biggest failure occurred in Indonesia and affected ~ 100 million people;
  - Wind turbines were blamed for the November 4, 2006 blackout in Europe (they accounted for 40% of German production at the time of the incident).

Integrating a mosaïc of energy sources

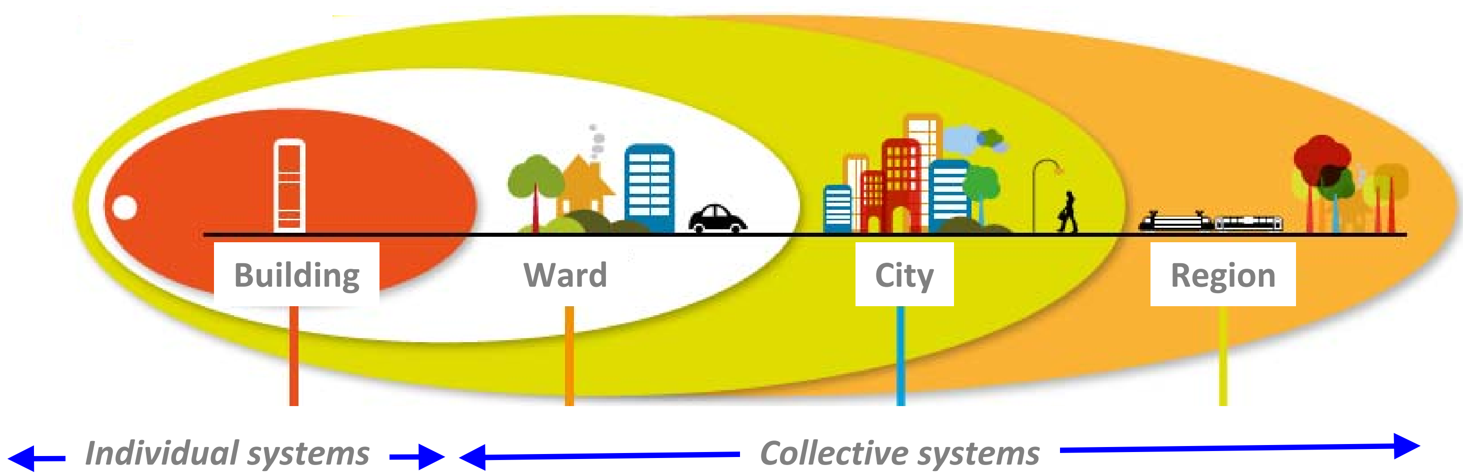
- Users will be more and more producers of power for their own needs, by means of micro wind turbines, photovoltaic solar panels... They will resell their surplus production or their voluntary reduced consumption to the utility.
- New grids should easily combine:
  - predictable and unpredictable sources of energy;
  - power generators with opposite capacity production: from domestic solar panel to nuclear central…;
- We need an « *energy web* » capable to absorb all kinds of energy and to redistribute them according to the needs.
  - This implies that the grid's architecture of the future should be more flexible and modular.
- In the US, Japan or France, the former challenge was to integrate nuclear very high capacity production plant into the power grid. Today it is to integrate many intermittent, low capacity and scattered sources of production into the grid.
- In order to optimise this multi-source/multi-use network, a smart management system has to be implemented.

Moving to a « one-way grid » to a « multi-way grid »

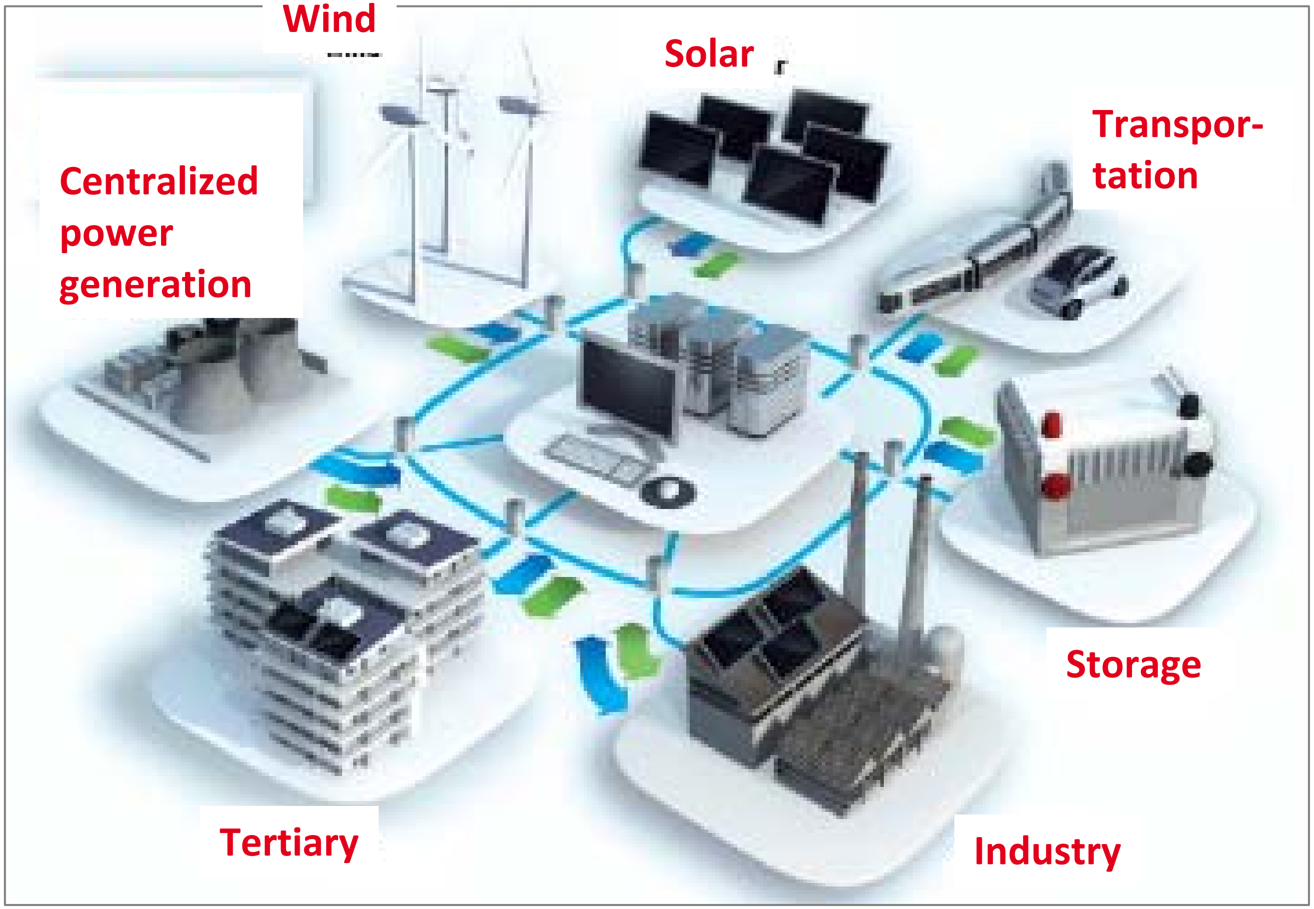
- A smart grid is a revolution which transforms both side of networks - electricity production and electricity consumption - and also the system itself.
- A smart grid is a communicating grid. Its components are linked not just physically, by electric lines, but also virtually through meters and communicating devices. The physical power grid is paired with a communication network.
- A smart grid uses the latest ICTs to collect and manage real-time production and consumption. By providing access to information, it makes the interactivity between end users and the grid possible.
- A smart grid is a tool for better controlling demand and managing peak periods, through voluntary consumption reduction.
  - The offloading policy has already been successfully applied:
    - California has set up offloads mechanisms for energy suppliers. It is cheaper for them to encourage their customers to save energy that to build new power production plant;
    - However, this approach is effective because the price of kWh is higher in California;
  - According to IEA, smart grids could avoid the world to increase power production by 13% to 24% to satisfy needs during peak periods and avoid to reject 2 Gigatons of CO_2 per year.

What is also at stakes with smart grids ?

- The deployment of electric vehicles: this move will sharply boost demand for power.
  - Electric vehicles will impose constraints on grids and affect the economic equation. The main risk will involve recharging points at the end of the day. Smart charging technology and recharging batteries at night should prevent spikes in demand.
  - But electric vehicles are also a potential opportunity. The batteries of the millions of electric cars can be used to store electricity when they are inactive, and provide energy back to the grid to be used by other consumers.
- The search of an optimum between individual and collective solutions
  - Cities want to capture the many sources of energy gushing in their midst rather than ignore them as they did in the past. But once captured their internal sources of energy, they have to integrate them into the power grid without destabilizing it.
  - Thus a key issue related to smart grids consists in finding the optimal balance between collective systems and area-specific solutions, which are often individual ones.



Part II – The emergence of a new function in the energy business



A new professional capacity to be fullfilled, that of « energy aggregator »

- An aggregator is an intermediary between the power system and users.
  - It manages energy distribution based on the electricity generated and consumed, acting like **a virtual power plant.**
  - It help balancing the grid in real time.
- This improved control of electricity flows allows to anticipate peak consumption periods:
  - by offloading some devices connected to the smart grid in order **to artificially create additional capacity;**
  - by starting backup generators available at other sites.
- This will smooth out the peaks and make the grid more effective, as well as ensuring that large peak-load power stations - which emit huge quantities of GHG - are switched on later or not at all.
- Aggregators generate **local flexibility** and create value for them and their clients by selling that flexibility to the power system.

Electric vehicle plugged into a recharging point

Power storage: a major cog in smart grids, an essential piece of the puzzle for adding flexibility

- The power sector is one of the few industries that has no systematic storage system! In the US, 2.5 % of electricity produced is stored; in Japan 15%. This means **power production must constantly equal consumption**. The grid operator is responsible for keeping the two in balance.
- To better regulate distribution and stabilize the grid, operators need to store electricity during off-peak periods and to use buffer stocks when the demand increases or when the source stops generating electricity (e.g. at night for solar technology).
- Yet efficient solutions have been developed that are good enough to be deployed:
  - Households: high-temperature batteries, hot water stored in tanks ;
  - Buildings: photovoltaic panels, cold water stored into air-conditioning systems…;
  - Communities: dams and water towers, since water is a wonderful way to store energy.
- Now it's time to organize the storage system on a larger scale. However, breakthroughs are still needed in decentralized storage technologies:
  - to optimize charge and discharge cycles;
  - to reduce the cost of batteries;
  - to better understand how storage devices age.

With smart grids, we observe a redefinition of the energy business

- The business of our Energy Division is optimizing energy use alongside its customers. Our skills and expertise make the aggregator field a natural fit for a us. However, this is a new field that requires R&D.
- Smart grids are a new frontier for energy operators. To function in their roles, aggregators need:
  - to make the sites they manage "*intelligent*";
  - to analyze energy consumer profiles;
  - to write software to model the consumers' reactions to various situations (eg: buildings, which turn to be micro-generator);
  - to have information systems that can forecast the grid's future situation and leverage the availability of power created;
  - to produce GHG emissions data and climate data;
- There is a need for a professional management of smart grids:
  - If poorly designed or poorly managed, an electricity network may become an energy guzzler. When properly operated, it saves energy.
  - No matter how much R&D you do, it will amount to nothing if the technologies invented are not used in a professional manner.

Part III – Our Reflexe project

Réflexe is short for "Réponse de flexibilité électrique".

There are a great many operational obstacles to overcome, when we are to generalize smart grids

Technical obstacles:

- Disparity of technical equipments already installed;
- Designing sensors capable to collect data on the energy consumption of all buildings, shutdown devices, protection systems, etc;
- Information management systems. Processing billions pieces of data in real time requires:
    - communication standards and interfaces capable to transfer all these data between the grid's different components;
    - Adapted software for processing the data.
- Stabilizing the grid, which is a major issue;

Socio-economic obstacles:

- The price of smart meters (if totally born by consumers);
- The abundance and complexity of data provided, which generates a reluctance to use it;
- Uncertainties about the consumers' willingness to accept offloads during peak periods;
- Few large size experiences of market mechanisms to pay or credit consumers for offloads.

Réflexe, France's first smart grid

- A project selected as one of the country « *investments for the future* ».
- It was given the green light on December 2010, by Prime Minister.
- Reflexe is a smart grid project managed by engineers at Veolia and supported by specialists at Alstom, Sagemcom, CEA-INES and Supelec.
- This three-and-half year project aims to demonstrate the practical and financial feasibility of smart grids.
- Located near Nice, it connects some 20 sites, including offices, shops, a wastewater treatment plant, hotels and a solar power station.
- The project is implemented in 2 phases:

1) Taking a census of **all** the installations connected to the grid, such as air conditioning and lighting systems. They will then be fitted with meters and communication technology to monitor their energy consumption and identify any spare capacity;

2) Operation of the grid. The smart grid will be controlled by an aggregator to optimize total consumption. This phase will begin in 2012 and will last for over 2 years.

Réflexe gives a glimpse of the decentralized, interactive and flexible power grid of the future

- This smart grid demonstration project has several purposes:
  - to experiment with connecting intermittent renewable energy to the grid;
  - to act as a test bed for consumer technology;
  - to develop business models for smart grids. We're not yet totally sure where value will be created and which link in the chain should benefit from it: energy supplier, distributor, aggregator or consumer.
- In Reflexe, the aggregator will monitor the smart grid's energy consumption, generation and storage.
  - When demand is high, it may turn down the lighting, heating or air conditioning in buildings it manages without affecting users' comfort, or use energy stored during off-peak periods;
  - In peak periods, Réflexe will provide at least 1 MWh of added capacity to help smooth peak usage in the region;
  - The aggregator will control equipments connected to the Réflexe grid, such as turbines powered by Nice water supply network. This will create complementary power capacity by creating reserves of water upstream of the turbines which can then be released to produce electricity on demand.

– Part IV –
New economic models and new relations to customers induced by smart grids

The main features of the new economical models for electricity

- Electricity economic models of the future will be local models, blending local resources with local uses.
  - When we thought over energy, we thought over large capacity production units. It is no more true today.
  - The 20th century saw the triumph of large power infrastructures. The 21st century will see a proliferation of small equipments decentralized at local level.
  - Since energy sources will be located close to the needs, there will be less need to build high-voltage lines to transport electricity over long distances.
- A give and take relationship between network operator and consumers is emerging:
  - Smart grids induce deep changes in state-market relations and in utilities-subscribers relations;
  - The million urban energy consumers will become temporary producers;
  - Smarts grids are going to transform both the meter and the bill.
- The respective importance of electricity production and consumption will be reversed in tomorrow's economic models.
  - Managing demand will be the priority, supplanting the policies of endless expansion of production that have dominated in the past.
  - Major challenges rely in small daily decisions made by every people. Smart grids will help them choose the right behavior and save energy.

Inventing new frameworks and economic models

- Eco-efficiciency relies both on the quality of equipments and the behavior of consumers. Besides technological innovations, we also need to think about the socioeconomic and organizational framework in which smart grids can be set up.
- Outlets are already existing, which is a key point. The issue is yet the economical signals given to domestic users to produce, consume and invest: it should be clear enough and easily understandable.
  - The incentive to encourage customer investments in renewable forms of on-site power generation should be significant;
  - The incentive for consumers to accept to reduce their energy consumption during peak period should also be significant.
- Economic models should split gains between consumers and the service operator, to encourage the 1rst ones to reduce their consumption during peak periods
- Public authorities, energy utilities and aggregators have:
  - to create new economic models that are flexible enough to leverage the full potential of local power production;
  - to identify the factors likely to make households behave as if they are stakeholders in the system, notably in terms of controlling their energy use.

Bringing more intelligence into electricity networks and economic circuits

- Smart grids make it possible to generalize the shift from a volume-based economy to one based on "*non-volumes*" that remunerates energy resources saved.
- The underlying economic logic here is to encourage some clients to make energy savings - via a specific remuneration system - and then to use the energy saved to supply other clients.
- Many of the renewable energies and smart grids won't develop up to their promising potential without establishing appropriate pricing policies:
  - Too often, renewable energies and smart grids turned out too expensive because of competition from undervalued conventional sources (eg: coal in China). It makes the bankability of some smart grids project low;
  - For some renewable energies and smart grids projects, an economic model independent of subvention is still a work in progress.

Conclusion

Smart grids are a path to cleaner electricity and a step toward smart cities

- We are at the very beginning of smart grids. Progress in this area are still necessary to "*tame*" renewable energies and benefit from all their promising potential.

- Smart grids will create a breakthrough in electricity sector, equivalent to the one created by the Web in the telecomunication sector.

- « *For smart grids to be really useful, they must be '' smart'' across national borders as well as as across borders within different juridictions within a country. […] Grid technology must be coordinated and to a large extent be interchangeable* ».

- Smart grids are a component of the city of tomorrow. This city will be a more connected, more informed and more intelligent city.

Source: Living cities. Transforming APEC cities into models of sustainability by 2030. Kimberly Gray, Douglas Farr, David Dana - 2011

Thank you for your attention