Integrating renewable energies into electricity networks and boosting cooperation between stakeholders

VEOLIA

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– Part I –

It is not sufficient to reinvent sources of energy.

We must also reinvent electricity networks.

Integrating a mosaïc of energy sources into the grid

- The trend towards diverse energy mixes has significant impact on grids. New grids should combine i) predictable and unpredictable sources of energy; ii) power generators with opposite capacity production (from domestic solar panel to nuclear central).
- Current grids don't support the massive deployment of many decentralized sources of power production. They are not designed to accomodate renewable energy sources.
  - ➔The increase of intermittent energy sources (> 20% of the energy mix) makes the grid **unstable**
  - ➔Wind turbines cause disruptions when they stop operating because of too-heavy winds and disconnect from the grid. They were blamed for the November 4, 2006 blackout in Europe (they accounted for 40% of German production at the time of the incident). 45 million people suffered from this power outage.
- We need an *energy web* capable to absorb all kinds of energy and to redistribute them according to the needs.
- In the US or Japan, 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.

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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 ITs 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 grids is a tool** for better controlling demand and managing peak periods, through voluntary consumption reduction.

➔The offloading policy has already been successfully applied:

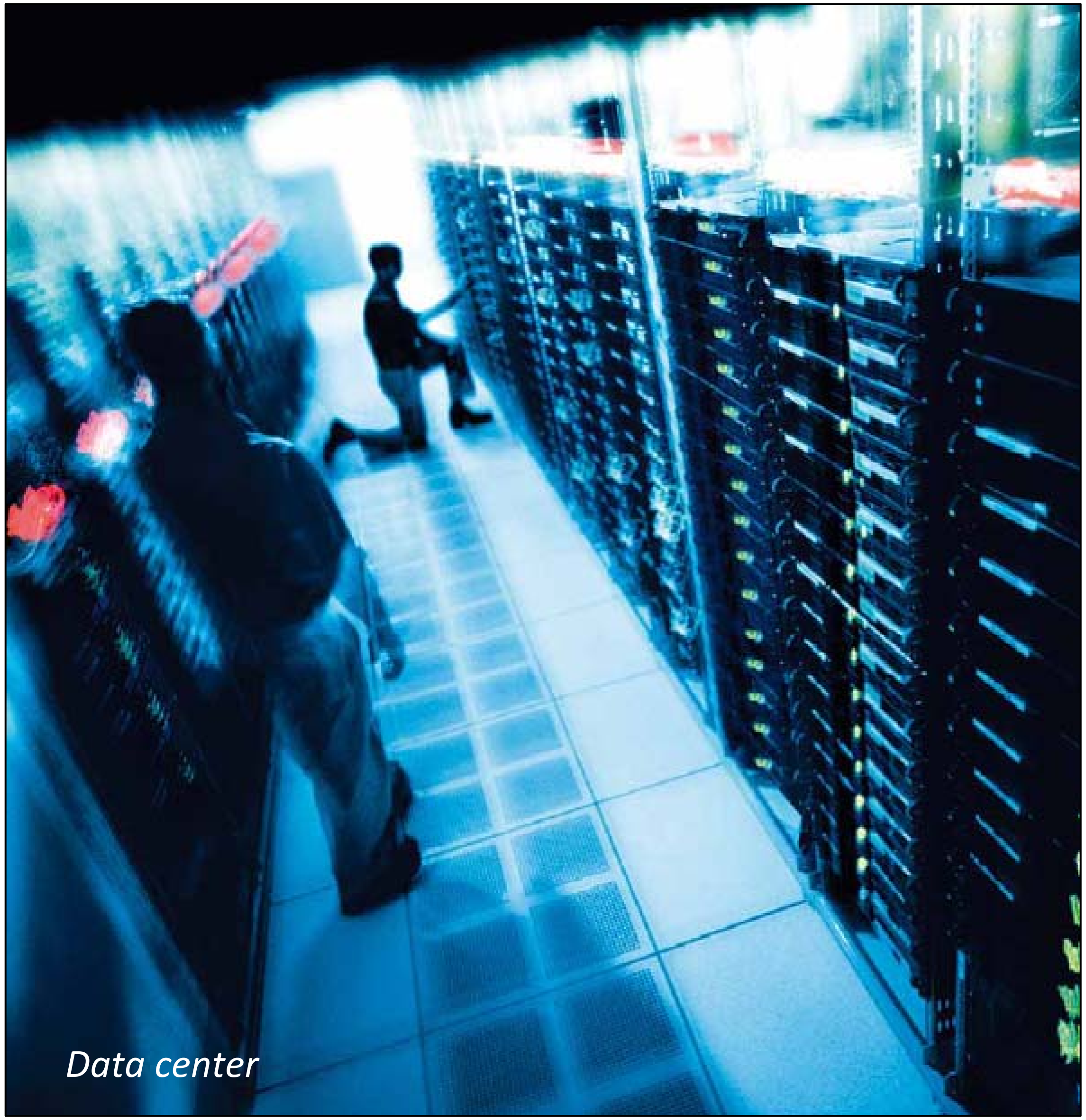
- California has set up offloads mechanisms for energy suppliers. It is cheaper for them to encourage their customers to save energy that to build new power production plant;
- This approach is effective because the price of kWh is high in California;

➔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.

However, 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.

Part II – We are entering into a new energy transition. We should also enter into a grid transition



Data center

To build grids adapted to the requirements of the 21rst century

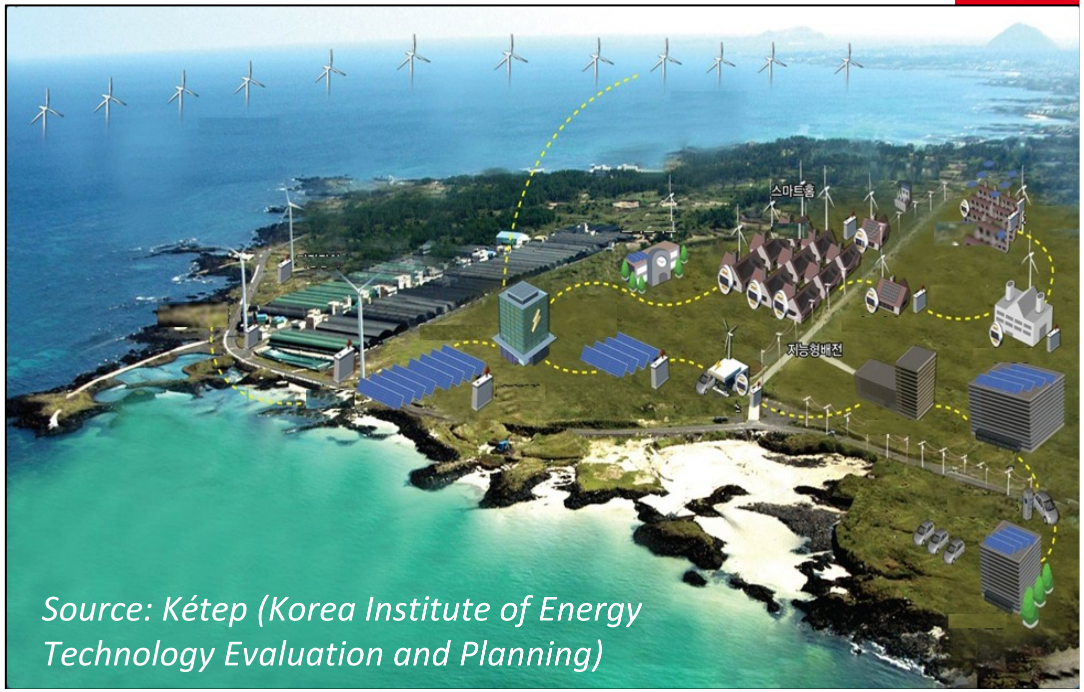
- Major PECC economies have launched projects to bring electricity grids from the 20th to the 21rst century (US, South Korea, Australia, Canada…).
- In the long run, the world smart grids market is presumed to reach $ 100 billion per year.
- Smart city market is assessed to reach $ 3,300 billion by 2025, with multiple opportunities to tap into infrastructure development, technology integration, and energy and security services.
- New grids will be decentralized, informational, interactive, flexible.
  - ➔A diverse energy mix provides greater flexibility but makes network management more complicated. Furthermore, conventional networks are not adapted to unconventional energies. Therefore changes in networks are necessary to tame renewable energies and benefit from their potential.
  - ➔Accurate data management helps to optimise this multi-source/multi-use network ant to fine-tune the performance of the networks.
    - ❖ Better information provides better answers for satisfying growing energy needs.
    - ❖ Information management is a central in smart grids: it is in-depth knowledge of consumer practices that makes it possible to anticipate and adapt production.

The Jeju island pilot's, a strategic investment for South Korea - 1

- South Korean context:
  - ➔97 % of its energy needs are covered by energy imports.
  - ➔South Korea planed to convert all its grids in smard grids by 2030. The objective IS to reduce electricity costs and energy consumption through the use of smarter technologies, increased efficiency and more renewable energy sources.
  - ➔South Korea aims at avoiding to spend € 2 billion in the construction of new power central, at saving € 31 billion of energy imports and at creating 1 million jobs.
- Main features of the Jeju island pilot's:
  - ➔It started in 2009 and was completed in May 2013.
  - ➔It includes 168 companies and 6,000 households.
  - ➔To date, it is the largest experimentation with regards to the number of technologies gathered.
  - ➔Project costs: 220 M$ (60 M$ invested by the government and 160 M$ by private sector).
- This grid demonstration project had 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 new grids.

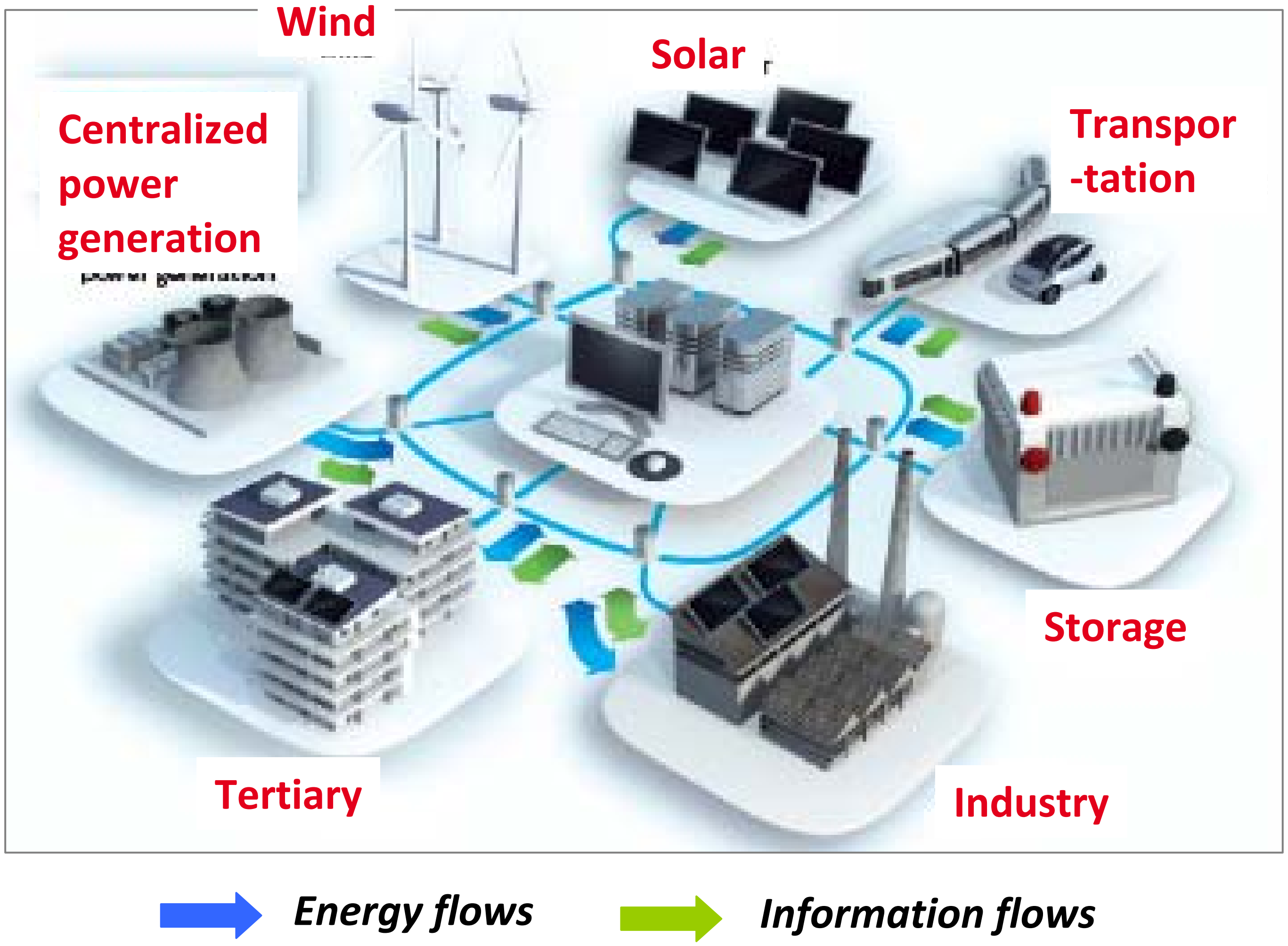
The Jeju island pilot's, a strategic investment for South Korea - 2

- A power market with real time price:
  - ➔45 business models and pricing systems were tested.
  - ➔The price of electricity changes every 5 minutes...
  - ➔The objective is to involve consumers more so that they can take control of their energy consumption, to move from a culture of supply management to demand management.
- Lessons learned:
  - ➔Energy savings slightly overpassed 10% (< IEA forecasts)
  - ➔When electricity price is too low, consumers are not encouraged to save energy. There is a conflict between cheap electricity to satisfy needs and boost economic development, and higher price to make smart grids projects bankable.
  - ➔Technologies are existing, but the market doesn't yet. What companies need is a real market with profitable business models. This depends on the laws, standards and regulatory systems the government will set.



Source: Kétep (Korea Institute of Energy Technology Evaluation and Planning)

Part III – New grids
and new kind of coperation between stakeholders



A new 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.
- Improved control of electricity flows allows to anticipate peak periods:
  - ➔by offloading devices connected to the 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. To function in this role, aggregators need:
  - ➔to make the sites they manage smart;
  - ➔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.

With Virtual Power Plants, we observe a redefinition of the energy business and the emergence of a new function

- Virtual Power Plants use computer technology to aggregate the production capacity of smaller facilities (with an output of at least 1 MW) and make it available to the grid.
- This gives additional capacity to produce electricity and reduces energy bills for customers.
- Veolia has established itself as a pioneer in Virtual Power Plant (VPP) technology.
  - ➔This solution was developed following tests in Hungary (combining the output of 50 facilities to provide a total capacity of 84 MW) and in Brittany, France, in 2009, with the operation of a 50-MW VPP system.
  - ➔As a result, a VPP went on-stream in Ireland in December 2012, using 4 facilities to provide an output of 21 MW. 8 sites will eventually be connected to provide a capacity of 45 MW.
- In VPP, the aggregator monitor the 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.

– Part IV –
Storing electricity, storing energy

Power storage, 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).
- Storing the electricity overproduction helps balance and stabilize the grid. It allows to integrate high part of intermittent sources in the energy mix.
- Yet efficient solutions have been developed that are good enough to be deployed:
  - Households: high-temperature batteries, hot water stored in tanks ;
  - Buildings: cold water stored into air-conditioning systems…
  - Communities: dams and water towers.
- 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.

Veolia electric cars, China

Borås (Sweden), energy storage for a carbon-free city

Context

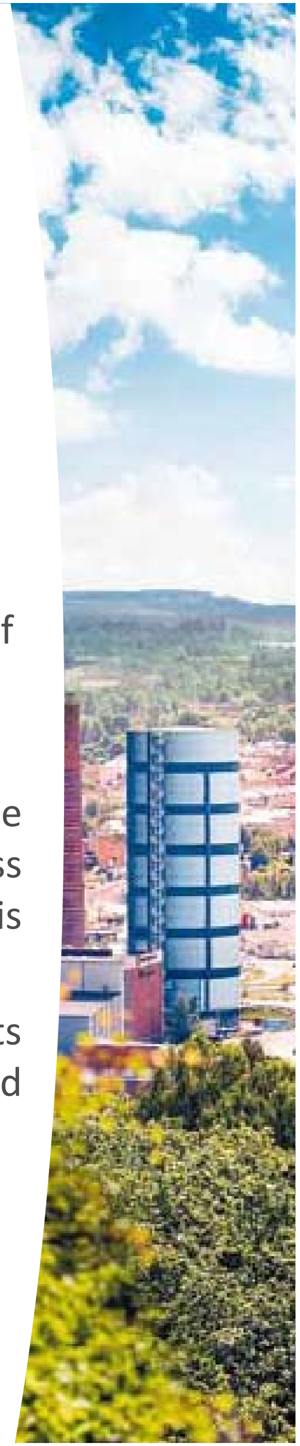
- Borås, a city of more than 100,000 people, is committed to being completely free of fossil fuels in 2025.
- Since 2005, Veolia is partner to Borås for energy services management.
- The thermal power plant consists in two 20-MW refuse-derived fuel boilers, two 65-MW biomass boilers and two 37-MW combined heat and power steam turbines.
- Borås has a large heating network comprising 350 km of pipes and 4,000 substations. In winter, the need to absorb spikes in heating use was one of the main "*black spots*" leading to massive use of fossil fuels.

Solution

- To offset the problem, the decision was made to build a giant storage facility (heigth: 80 m) heated only by renewable sources—such as biomass and waste incineration— during times of low consumption when there is little demand.
- The 37,000 m^3 facility is an enormous "*hot-water tank*" that releases its contents into the heating network in the evening to cover peak demand (≠ household water tank capacity of 0.3 to 0.5 m^3).

Results

- This super-storage facility has reduced both energy consumption and the carbon footprint of the district heating network since it came on stream.
- 5,500 metric tons of CO_2 emissions avoided every year.



Chilled-water storage for cooling services in Baltimore

Context

- Baltimore, Maryland, is one of the biggest ports on the east coast of the USA.
- Veolia Energy North America operates cooling services in the city.
- 16 kilometers of pipes linked to electrical cooling units provide air conditioning for 51 client sites.
- The city wanted to better control costs, why satisfying growing energy demand.

Solution

- Two large size storage facilities containing chilled water at 0 °C (32 °F) were installed, providing a cooling capacity of 263 MWh (75,000 tons-hours).
- The goal was to ensure production did not blindly follow demand without proper management of electricity costs, which can vary greatly depending on the time of the day.
- The reservoirs work a bit like batteries. The chilled water is cooled when it is most cost-effective to do so, then injected into the network to help manage peak consumption.

Business evolution

- Initially developed for electricity, the smart-grid concept is now being applied to heating and cooling networks. The goal is to provide greater flexibility and anticipation in managing systems to offset costly production spikes. Storage facilities and equipment for buildings are a central feature of these new "***thermal smart grids.***"

– Part V –
From smart grids to smart business models and smart relations with customers

Main features of the new business models for electricity

- Local business models, blending local resources with local uses.
  - The 20th century saw the triumph of large power infrastructures. The 21st century will see a proliferation of small equipments decentralized at local level.
  - 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 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:
  - 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 facilitiy and household. Smart grids will help them choose the right behavior and save energy.
- A shift towards real-time pricing schemes and towards smart pricing
  - Dynamic pricing will combine with smart grids to effectively adapt production to consumption in real time.
  - The success of the on-going energy transition partly hinges on the ability to implement innovative pricing schemes.
  - To put that in perspective, we need only think back to the way telecommunications were billed in 1990 and compare that with how we pay for mobile and internet services today.

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.
- 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 economies

- Due to public budget constraints, there is a pressing need for innovative solutions to avoid complementary capacity investments.
- The underlying economic logic of smart grid 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.
- A critical issue is to share the value created in the chain between energy suppliers, distributors, aggregator(s), consumers.
- Smart grids' benefits are spread among several players (customers, network operators, new service providers). But costs are mostly incurred by network operators, so they must be properly remunerated for this.
- Many of the renewable energies and smart grids won't develop up to their promising potential without appropriate pricing policies:
  - ➔Too often, renewable energies and smart grids turned out too expensive because of competition from undervalued conventional sources (eg: coal). 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

Making the data speak

- Stabilizing grids will become more and more an informationnal problem rather than an infrastructural one.
- Thanks to the IT revolution, it is now feasible to value former priceless data. Harnessing energy information in novels ways allows to produce useful insights or new services of significant value.
- Today, energy data is the source of new economic value. It allows to reshape the way we manage grids, to create new added value and to resistribute it between stakeholders.

- Since information is essential for markets transactions, there is a growing competition between data analysts on one side and operators of energy infrastructure (and thus data providers) on the other side, to gather and process data, extract the added value of the information and sell new services.
- However, big data requires discussion of the nature of decision-making. It affects how the energy businesses value the data they hold and who they let it access, it alters how organizations think about data and how they use it.


Thank you for your attention