IEA/ENARD Grid Policy Workshop

Smart Grids :
A Key Enabler in the Delivery of a Low Carbon Economy

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ÉLECTRICITÉ RÉSEAU DISTRIBUTION FRANCE

Introduction

Electricity, if we use it efficiently and scarce fully, is key to reduce CO_2 emissions

- **Whatever the initial situation, it is a unique energy vector that can guarantee a decarbonised economy for the long run**

- A 2050 scenario for France : "the sustainable Grenelle".
  - **This scenario is original because there are ruptures but it remains pragmatic and realistic (costs and policy wise).**
  - **What will the cities in 2050 look like ? (buildings insulation and heating, distributed energy, transportation)**
  - **What will be the energy mix in 2050 to reach a factor 4? What balance between centralised and decentralised generation ?**
  - **What technologies and costs evolution for solar PV, CCS, storage, nuclear Gen 3&4, large scale load shedding ?**

- What are the consequences for distribution networks ?
  - **With the revolution of IT technologies**
  - **The increase of electricity uses and the emergence of variable power flows directions**
  - **The role for customers who may participate to new load shedding mechanisms**
  - **Financial needs**

The IEA 2050 global scenarios show a significant substitution of fossil fuels by electricity and a substantial proportion of centralised generation

♦Emissions:

- The "Act" and "Blue" scenarios lead to a **substantial reduction of emissions** from the global electricity sector versus their current levels (divided by 2 in ACT and by 4 in Blue).

♦Electricity consumption:

- both categories of scenarios show a **significant de-correlation between electricity demand trends and GDP** but a consumption respectively 2.3 and 2.2 times higher than today, in spite of significant efforts in energy efficiency (impact of -23% on consumption in ACT and -33% in Blue);
- the development of highly efficient electrical uses leads to a **substantial substitution** of fossil fuels by electricity.

♦Electricity production:

- in ACT, fossil fuels account for slightly less than half of the electricity production, including a portion without any CCS (Carbon Capture and Storage), and renewable energy sources (RES) account for one third.
- The Blue scenario considers **considerable RES deployment (ca. 50% of total production, including hydropower),** with nuclear power representing about one fourth, and fossil-fired with CCS another fourth (no coal without CCS).

The "Sustainable Grenelle" scenario for France is aligned with IEA scenarios

♦Electricity consumption :

- Total demand increases 40% **mostly due to substitution of fossil fuel by electricity in the transportation sector**
- The demand level in the residential and commercial sectors results from a **virtually total substitution of fossil fuels by electricity and RESs** for heating and domestic hot water (DHW), and from efficiency gains due in particular to a complete renovation of existing buildings.
- No sudden change in the industrial sectors: factory relocations are offset by growing electrical uses (induction, industrial heat pumps).
- **Appropriate public policies** have been adopted with incentives for energy demand management and to develop renewables in new buildings.

♦Electricity production :

- The French mix in 2050 is dominated by **Nuclear and RES.**
- Centralised (wind and solar farms) and decentralised (rooftop solar photovoltaic-PV, heat pumps, etc.) RESs are expanding, although in a lesser proportion than in the Blue scenario
- For a successful nuclear/RES mix, all **available storage means (STEPs-pumped energy transfer stations) are used** (and therefore launched concurrently with the roll-out of wind power in order to limit the need for fossil-fired production top-up).

The city of 2050 is eco-efficient

- A compact city leads to minimised energy consumption in buildings and for transports
  - **Public policies driving “smart” housing conditions initiated as early as the years 2000, and steadily pursued over the entire time period**
  - **Higher energy costs have impacted public behaviours (lower preference for individual housing and transport).**

- In terms of buildings, the city of 2050 looks very similar to today's, but only in appearance
  - **Most built properties in 2050 consist of buildings already existing today (very low annual rate of building destruction, i.e. 1 to 2 /1000).**
  - **In the meantime, these buildings have been renovated and insulated.**
  - **Traditional heating systems have been replaced by high-efficiency processes (heat pumps, biomass) and domestic hot water heaters by solar hot water and heat pumps.**

- District heat networks have found their place provided that:
  - **They are fuelled in biomass (wood or straw) via energy-efficient transportation means (e.g. trains and barges), or**
  - **They draw on geothermal energy reserves.**

- Higher fossil fuel prices have led to the development and growing use of low CO2 emission public transport systems.
  - **development of EVs and PHEVs (reduces traffic nuisances: noise, air pollution).**

In 2050, zero direct emissions from buildings

- Thanks to upstream decarbonation and massive use of renewable sources, direct CO_2 emissions from buildings are reduced down to zero (versus 92 Mt in 2005).

- Half of the end-use demand is supplied by RESs, zero-carbon by design.
  - Heat pumps operating from 1/3 zero-carbon electricity and 2/3 free supply contribution represent up to 100 TWh.
  - Systematic use of available biomass resources: either in individual furnaces or centralised boilers in collective housing buildings or eco-district grids, or in CHP

Extensive development of electric transport (over 100 TWh in 2050)

♦Road travel and transport

The fleet of personal vehicles **(44 million) consists primarily of** PHEVs **(1 out of 3) and** electric vehicles **(1 out of 6)*.**

- The majority of **light utility vehicles** (under 3.5t) are **PHEVs** (2 out of 3).
- The majority of **urban buses** are **PHEVs** (2 out of 3).

♦Rail travel and transport

Significant growth of urban and inter-urban passenger transport by rail **(2/3 of urban transit): multiplied by 2.5 versus 2007.**

- Development of **freight transport by rail,** but to a lower extent (1/3 of total): multiplied by 3 versus 2007, but starting from a very low baseline**.**

V2G :

- load and unload periods are chosen by customers regarding their own needs and constraints. Using EV batteries for grid purposes is highly dependent on customers behaviour. Social acceptability should be tested with incentives tariffs.

No stationary storage processes are emerging (batteries, fuel cells) to ensure the **energy self-reliance of buildings or districts** at a **non-prohibitive cost**

- **Storage systems that would make buildings energy self-reliant include hot water tanks and batteries (low power).**
  - **Hot water accumulation tanks represent a tried and tested solution** (currently 28 TWh), but few developments are to be expected to the extent that gas water heaters are replaced by heat pumps.
  - **The least expensive batteries are lead batteries** (€50 to €100/kWh) but present drawbacks (safety, volume). Lithium-ion batteries are denser, but too expensive (€900/kWh in 2007 and €300/kWh in mid-term target) for stationary daily use, and even more so for weekly uses.

- **For districts (medium power):**
  - NaS batteries remain expensive (-20% vs. 2007 at €1000-€2000/kW); Redox batteries (low to medium power) also remain very expensive (€1000-€3000/kW in 2007).

- **Technology breakthroughs would be needed to move a step further**
  - Emergence of **nanostructured batteries**
  - Manufacturing processes for Li-ion batteries that would lower the cost below €100/kWh in volumes compatible with urban planning requirements.
  - Even such breakthroughs would fail to solve the issue of solar PV seasonality (lakes alone can solve this problem**).**

- **Regulatory changes will have been implemented by then**:
  - to send off the right price signals to producers and consumers, and
  - to enable the development of new pumped energy transfer stations (changes in purchasing and supply tariffs).

In 2050: RES account for nearly 30% of production, Nuclear for over 60%, with fossil fuels supplying a top-up for peak and short semi-base

Out of the total production, one third of the electricity in France is generated by renewable sources.

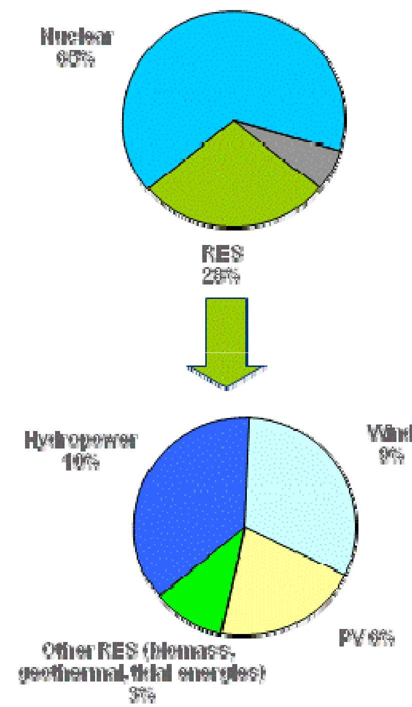
- RES are developed by order of competitiveness (**onshore wind and biomass first**, followed by solar PV and offshore wind); considering the costs, the physical limitations and the problems of integration into the electrical system due to their intermittent nature, **this level probably constitutes an upper limit.**

Nuclear remains dominant.

- Existing sites are re-used.
- Decommissioned current units are replaced gradually by EPRs and Gen4 reactors.

Fossil fuels are not competitive against nuclear power once CO2 penalties are included. They are removed from the energy landscape, except for short semi-base.

- ❖ CCS may be required in spite of the limited number of hours·
- ❖ **The use of fossil fuels may be further reduced if load management mechanisms for customer demand can be generalised, in particular with "smart meters" and distributed load shedding.**



Generation by intermittent RES accounts for up to 100TWh (60 GW in simultaneous operation) which is probably the upper limit

Intermittent RES	✓ Wind: limitations linked to wind regimes, to required land surface and to local public acceptance (onshore estimate: 50 to 60 TWh; offshore estimate: 15 to 35 TWh). ✓ Solar: limitations linked to local sunshine and required surface area (land-based solar plant estimate: 10 TWh; rooftop estimate: 30 TWh).
Non-intermittent RES	✓ Hydropower: physical acceptable potential already reached in France (2007 level maintained at 70 TWh). ✓ Biomass: limited potential (max. 15 TWh) ○ Domestic raw material access and prices, competition with other uses, few sites, low efficiency ratios, CO_2 emissions linked to transport
Limitations linked to system optimisation	✓ A higher proportion of RES (e.g. 50% of mix) would lead to a PV installed base higher than the summertime demand and generating substantial surplus costs and a degraded system optimisation.

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Summary of main outcomes from the "Sustainable Grenelle" scenario

Residential & Commercial consumption

- Total demand is 680 TWh (1.4 times the 2007 demand), incl. 340 in residential & commercial.
- The fossil-free home is generalised; fuel-oil and gas disappear; 70% of all buildings are heated with heat pumps
- Heating requirements for existing buildings are reduced by 40% (renovation/insulation); 25% homes and 75% commercial premises are equipped with solar photovoltaic and 30% with solar collectors for domestic hot water (DHW)

Transport

- Electric and plug-in hybrid vehicles take off as of 2020 reaching respectively 15-20% and 35-40% of the private vehicle fleet in 2050, i.e. a power consumption of 70 to 100 TWh
- Rail reaches a power consumption of 30 TWh primarily due to passenger transport

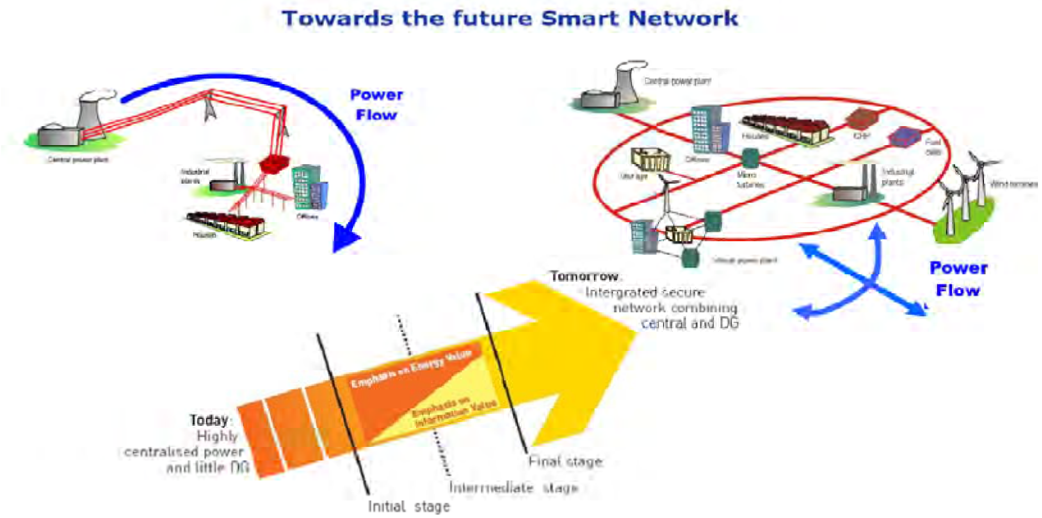
Generation

- RESs supply 28% of the demand in 2050, i.e. 190 TWh (for a total domestic demand of 680 TWh)
- Excluding large hydropower (70 TWh, stable), wind power predominates (60 TWh); solar PV reaches 40 TWh.
- Nuclear is stable at 445 TWh; a fossil fuel residue of 45 TWh subsists.

Emissions

- CO2 emissions from the electrical sector reach at most 20 Mt in 2050 (currently 50% of emissions per kWh)
- The Sustainable Grenelle scenario is a "factor 4" scenario: total emissions in the country drop from 412 Mt in 2006 down to 100 Mt in 2050.

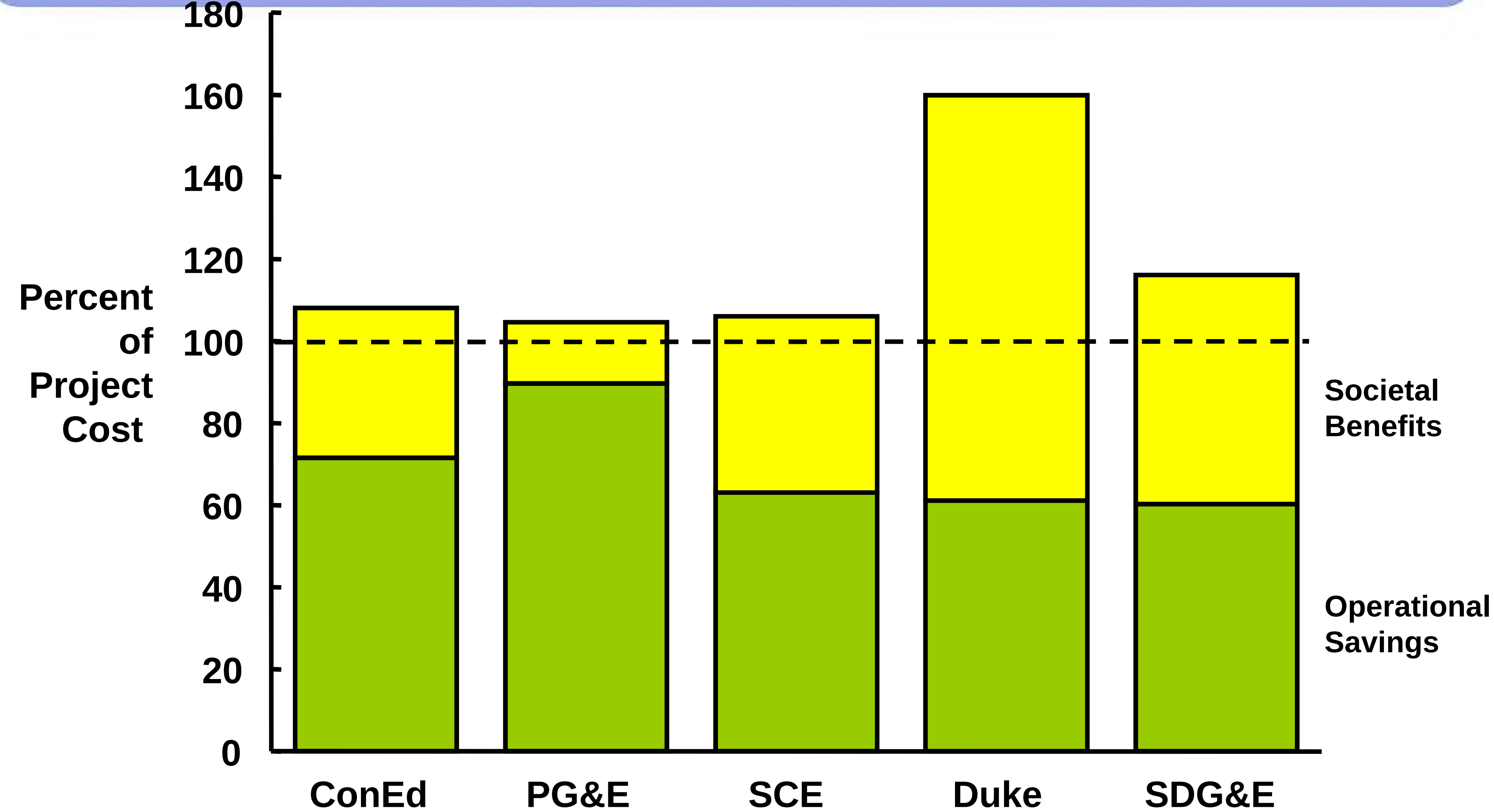
If electricity is key to limit CO2 emissions, Smart Grids are key to manage the electrical system



- A more complex system :
  - **Increased uses of electricity, with less kWh per use**
  - **Variable power flows directions**
  - **Changing behaviour of consumers**
- A revolution made possible by the revolution of IT technologies

- As network components have very long life times, **the network in 20-30 years will be based largely on already installed lines and transformers** : the change will come from new IT tools monitoring the system
- New players will appear : **aggregators, virtual power plans operators**,…
- The role of DSOs will evolve : they will have a major role to enable the **secure operation of local systems** and facilitate the implementation of local energy policies
- A smart grid will require a **smart regulation**

AMI and Smart Grid Project Benefits as a Proportion of Cost



Source: IHS Cambridge Energy Research Associates.
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Conclusion for smart grids

- Smart grids are key for a de carbonised economy
  - **Benefits for customers**
  - **RES integration, DSM, storage**
  - **Better use of resources in Europe : trans European networks (implementation quite difficult)**
  - **Implementation of local energy policies : regional/local energy planning, micro-grids**
  - **Optimised system operation : maintenance, reduced outage duration, remote operation**

- Need to improve DSOs efficiency : fields of R&D
  - **Metering : remote reading, market enhancement, DSM facilitation**
  - **Asset management : optimised maintenance and new build (data collection and analysis, forecasts, diagnosis)**
  - **Network control and operation : self-healing, LV network control, field force management.**

- Transition towards a low carbon economy : fields of R&D
  - **Cost reduction**
  - **RES integration : connection, operation, regulation**
  - **DSM active demand : customer information, new tariff offers, load management**
  - **Storage : connection and operation**
  - **Electric vehicle and heat pumps : network development, load management**

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Appendix

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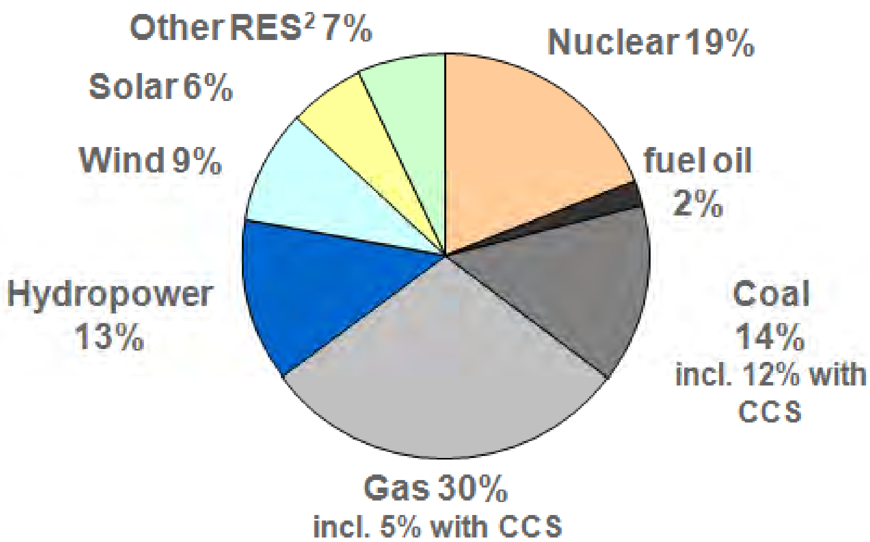
Production mix in 2050 in IEA Act and Blue scenarios

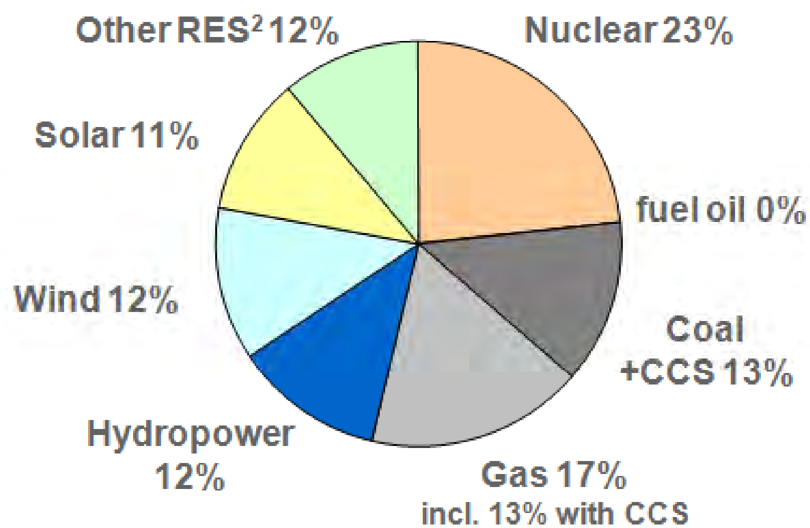
Scenario Act Map

RES[1]: 35%
Nuclear: 19%
Fossil fuels: 46%



Scenario Blue Map

RES[1]: 47%
Nuclear: 23%
Fossil fuels: 30%



(1) In 2005, 18% RES in global mix
(2) Bio-energies, geothermal, waste, tidal energy