Example of the French electricity mix

Christophe TRZPIT
Generation Economics & Strategy Deputy Director
EDF - Nuclear & Thermal Generation Division

ENYGF
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The French electricity mix

Contents

- System characteristics
- Main benefits
- Challenges for tomorrow
A WORLD ELECTRICITY GENERATION MIX STILL DOMINATED BY FOSSIL FUELS

Nowadays 2/3 of worldwide electricity is generated from thermal sources

World Generation 2012
- Fossil: 68%
- Nuclear: 11%
- Hydro: 16%
- Other RES: 5%

Nowadays 2/3 of worldwide electricity is generated from thermal sources

World Generation 2040
- "New Policies Scenario"
- Fossil: 55%
- Nuclear: 12%
- Hydro: 16%
- Other RES: 17%

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Europe has a more balanced mix between Coal, Gas, Nuclear and RES (about 1/4 of electricity generation each)

Coal ≥ 800 gCO2/kWh
Gas ≈ 400 gCO2/kWh

Source: IEA WEO 2014
BY COMPARISON, FRENCH ELECTRICITY MIX IS 95% LOW CARBON

French electricity mix end 2014 (GW)

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>63,1</td>
</tr>
<tr>
<td>Hydro</td>
<td>25,4</td>
</tr>
<tr>
<td>Other RES</td>
<td>16</td>
</tr>
<tr>
<td>Fossil</td>
<td>24,4</td>
</tr>
<tr>
<td>Total</td>
<td>128,9</td>
</tr>
</tbody>
</table>

French electricity generation in 2014 (TWh)

- Nuclear: 77%
- Hydro: 13%
- Fossil fuels: 5%
- Other RES: 5%

Source: RTE - Electricity report for 2014
EDF is the first nuclear operator in the world

- **58 reactors** across 19 sites
- COD between 1977 and 1996
- Average age: 29 years
- **63,1 GW** capacity
- **416 TWh** generated in 2014
- **1 EPR under construction** at Flamanville
RENNEWABLES FLEET IN FRANCE

In 2014: more than 40 GW & 90 TWh
19.5% of power consumption

Renewables fleet in France end 2014 (GW)

Hydro (inc. pump storage) 25.4
Wind 9.1
PV 5.3

Source: RTE - Electricity report for 2014
The French electricity mix provides major benefits

- Low carbon electricity generation
- Affordable electricity
- Security of supply, supporting the trade balance
- A large number of jobs in high performing industries
CO2/kWh much lower in France than European average

- French electric system CO2 emissions = 19 Mt in 2014 (continental France)
- CO2 factor of EDF mix = 17 gCO2/kWh in 2014 (metropolitan France + part of overseas systems)

**EU (27) average = 352 gCO2/kWh**

Source: AIE Edition 2013, CO2 Emissions from fuel combustion
**GENERATION MIX AND CO2 EMISSIONS (2)**

**CO2 emissions by sector in 2012**

40% of the CO2 world’s emissions come from electricity and heat production. Low carbon electricity is a solution to decrease CO2 emissions at national level.

* Others include commercial/public services, agriculture/forestry, fishing, energy industries

Source: CO2 Emission from Fuel Combustion Highlights, IEA 2014
FRENCH CONSUMERS PAY THEIR ELECTRICITY CHEAPER THAN OTHER EUROPEANS

An electricity 30% cheaper than the EU average for residential customers

End customers price, tax included, in €/MWh
(source: Eurostat 2H 2013 as of 14 May 2014)

Average of €233/MWh in Europe (17 countries excluding France)
AN AFFORDABILITY POSSIBLE THANKS TO COMPETITIVE GENERATION MEANS

Current regulated PPA or feed-in tariffs for RES
(without taking account of the system overcosts)

FOR FRANCE

- Existing Nuclear: ≈ 55 €/MWh
- Gas, Coal, New Nuclear: ≈ 70 to 100 €/MWh
- On-shore wind: ≈ 82 €/MWh
- Off-shore wind: ≈ 190 €/MWh
- Photovoltaic: 100 to 262 €/MWh

Source: EDF, 2015 based on CRE and Cour des Comptes information
A MIX PROVIDING ENERGY INDEPENDENCE

Contractual exchanges from France in 2014 - TWh

**UK**
- Exports: 15.9 TWh
- Imports: 0.8 TWh

**SPAIN**
- Exports: 6.5 TWh
- Imports: 2.9 TWh

**BELGIUM**
- Exports: 17.4 TWh
- Imports: 0.8 TWh

**GERMANY**
- Exports: 7.3 TWh
- Imports: 13.2 TWh

**SWITZERLAND**
- Exports: 25.5 TWh
- Imports: 9.1 TWh

**ITALY**
- Exports: 19.8 TWh
- Imports: 0.5 TWh

**Total FRANCE**
- Exports: 92.4 TWh
- Imports: 27.3 TWh
- Balance: 65.1 TWh

In 2014, positive balance of €2.1bn

Source: RTE - Electricity report for 2014
A MIX CONTRIBUTING TO EMPLOYMENT

EDF generation mix in continental France

Direct employments

Total employments

41 375 jobs

197 300 jobs

x 4,8

Total including taxes

112 700 jobs

x 2,7

With indirect employments

French nuclear industry is the third French industrial sector (220 000 jobs)

Source: EDF, 2014 Utopie study
DISPATCHABLE MEANS NECESSARY TO FACE PV AND WIND POWER INTERMITTENCY

Cold wave winter 2012 in Germany (1/2 – 15/2/12)

Wind rises... when it’s no longer cold

High PV generation during daytime

Low wind power during cold wave

EDF Copyright
Challenges for tomorrow

- Industrial challenges
- Market design and regulation
- Future electricity needs
THE INDUSTRIAL CHALLENGE OF “GRAND CARENAGE” PROGRAMME

• EDF faces an important programme of investments until 2025 in order to renovate and increase even more the safety of its reactors:
  • Replacement of several main components (steam generators, transformers, alternators...)
  • Significant safety modifications, taking into account lessons learned from Fukushima accident

• An amount of about €55bn investments until 2025

• This programme will be progressively engaged, in coherence with the strategic plan the new French law about energy transition will require from EDF and the Energy Multiannual Programme
THE INDUSTRIAL CHALLENGE OF NUCLEAR NEW BUILD

• EDF is constructing an EPR at Flamanville

• This EPR is a first of a kind for France:
  • in a context where no new reactor has been built for years
  • with a safety step (GEN3)

• Lessons learned will be driven from this development

• Work in progress on basic design optimisation by EDF and AREVA
MARKET DESIGN AND REGULATION ISSUES

In a context where:

- RES development is regulated “outside the market” (via feed-in tariffs, calls for tenders)
- Retail prices are rising ... while wholesale prices have much fallen

Need for adaptations:

- **CO2 price regulation**: visibility on a more representative CO2 price
- **Capacity mechanisms**: a capacity obligation in 2017 in France
- **Sustainable regulation for renewables and others**
FUTURE WORLDWIDE POWER NEEDS WILL REQUIRE LOW CARBON AND COMPETITIVE GENERATION

A possible increase of power needs around +80% in 2040

Increase of electricity generation (TWh) 2012-2040

Evolution of generation fleets (GW) between 2012 and 2040

Source: IEA WEO 2014
Conclusion

No doubt nuclear will find its place:

As a sustainable, secure and affordable energy,
As a good solution to secure an electricity mix together with the development of RES

In France:

Nuclear will stay the basis of the generation mix
Nuclear and RES are complementary

In the World:

Nuclear is part of the solutions to decrease CO2 emissions from electricity
Thank you for your attention