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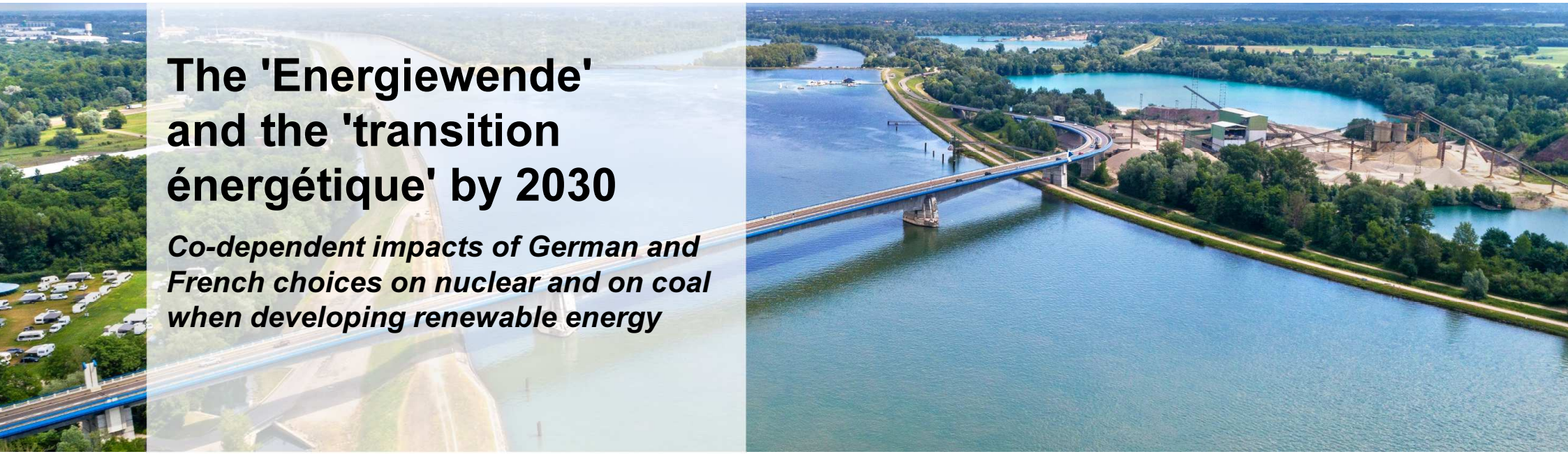

The 'Energiewende' and the 'transition énergétique' by 2030

Co-dependent impacts of German and French choices on nuclear and on coal when developing renewable energy

D. Pescia – N. Berghmans

BERLIN, 05.06.2018

Artelys
SOLUTIONS EN OPTIMISATION

EU power systems transformation towards 2030: increasing renewable electricity generation, deeper EU integration and stabilization of electricity demand, debate on higher ambition

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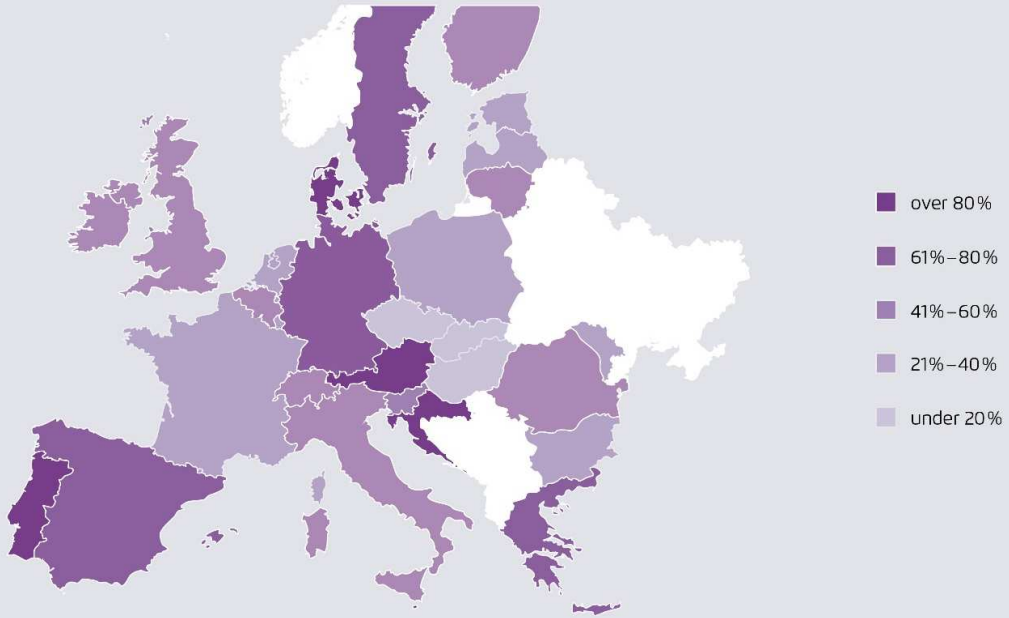
Share of renewables in electricity consumption in Europe in 2030



Agora Energiewende based on E3MLab/IIASA (2017)

- Cost of renewables continues to decline; Proposed EU targets* imply a share of 50% RES in the power sector by 2030
- Clean Energy for All Europeans-package will:
  - advance integration of EU power markets and systems (EU power market design, 15% interconnection target).
  - stabilise electricity demand as energy efficiency gains compensate additional demand by heat pumps or electric vehicles.
- France leading a coalition of countries willing to strengthen EU climate ambition from -40% in 2030 to -55% and to introduce new climate instruments (e.g. CO_2 tax/ minimum prices)

* Proposed EU targets for 2030 are : a reduction of CO_2 emissions by at least 40% CO2 by 2030 (against 1990 levels), a share of at least 27% renewables in the final energy consumption in the EU, 30% energy efficiency target

The *Energiewende* and the *Transition énergétique* face similar challenges towards 2030: integrating renewable energy while reducing the conventional power production fleet

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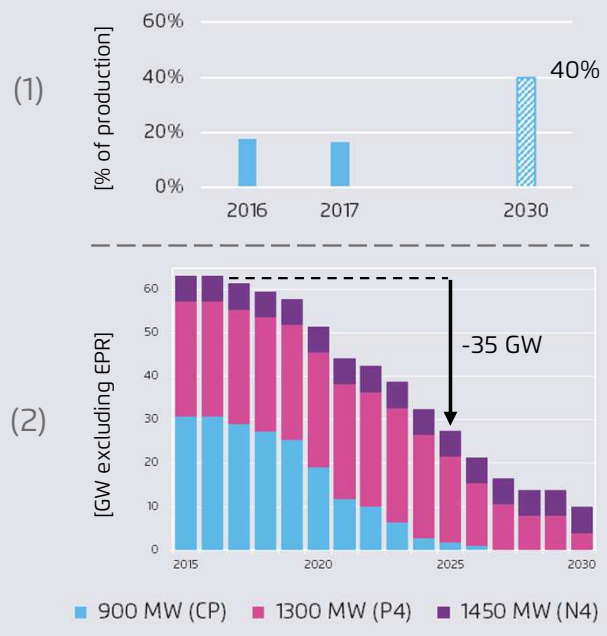
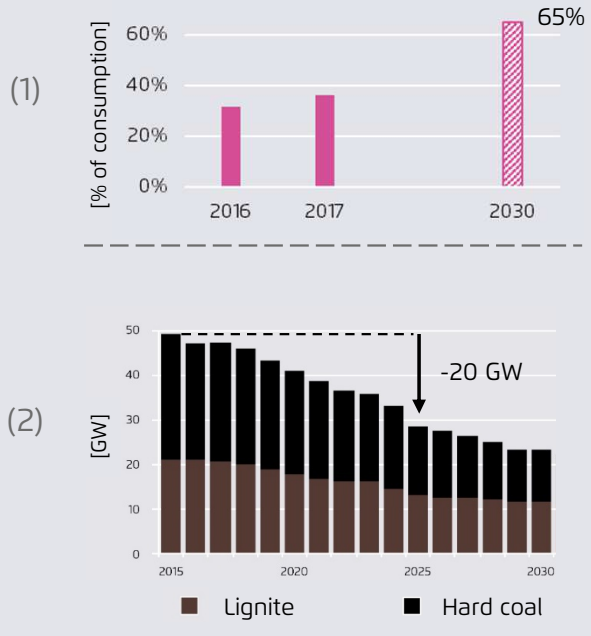
France: (1) RES targets & (2) expected evolution of nuclear production capacity assuming a 40-years reactor lifetime



Rudinger et al., 2017

Germany: (1) RES targets & expected development of coal-fired power plants assuming no renovation investment*



Agora Energiewende, 2016*

- Starting points in Germany and France are different, but long-term priorities are comparable: climate protection, higher RES, energy efficiency and electrification of heating and transport
- Ambitious targets in both countries for RES electricity in 2030:
  - 40 % of production in France
  - 65 % of consumption in Germany**
- Future of conventional power uncertain
  - In FR: How and when to reach 50 % target on nuclear? (revision of PPE, the multi-annual energy plan)
  - In DE: discussion on coal phase-out to meet German and EU climate targets (“coal commission”)

* Assuming a 50-years lifetime for lignite-fired power plants and a 40-years lifetime for hard coal-fired power plants
** as set in the Coalition treaty from February 2018 between the CDU/CSU and the SPD

The Agora Energiewende-IDDRI study analyses several intersecting scenarios of the French and German power systems by 2030

CO_2 reference price of €30/t	High nuclear (63 GW), PPE RES	Medium nuclear (50 GW), PPE RES	Low nuclear (40 GW), PPE RES
Medium coal* (24,3 GW) RES ~ 50%	✓	✓ + CO_2 high price €50/t	✓
Low coal (18,6 GW) RES ~ 60%	✓	✓	✓
Low coal (18,6 GW) RES ~ 50%	✓		

Power demand in line with recent projections: efficiency gains compensate for new electricity uses

Ambitious but realistic development of grid interconnectors : ~50 % of the new TYNDP projects are realised by 2030

→ **Focus of the study :**

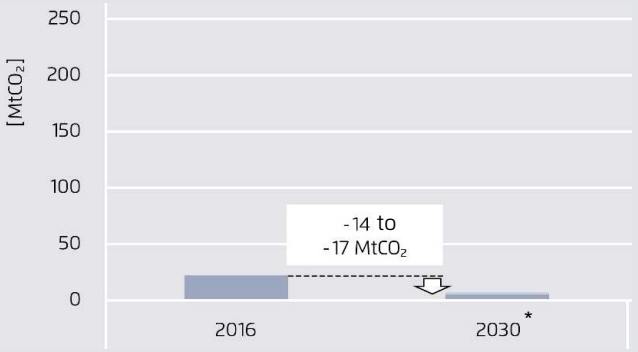
- In a more integrated power market, what would be the impact of national decisions on power mix?
- How will the planned development of RES impact the utilization of conventional power plants (coal and nuclear) ?
- What would be the result in terms of power flows, CO_2 emissions, market prices and revenues ?

→ Modelling performed by the consultancy Artelys.

→ Project framework and preliminary results discussed with various stakeholders in France and in Germany.

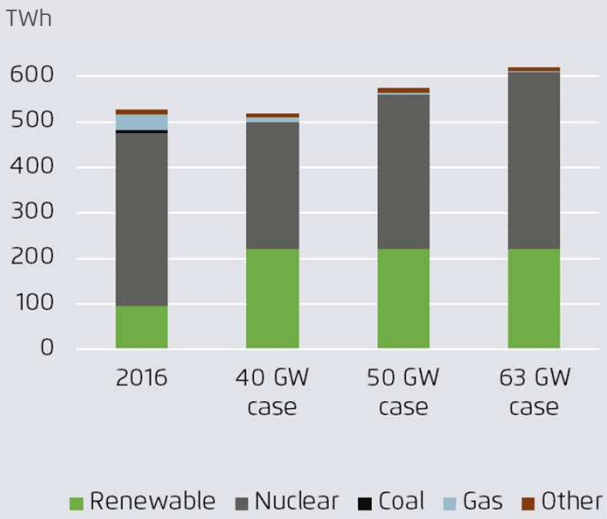
Result 1: The level of nuclear capacity maintained in France in 2030 has a limited impact on French domestic CO_2 emissions

CO_2 emissions in the French power system in 2016 and in 2030



Agora/IDDRI/Artelys

French power generation by fuel type in 2016 and in different scenarios in 2030



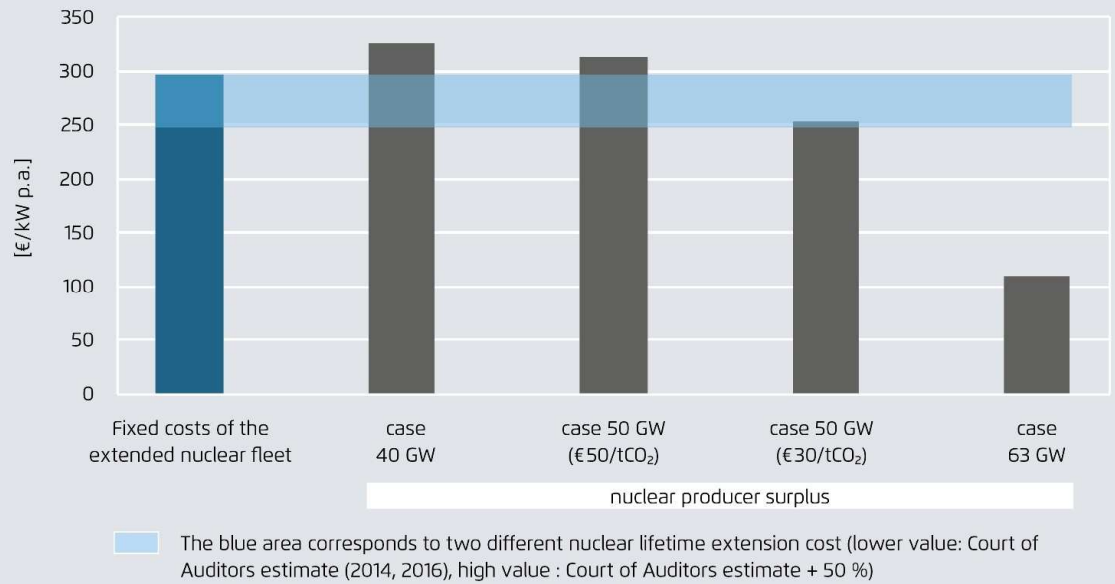
Agora/IDDRI/Artelys

- French CO_2 emissions decrease strongly in all scenarios due to coal power plant closure
- Security of Supply standards (3h of LOLE) are met in all scenarios.
- Above 40GW nuclear capacity, the objective of reducing nuclear generation to 50 % is not achieved in 2030. Additional nuclear production is mostly exported

(*) Without taking into account the emissions of biomass and self-consumption on industrial sites.
The value range represents the various levels of nuclear capacities in France, the German decisions on coal and RES, and CO_2 prices.

Result 2: Reinvesting in a nuclear fleet greater than 50 GW while developing renewables poses a significant risk of stranded investment

Fixed costs of nuclear power production compared to the nuclear producer surplus in different scenarios for 2030 (*)



Agora/IDDRI/Artelys (Analysis of the authors and Artelys Crystal Super Grid model results)

- Wholesale electricity prices in France decrease with a higher nuclear fleet (23 €/MWh in the 63 GW case and 42 €/MWh in the 50 GW case)
- Above 40 GW nuclear capacity, the profit per installed kW decreases, even when assuming a CO_2 price of 50 €/t in 2030
- Above 50 GW nuclear capacity, investments for extending the life-time of the nuclear fleet could are not covered by market revenues
- Surplus for nuclear producers is twice as high in scenarios with 40 and 50 GW nuclear capacity, compared to a scenario with 63 GW
- Market revenues for RES producers will also be affected: 4 bn €/year difference between high and low nuclear scenarios. This difference would contribute to increase the CSPE (French equivalent to the German *EEG Umlage*)

* Two variants on the retrofitting costs for nuclear power plants : **1184 €/kW** (“Grand carénage”) and **1 776 €/kW** (+ 50 % due to uncertainties)

Result 3: The development of flexibility solutions facilitates the integration of variable renewables in France and Germany

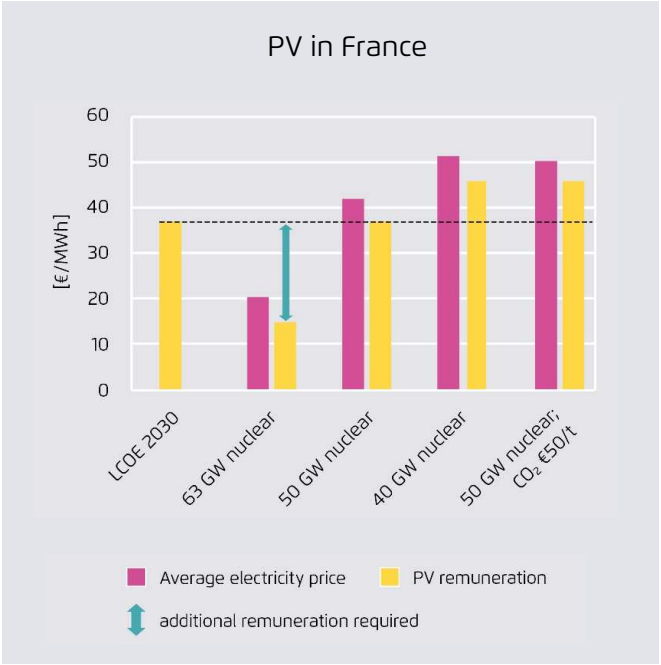
Production and consumption pattern during a week in November 2030 in Germany (left) and in France (right)*

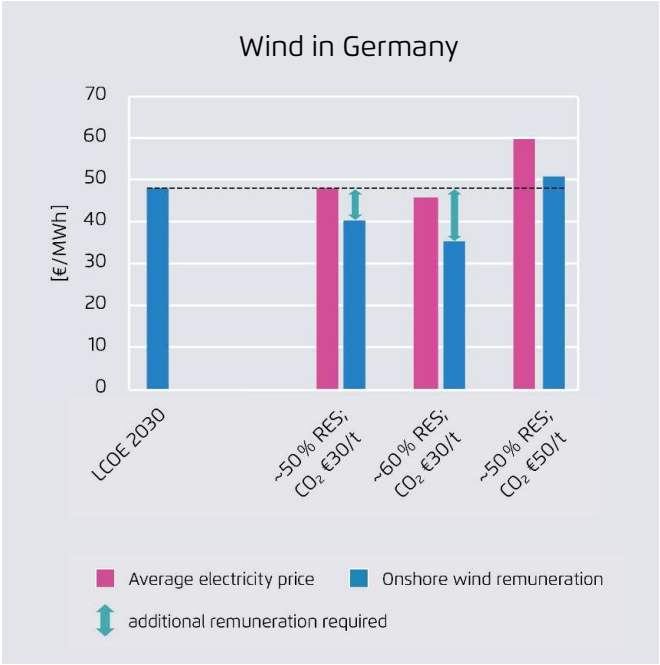
- The development of flexibility solutions (DSR, cross-border exchanges, EV, pumped-hydro storage, batteries) helps to keep the curtailment of renewable energy low in all scenarios in DE and FR (below 5 TWh per year)
- In Germany, RES cover more than 80% of national demand during 9 weeks in 2030. RES cover more than 100% of the demand during 930 hours
- The French power system shows high flexibility potential that facilitate the coupling between renewables and nuclear
- Despite new flexibility solutions, flexibility provided by conventional generation remains important : gas and remaining coal power plants in Germany, hydro and nuclear in France

* Note that those two exemplary weeks are not the same ones. Scenarios : low coal, high RES in Germany; low nuclear in France.

Result 4: With declining costs, the ability of renewable producers to cover their costs through market revenues improve significantly, especially if CO_2 price is higher

Electricity prices and remuneration in 2030 for PV in France and wind energy in Germany



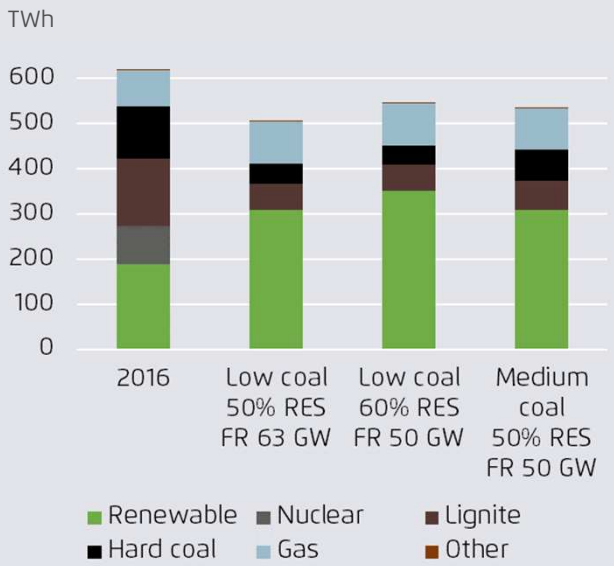


Agora/IDDRI/Artelys (Analysis of the authors and Artelys Crystal Super Grid model results)

- PV costs could be covered solely by market revenues by 2030 in France and Germany. Exception is in France if nuclear capacity is kept at 63 GW
- Wind production costs are not covered by market revenues with CO_2 at 30 €/t. A price of 50 €/t would be necessary
- Faster development of renewables in Germany to reach 60% has limited impact on average electricity price. However, it reinforces the « cannibalisation effect »
- Developing flexibility options, storage in particular, supports the market value of renewables

Result 5: German wholesale prices in 2030 are at 42-50 EUR/MWh – even in a coal phase-out scenario this is below 2007-2012 levels

German power generation by fuel type in 2016 and in different scenarios in 2030



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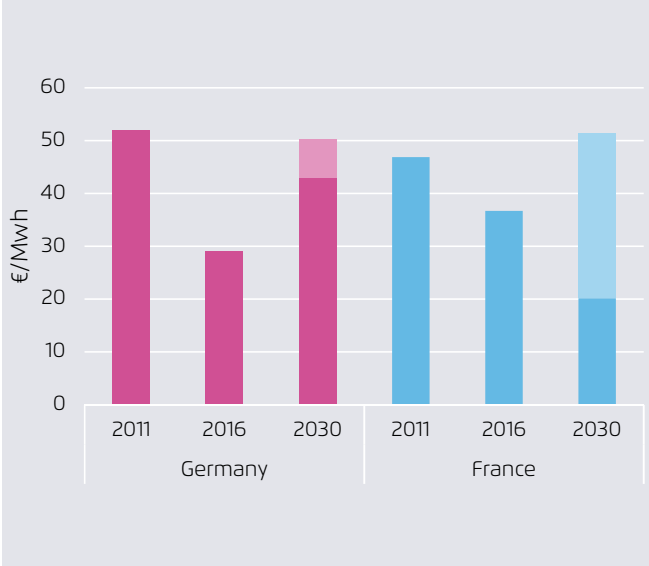
Average electricity prices in 2011, 2016 and in the different scenarios 2030 (CO2 prices 30€/t)



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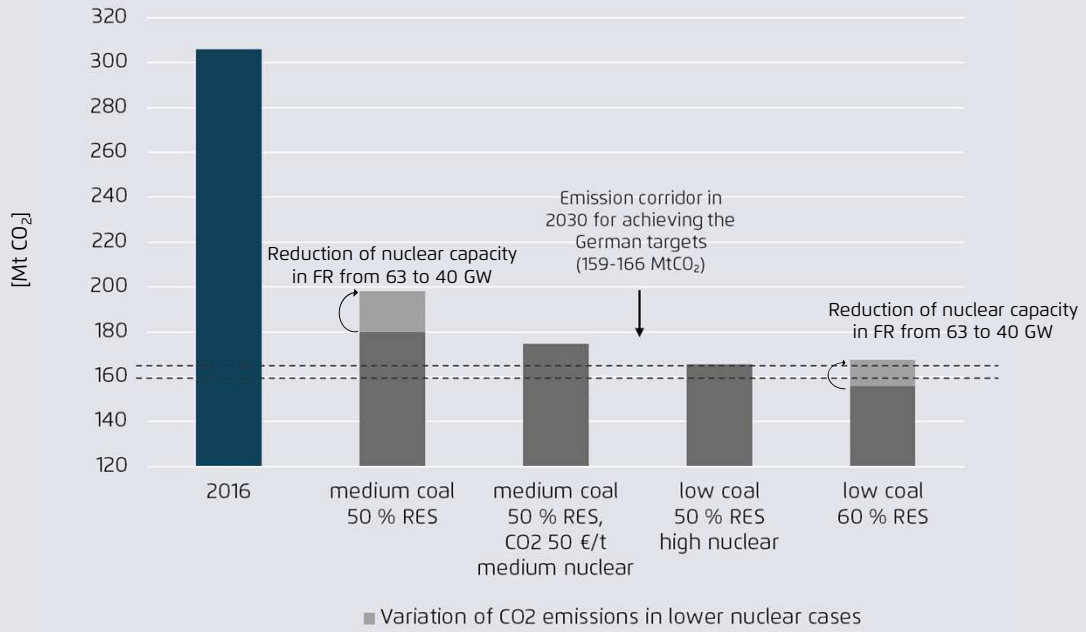
- In all the investigated scenarios, security of supply is guaranteed in Germany, even if coal capacity is reduced by 40%** and French nuclear is sized down to 40 GW
- With a CO2 price of 30€/t in 2030, average wholesale prices in Germany are below those observed on average between 2007 and 2012, even in a coal phase-out scenario
- In 2030, wholesale prices in France and Germany would be comparable if France reduces its nuclear capacity below 50 GW. They would be much lower in France in the 63 GW case.

* comparison between a 63 GW and a 40 GW nuclear scenario in France
** Assumption of 38 GW gas power plant in Germany in 2030 (NEP 2030-B, 2017)

Result 6: Halving coal power is a must for Germany to meet its climate targets. The French decision on nuclear has impacts on Germany's CO2 emissions of some 10-20 Mio. t, depending on its RES level in 2030

German CO_2 emissions in 2030 under different scenarios for France and Germany



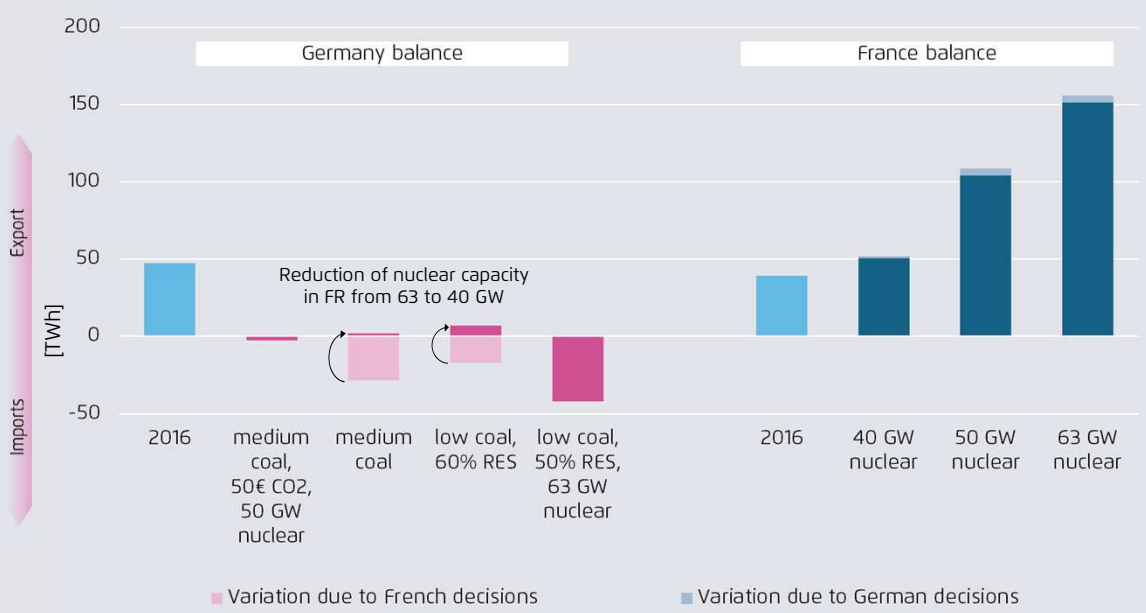
Agora/IDDRI/Artelys (Analysis of the authors and Artelys Crystal Super Grid model results)

- A coal phase-out combined with an increase in RES to >60% enables Germany to achieve its 2030 climate targets, whichever decisions are made in France. A coal phase-out improves the remuneration of remaining power plants.
- A decommissioning of coal power plants at the end of their technical lifetime is insufficient to meet climate targets. CO_2 prices are expected to stay too low (below 30€/t by 2030) to reduce significantly the use of coal. With a CO_2 price of 50€/t in 2030, Germany would reduce further its emissions but not reach its climate goals[1].
- More or less nuclear in France leads to less or more fossil power production in Germany. The difference ranges from 10 to 20 Mio. t CO_2.The higher the RES in Germany, the lower the impact of the French nuclear decisions on the German power sector and its CO_2 emissions.

[1] A level of ~60 EUR/tCO_2 would be needed to decommission the most recent lignite-fired plants

Result 7: High nuclear together with higher renewables in France push French exports. If Germany combines coal phase out with 65% RES, its electricity exports/imports remain balanced

Electricity trade balances of Germany and France (in TWh) in all 2030 scenarios, compared to 2016

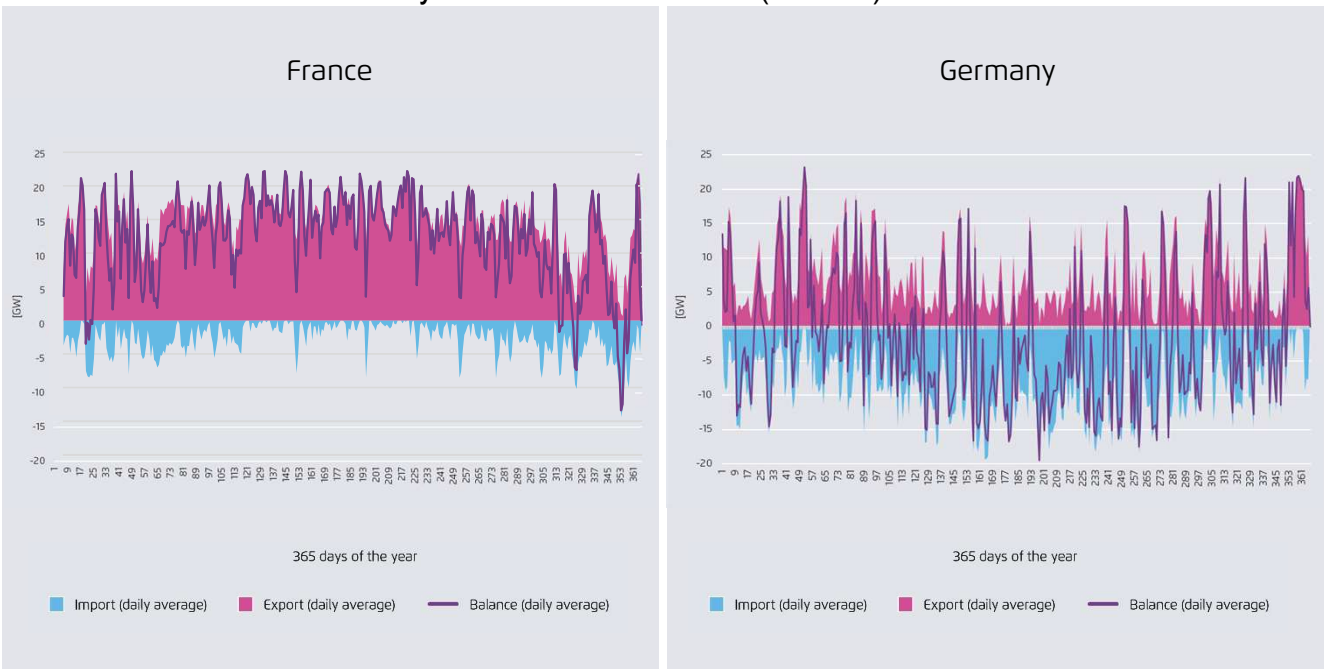


Agora/IDDRI/Artelys (Artelys Crystal Super Grid model results)

- France is increasing its net exports to the rest of Europe in all scenarios. If the nuclear fleet stays at 63 GW, exports are more than tripling to 150 TWh by 2030. The lower the nuclear fleet, the lower the increase in exports. German decisions on coal have little impact on the French import-export balance.
- The more Germany phases out coal to comply with climate objectives, the more Germany's current exports will decrease. The balance may turn to net imports, depending on decisions made by France and other neighbours
- By increasing RES to 65%, Germany can keep its net annual imports/exports more or less balanced, even if the French nuclear fleet stays at 63 GW.

Result 8: Both countries have an interest in increasing continental cooperation and cross-border exchanges

Daily balance of cross-border electricity trade in Germany and France in the scenario “low coal 60% RES“ for Germany and “medium nuclear (50 GW)” for France



Agora/IDDRI/Artelys (illustration of the authors based on Artelys Crystal Super Grid model results)

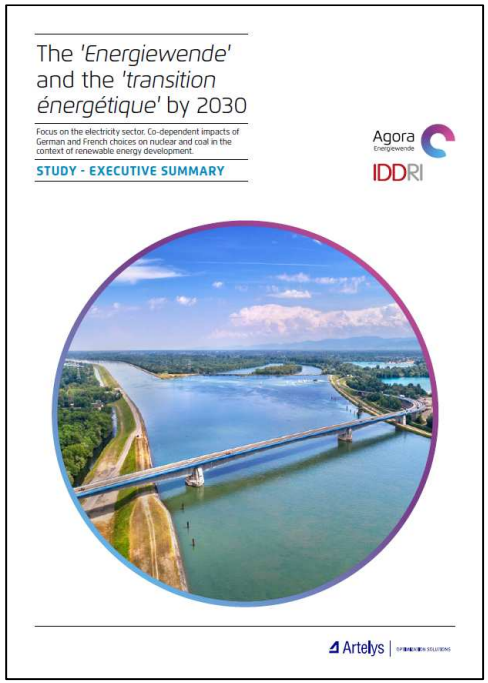
Despite some divergence on the power mix, both countries have an interest in increasing continental cooperation. Cross-border exchanges are key to lower the costs of the energy transition:

- → Germany aims at exploiting cross-border trades in order to better integrate variable RES
- → In France, high nuclear and RES development would push exports. The success of such a strategy relies on the development of interconnectors and higher CO_2 prices

Learnings for the French-German energy cooperation

1.	**National strategies on coal and nuclear should be defined quickly,** based on the 65% renewables energy targets in Germany and the 40% renewable energy target in France.
2.	**Initiate consultations on the cross-border impacts of national strategies,** for example in the framework of the NECPs consultation.
3.	Engage in **joint actions for the implementation of energy transition in Europe** at bilateral, regional and European level: regional cooperation on CO_2 pricing?, cross-border RES auctions ?...
4.	**A political deal between the two countries?** Germany could commit to a CO_2 minimum price, France to reducing its nuclear generation capacity -> Result: Emissions decrease, markets could refinance all low-carbon assets *and* electricity trade would be more balanced in both countries.

Key findings



1. **With the growth of renewable energy, France and Germany are facing common challenges regarding the restructuring of their conventional power plant fleet.** With a renewable electricity target of 40% in France and 65% in Germany by 2030, the two countries will significantly increase their production of wind and solar energy. Their conventional power plant fleet will have to be resized accordingly to avoid stranded costs.

2. **In France, the targeted development of renewable energy alongside the reinvestment in the nuclear fleet greater than 50 GW would pose a significant risk of stranded costs in the electricity sector.** A nuclear fleet exceeding 40 GW in 2030 would increase the national electricity export surplus and additionally postpone the achievement of the objective of reducing the share of nuclear power to 50% to beyond 2030. The profitability of a nuclear fleet that is greater than 50 GW would not be assured in 2030, even when assuming a 60% increase in French export capacity, a doubling of interconnectors capacity in Europe and a CO_2 price of 30 euros per ton of CO_2.

3. **In Germany, achieving climate targets requires a halving of coal-fired power generation and an increase in the national renewable electricity target to at least 60% of electricity consumption in 2030.** In this case, Germany's electricity trade balance with its neighbours is balanced. The new planned target of 65% renewable energy in electricity consumption by 2030 will ensure that Germany will not depend on undesired electricity imports while phasing-out coal.

4. **France and Germany should rapidly define their national strategies regarding their nuclear and coal fleets, closely consult each other on cross-border consequences and initiate joint actions for the implementation of the energy transition at bilateral, regional and European levels.** These joint actions could take the form of initiatives led by the two countries on the development of renewable energy, interconnectors or CO_2 pricing.

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