

Europe's Coming Challenges in Meeting Decarbonisation Objectives

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EPRI-IEA Workshop on Challenges in Electric Sector Decarbonisation

28 September 2015, Paris



EU electric sector will be driven by renewables

■ Many questions remain:

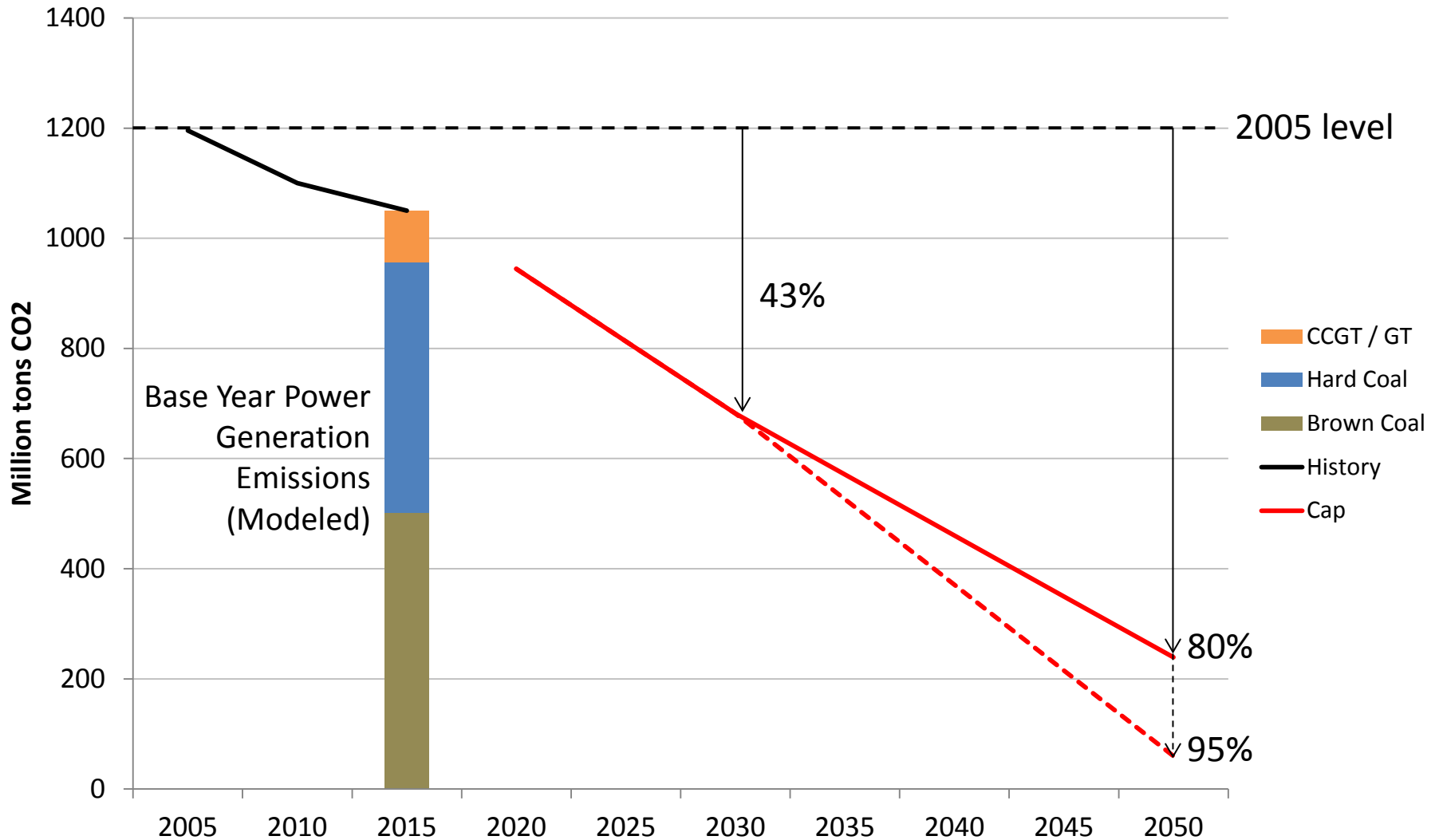
- How far and how fast?
- What mix of wind and solar?
- What regional distribution?
- What technologies will balance the system?

**Depends on national policies
vs. EU-wide implementation**

■ Implications for conventional capacity:

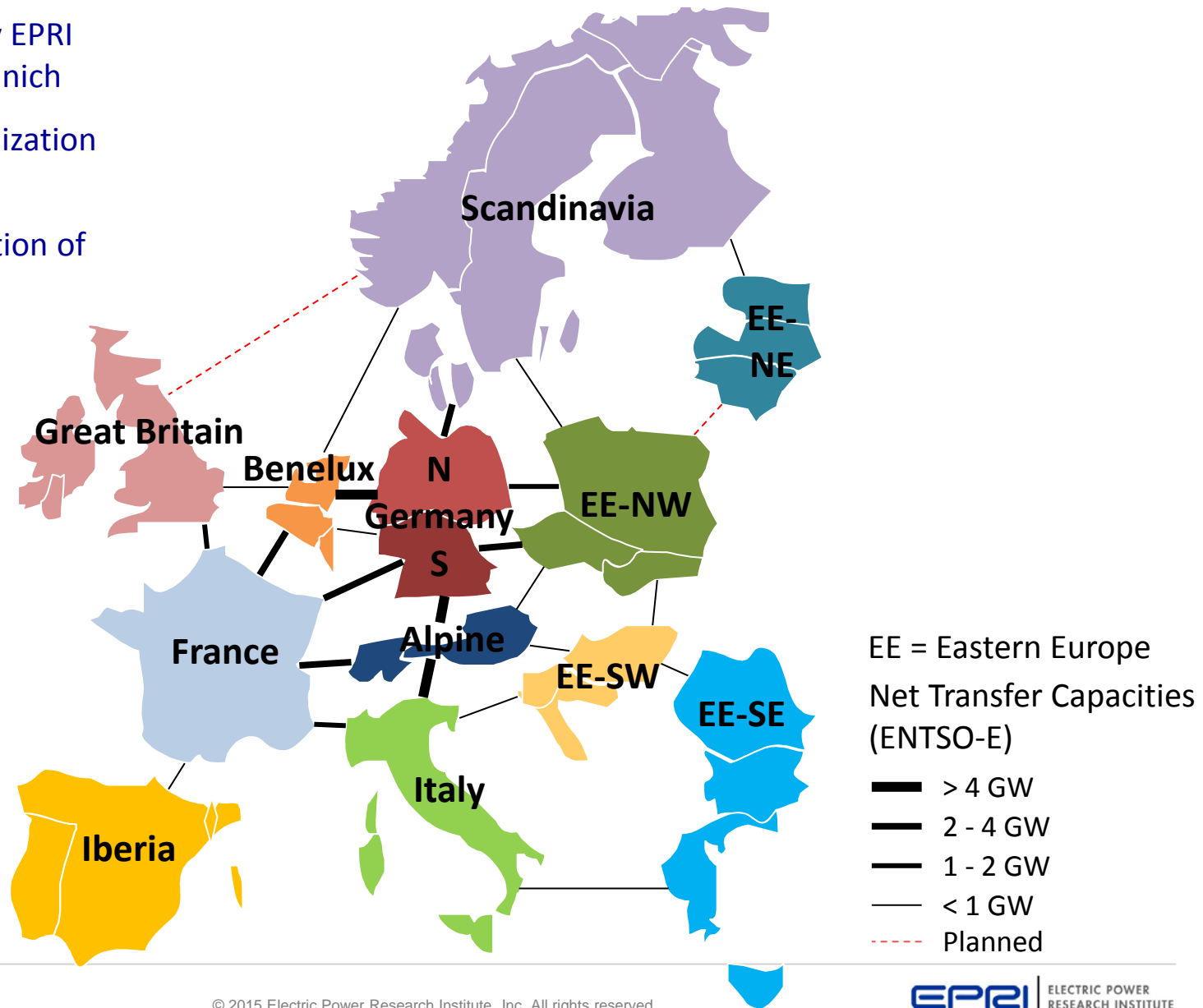
- How much currently installed fossil capacity is “slack”?
- What value will existing fleet provide in the future?
- What about new investments?

Power Sector Under the EU-ETS



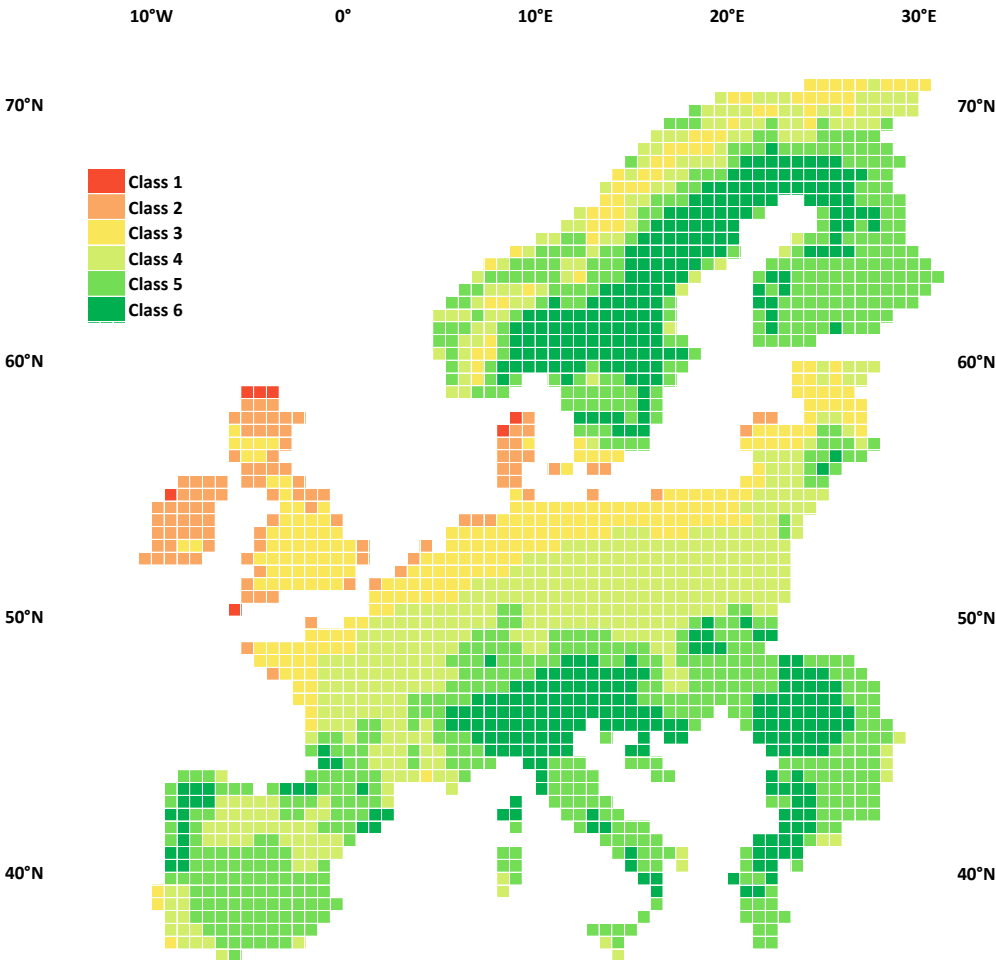
EU-REGEN Model of Electricity Investment/Dispatch

- Jointly developed by EPRI and Ifo Institute, Munich
- Intertemporal optimization through 2050
- Detailed representation of renewable profiles

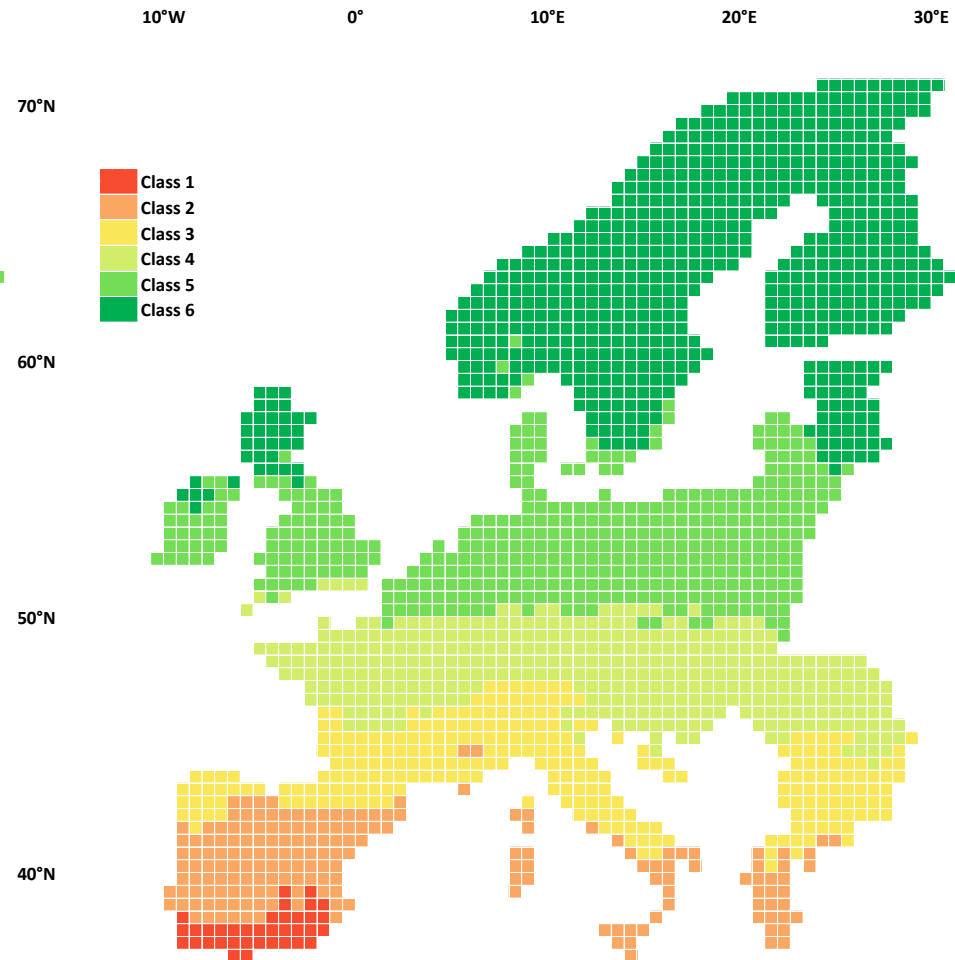


Renewable Resource Distribution

Wind (on-shore)



Solar



Based on MERRA reanalysis hourly dataset from US NASA, 1979-2013

Regional System Adequacy (one definition)

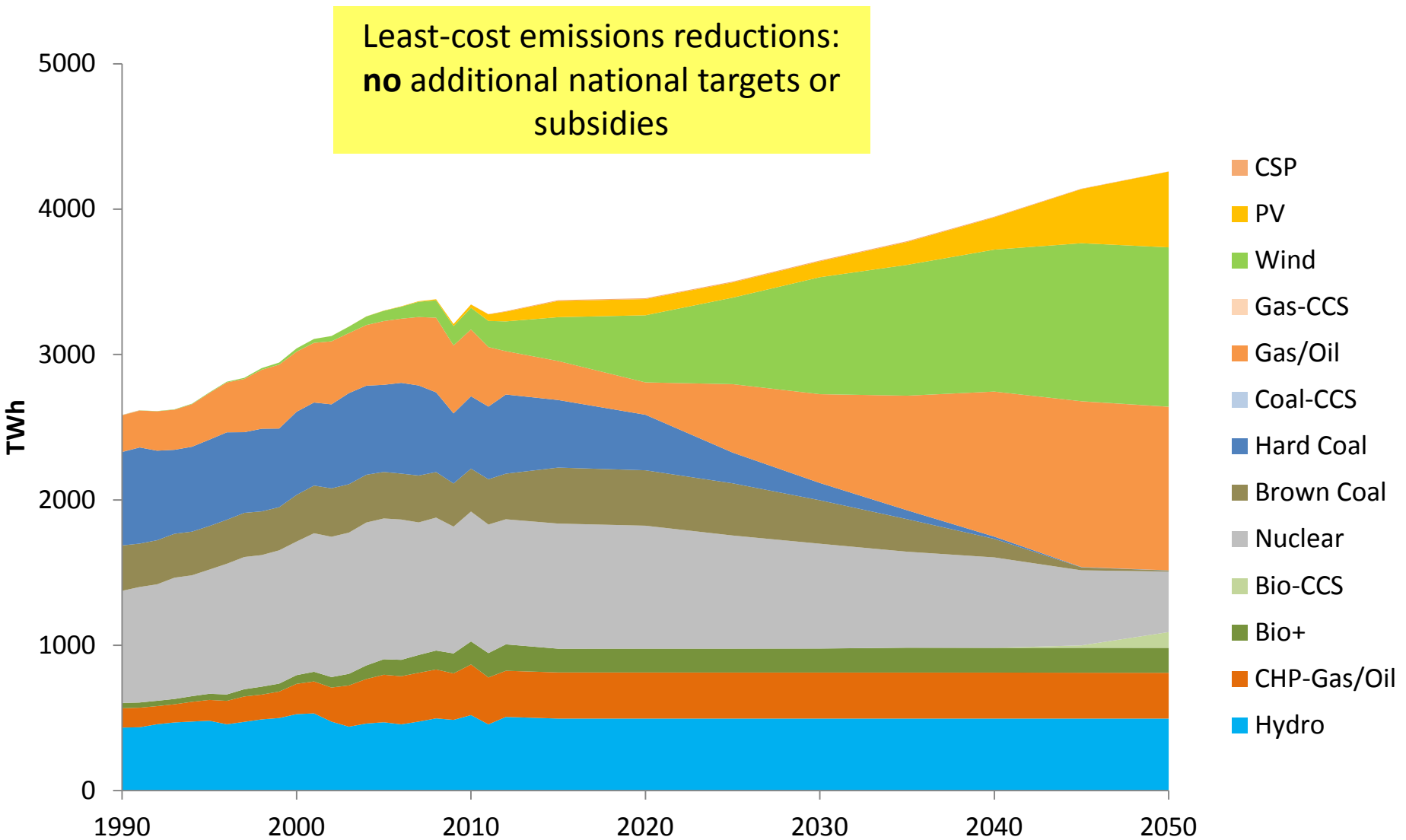
- Market-clearing condition requires that supply equal demand in each segment/hour in each region:

$$\text{Non-Intermittent Dispatch} + \text{Net Discharge from Storage} + \text{VRE feed-in} + \text{Net Imports} = \text{Load} * (1 + \text{loss})$$

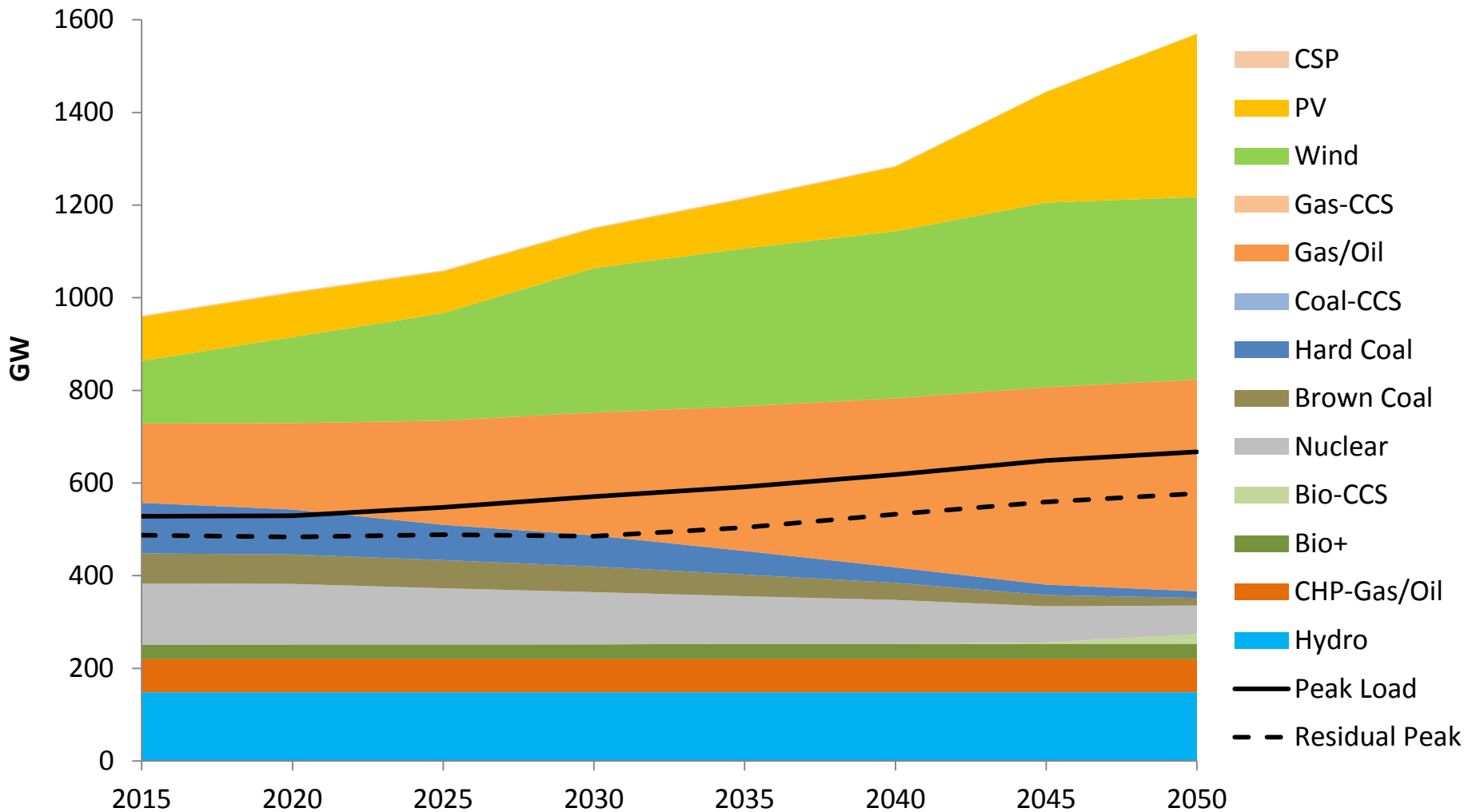
- We include an additional constraint that local available non-intermittent capacity must be sufficient to meet peak load:

$$\text{Non-Intermittent Available Capacity} + \text{Storage Discharge Capacity} = \text{Peak} * (1 + \text{loss})$$

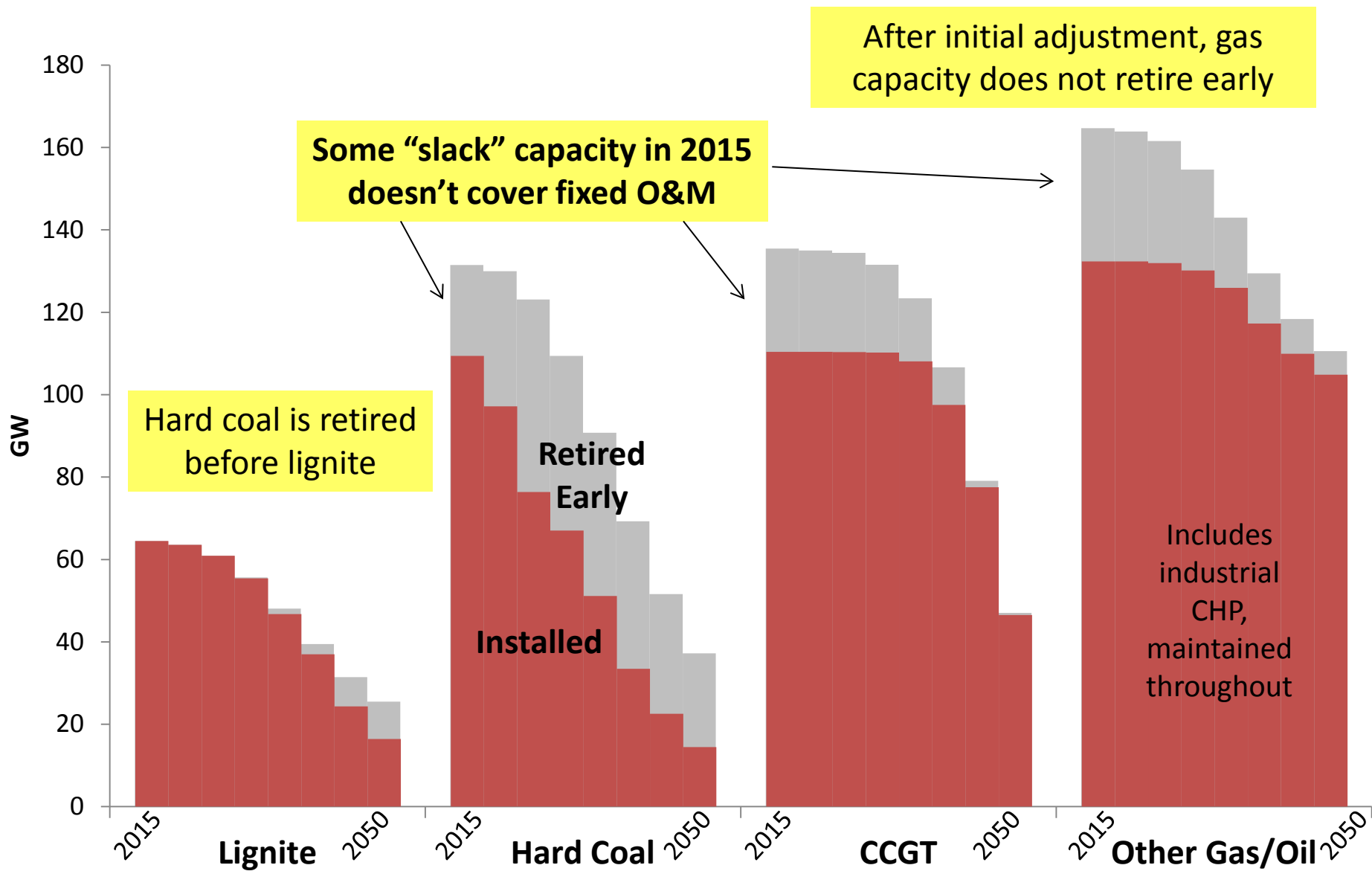
EU Generation Mix: 80% by 2050 Policy



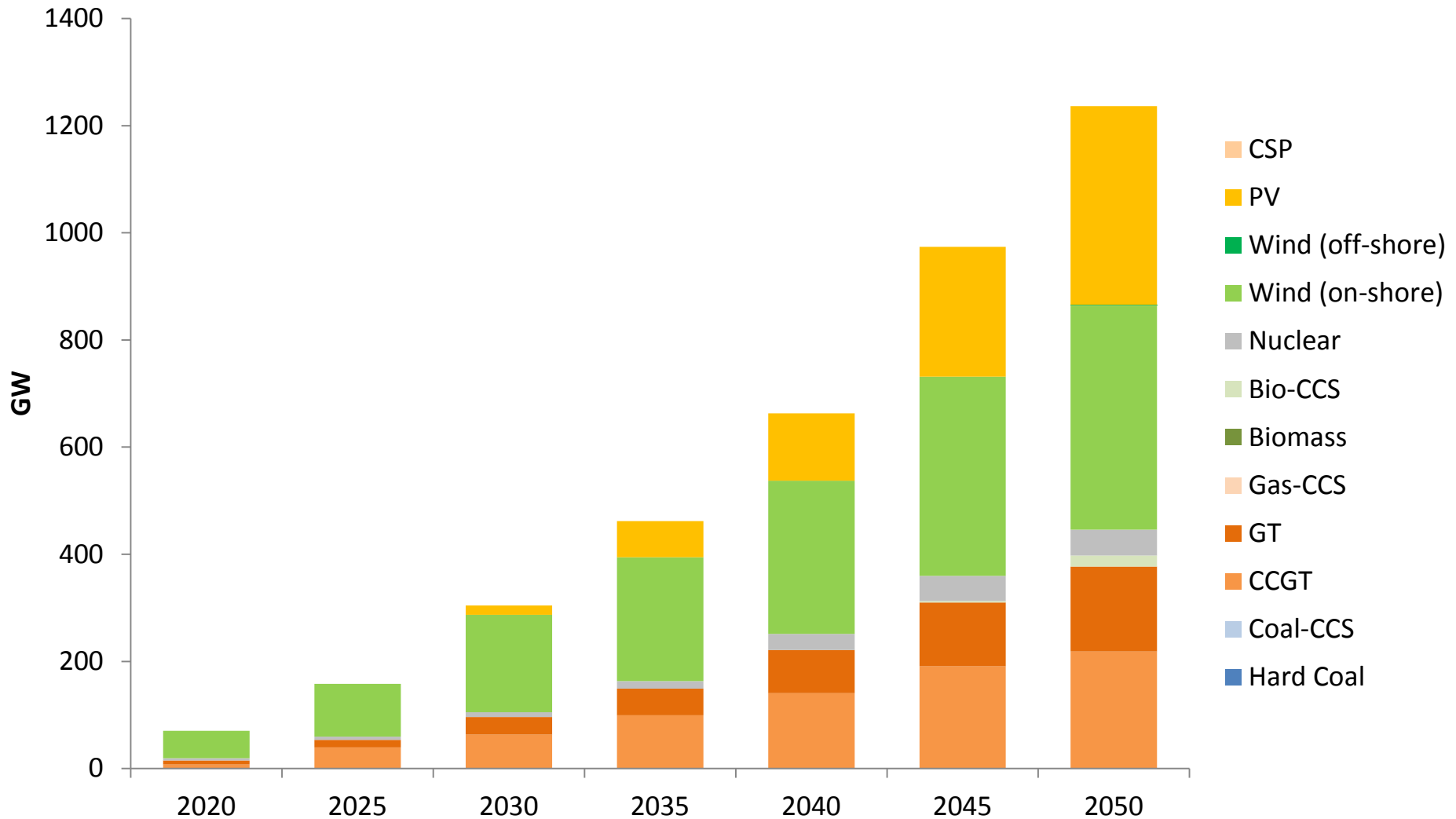
EU Installed Capacity: 80% by 2050 Policy



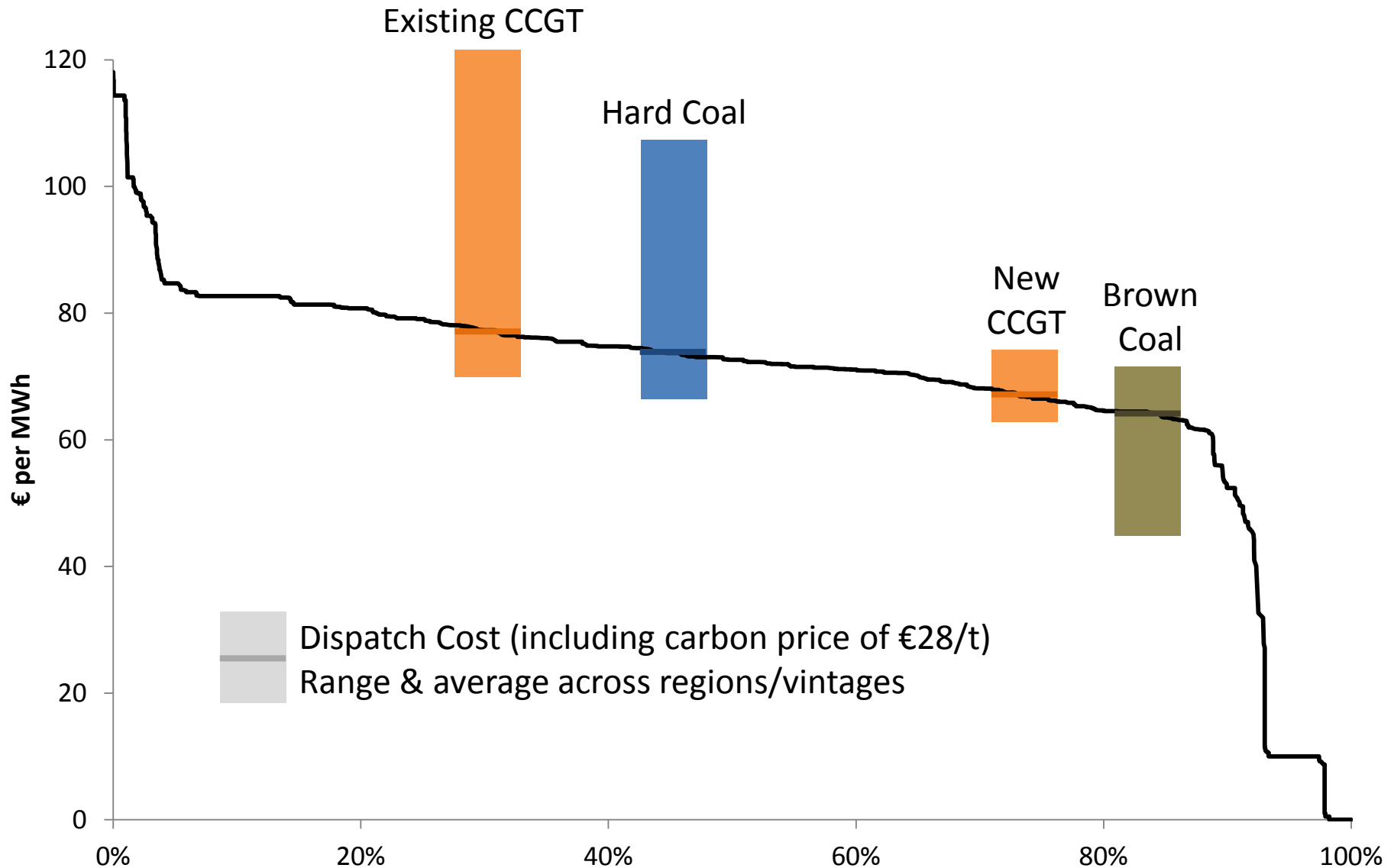
EU Fossil Capacity 2015-2050



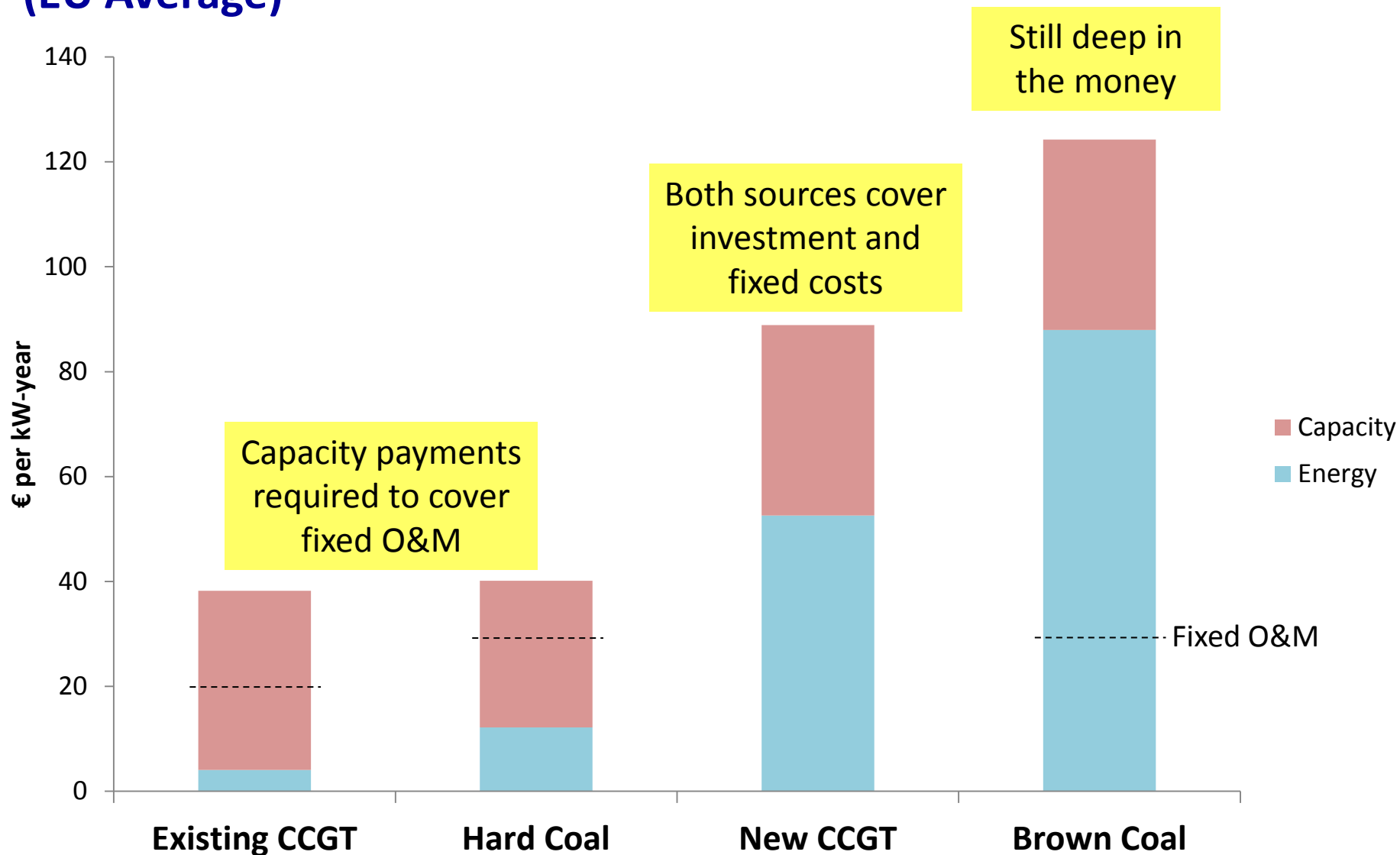
EU Cumulative New Capacity Investments



Energy-Only Price Distribution in EU, 2030



Net operating revenue from energy and capacity, 2030 (EU Average)



Conventional capacity under decarbonisation

- Coal/lignite plants will inevitably scale down production
- However, generation falls faster than installed capacity
 - Some units retire early, many stay online
 - Fewer hours, lower margins in energy market
 - Capacity payments are crucial for managing this transition
- Natural gas capacity (both CCGT and GT) expand
 - Hours for CCGT increase, even with rising renewable share
 - Still, approximately half of new CCGT net operating revenue from capacity payments
- Nuclear declines overall, only grows in East
- CCS only plays role with 95% target, even then only with bioenergy or gas – coal CCS is far out of the money

Important factors not modeled here = Ongoing research priorities

- Operational constraints
 - Unit commitment, especially start-up and shut-down costs
 - Voltage and frequency stabilisation, system inertia
- Interaction with demand side
 - Changing end-use mix could significantly change load shape
 - DSR may be a cost-effective contributor to capacity needs
- Coupling with other sectors
 - Economics of CHP under carbon constraint
 - “Power to X” technologies (e.g. hydrogen, heat)

EPRI Webinar on EU Electric Sector Scenarios

- November 2015, TBC
- Explore other results and scenarios with EU-REGEN, e.g.
 - Role of renewable technologies, national targets
 - Transmission scenarios
 - Regional details
 - Storage
 - Unit commitment constraints
- See EPRI staff for more information



Together...Shaping the Future of Electricity

Extra Slides

Regional Generation Mix (TWh) (80% by 2050)



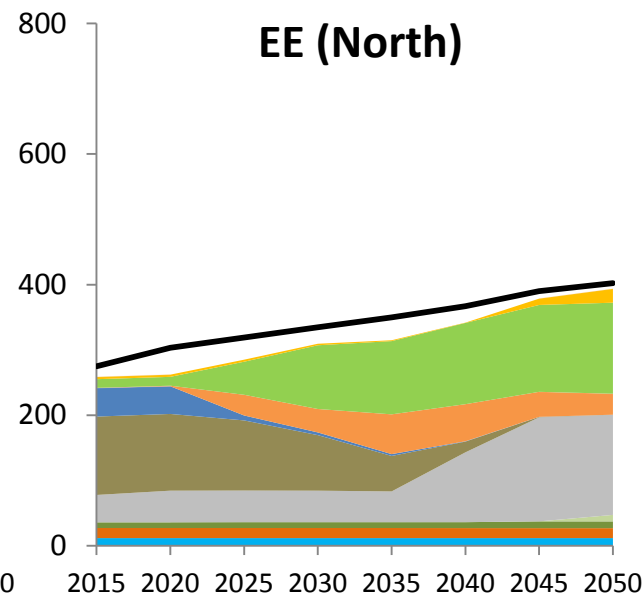
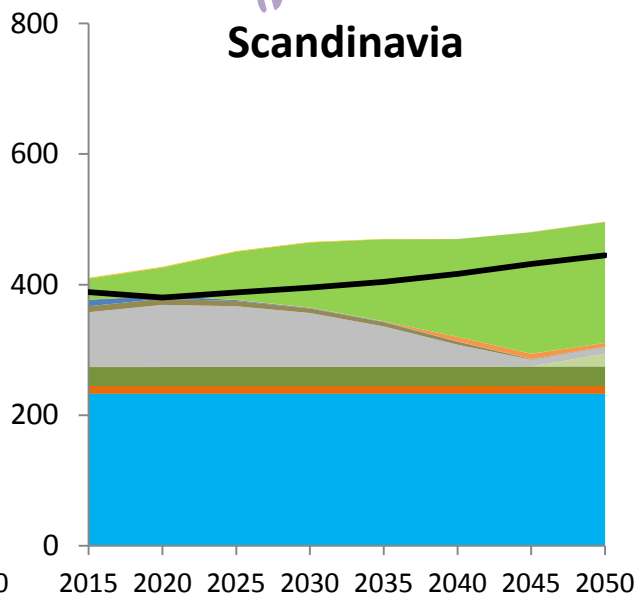
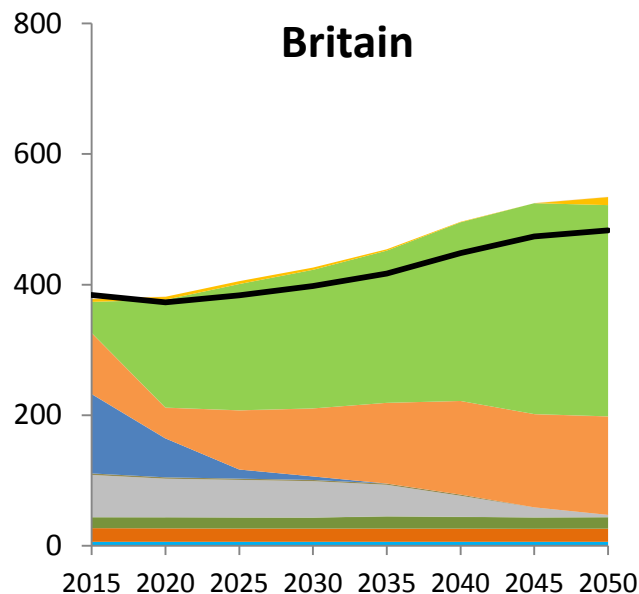
Britain



Scandinavia



EE (North)



- Hydro
- CHP-Gas/Oil
- Bio+
- Bio-CCS
- Nuclear
- Brown Coal
- Hard Coal
- Coal-CCS
- Gas/Oil
- Gas-CCS
- Wind
- PV
- CSP
- Energy for Load

Regional Generation Mix (TWh) (80% by 2050)



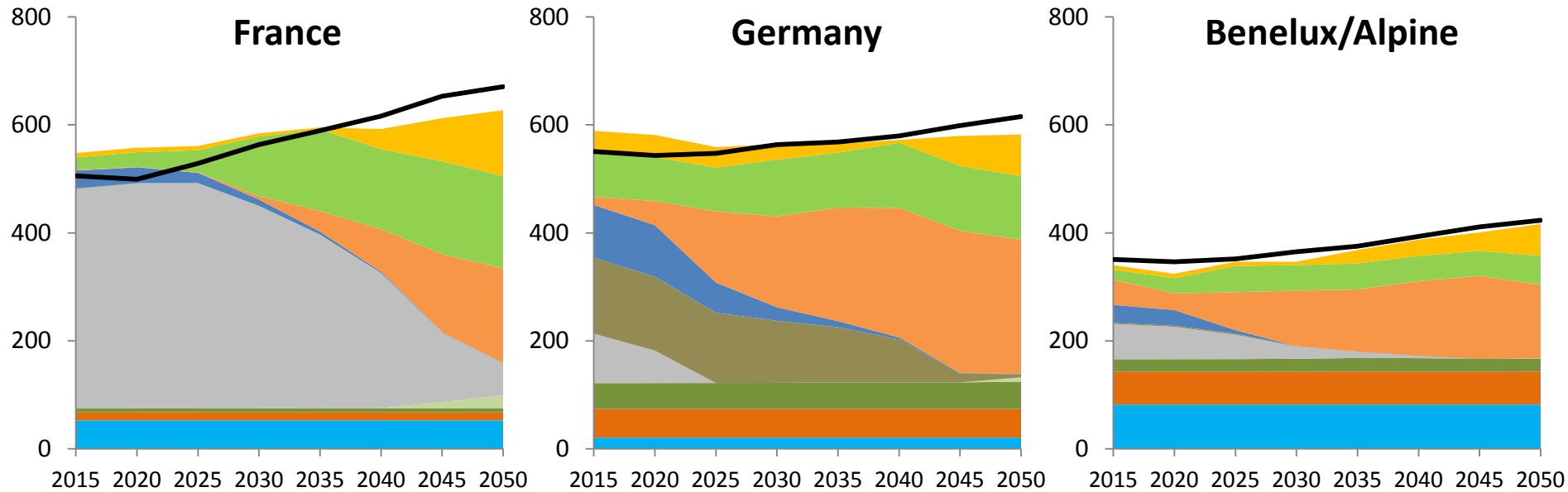
France



Germany



Benelux/Alpine



- Hydro
- CHP-Gas/Oil
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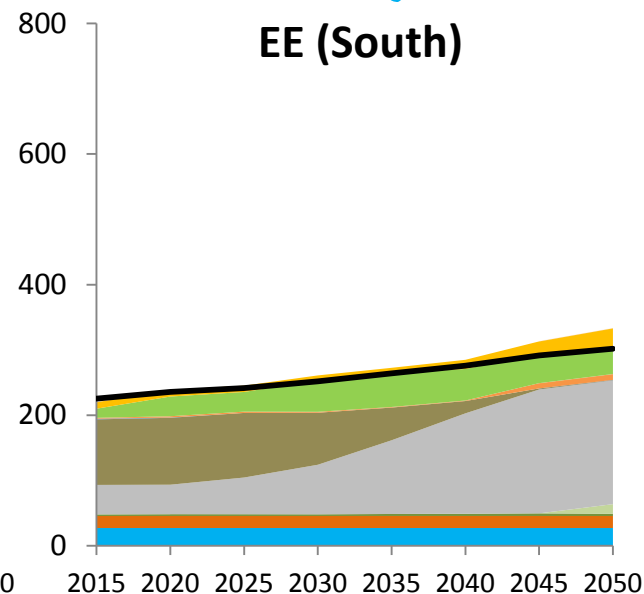
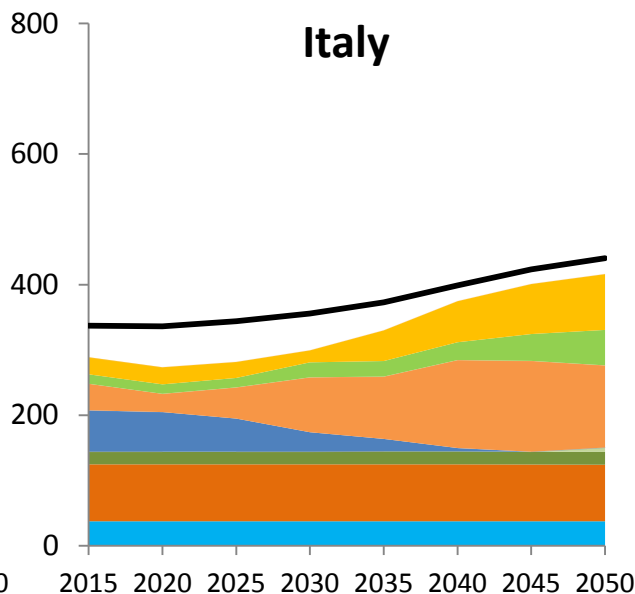
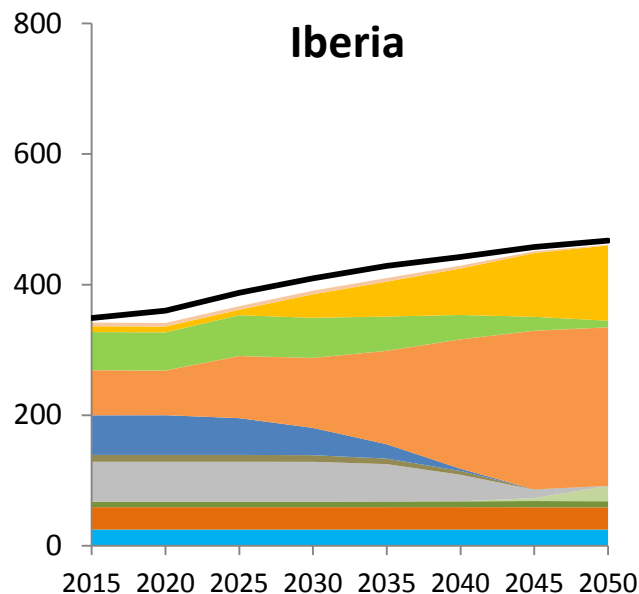
Iberia



Italy

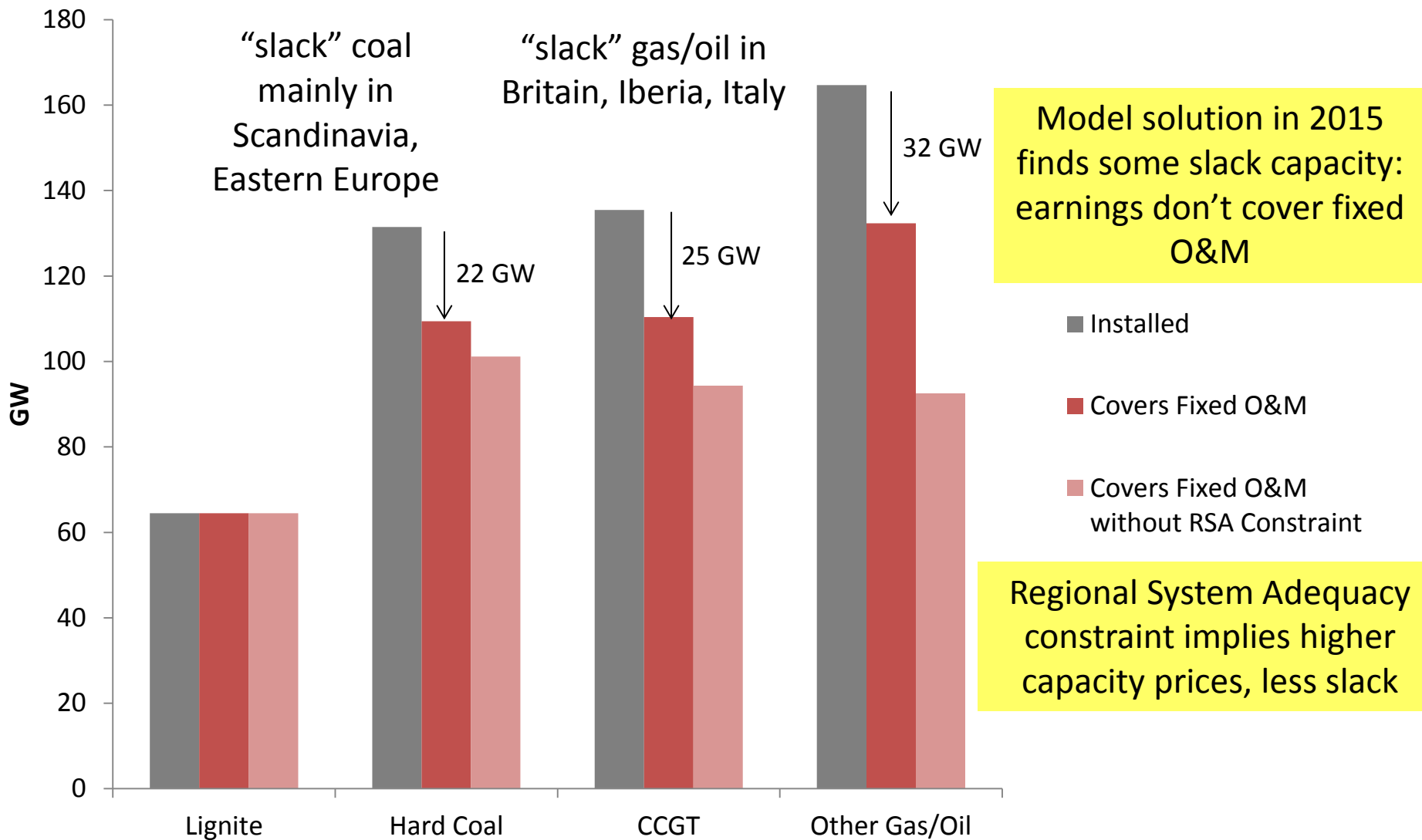


EE (South)

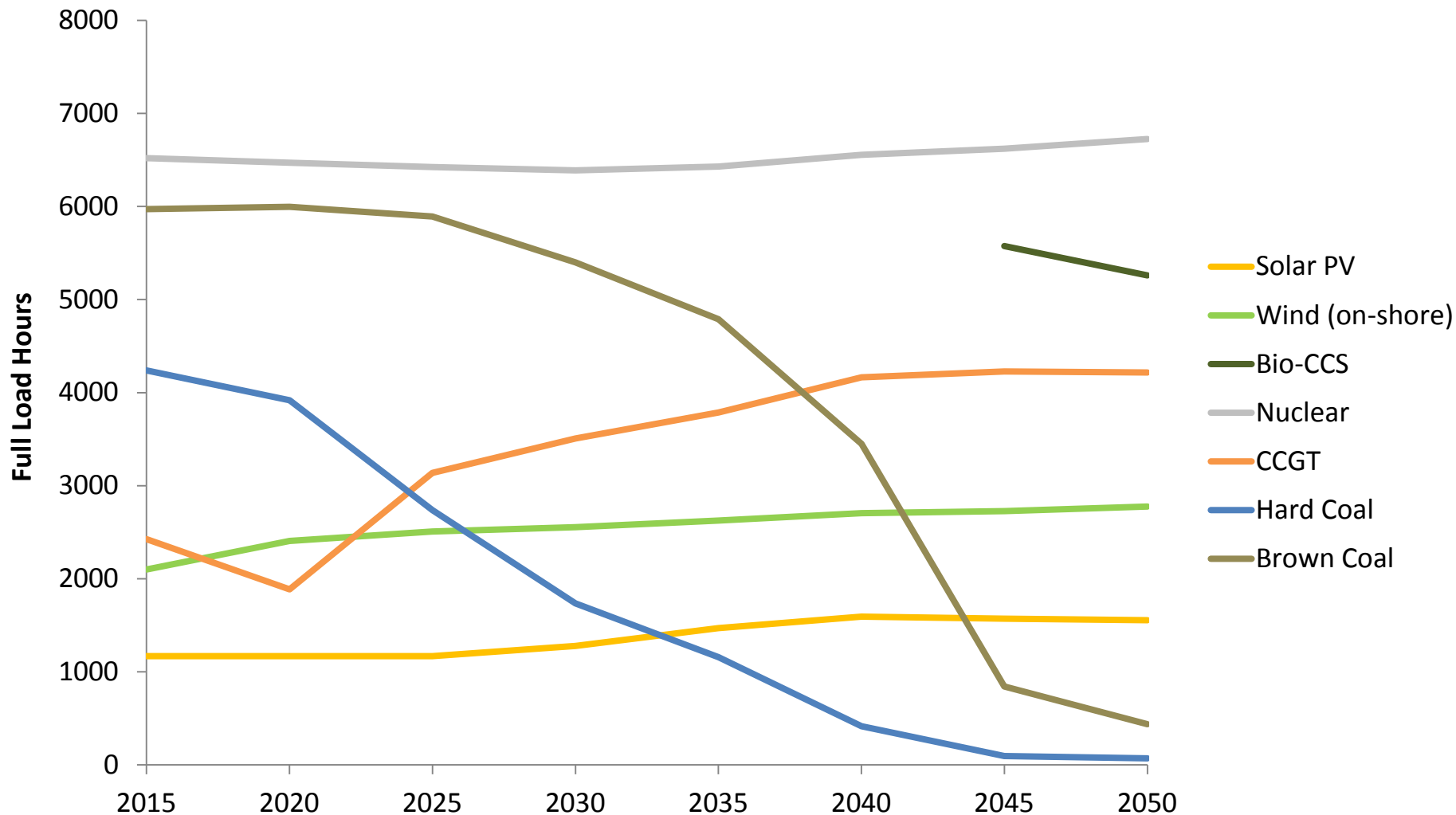


- Hydro
- CHP-Gas/Oil
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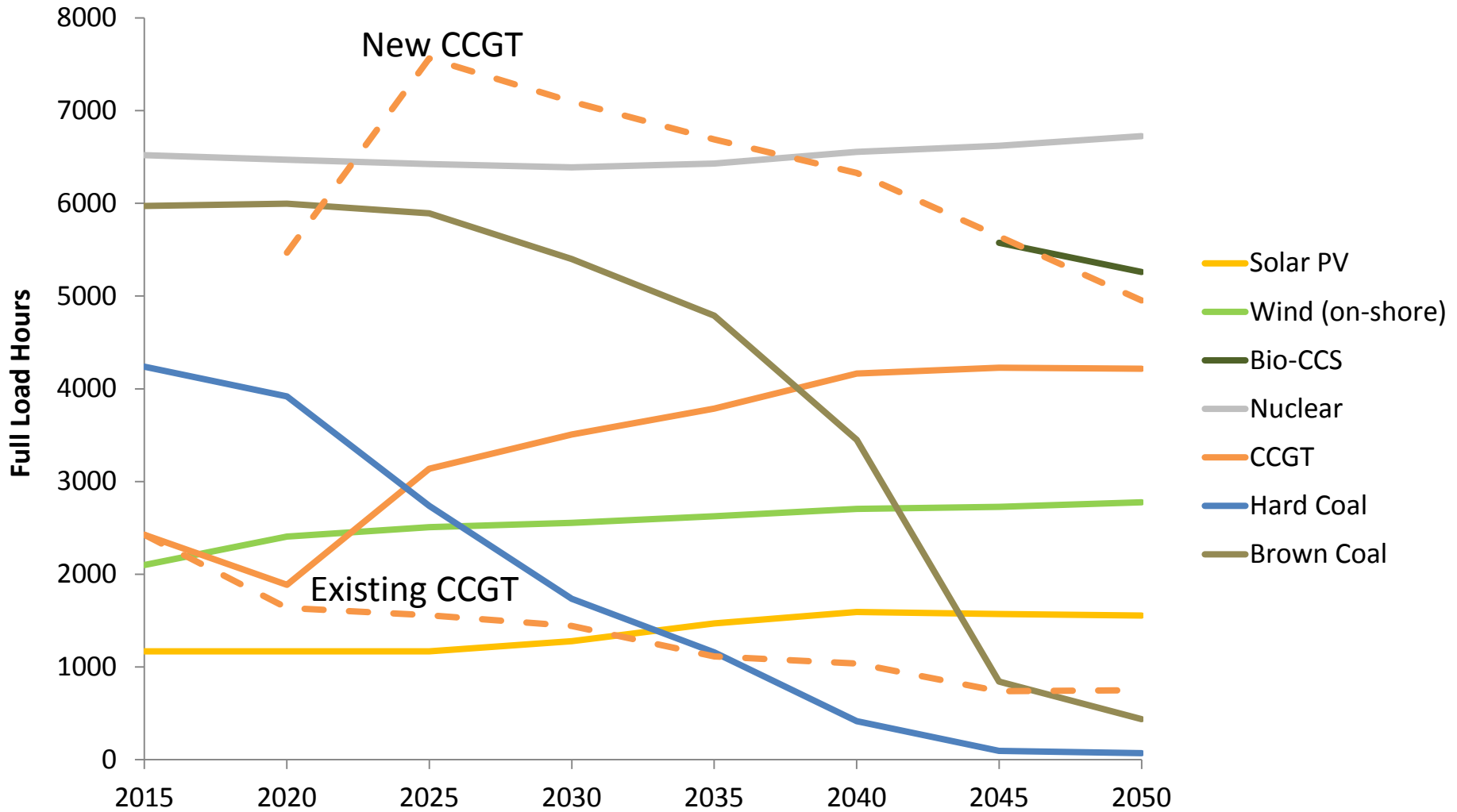
EU Fossil Capacity in 2015: Over-subscribed?



EU Average Full Load Hours by Technology



New CCGT is much lower in the stack



“Efficient” Role of Renewables in EU

- Wind in North is most valuable renewable resource
- Solar in South is competitive (with a carbon price) when costs are lower than:
 - ~1000 euro/kW for PV
 - ~3000 euro/kW for CSP (with 2.5x solar multiplier)
- Least-cost mix involves mainly on-shore wind in Britain, Scandinavia, France, and Baltic / North Sea coasts
- Wind and solar reach maximum generation share ~33%
- This mix could be superseded by national objectives