Quantifying the Impacts of National Renewable Electricity Ambitions using a North-West European Electricity Market Model

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China

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Overview

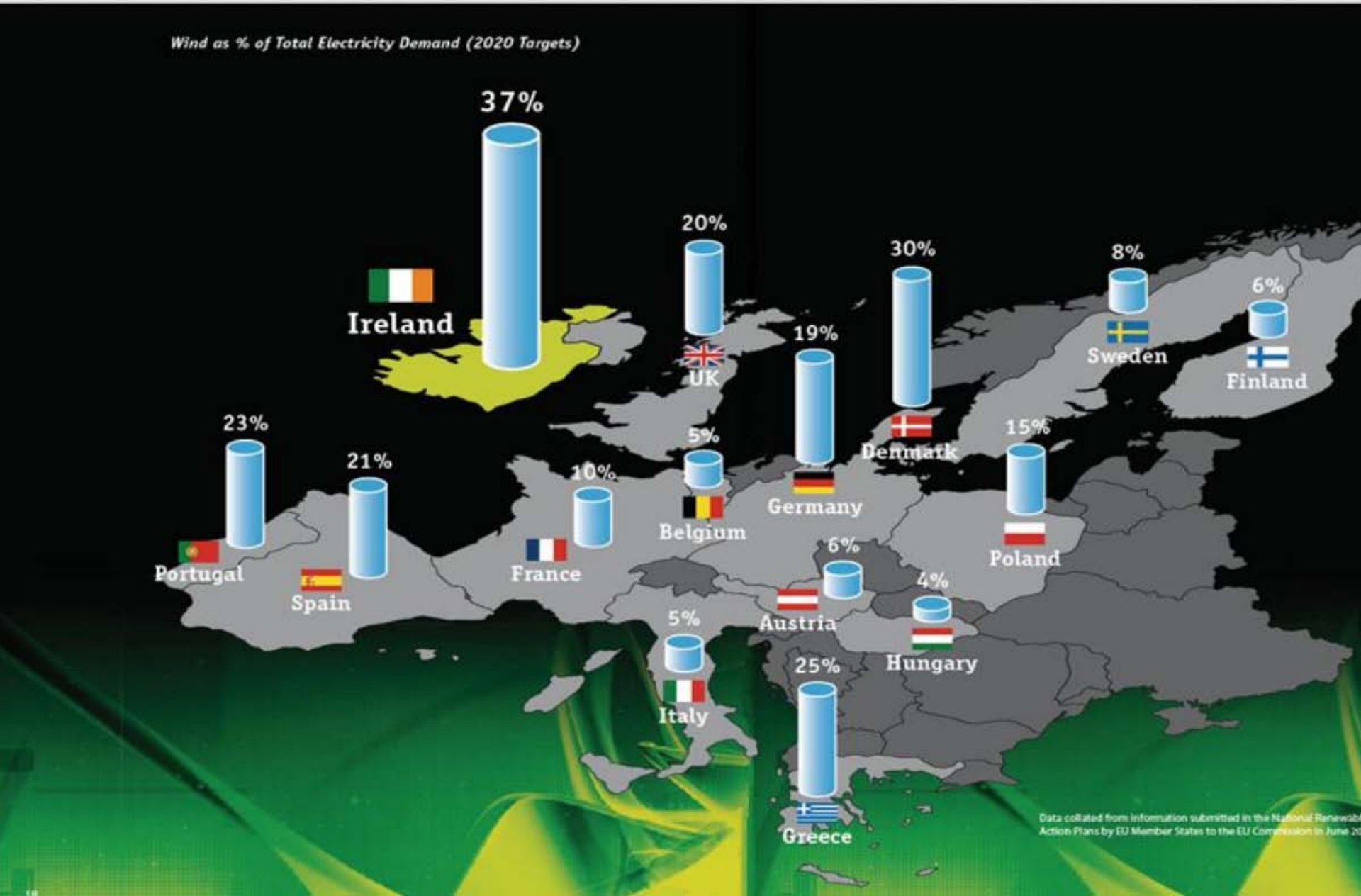
- National Renewable Energy Action Plans 2020
  - focus on renewable electricity
  - Plans formulated independently of each other
- Modelling the impacts at a regional level
  - PLEXOS
  - Interconnection
  - emissions, congestions, imports / exports, electricity prices
- Conclusions
  - Value of targeted modelling

NREAPs

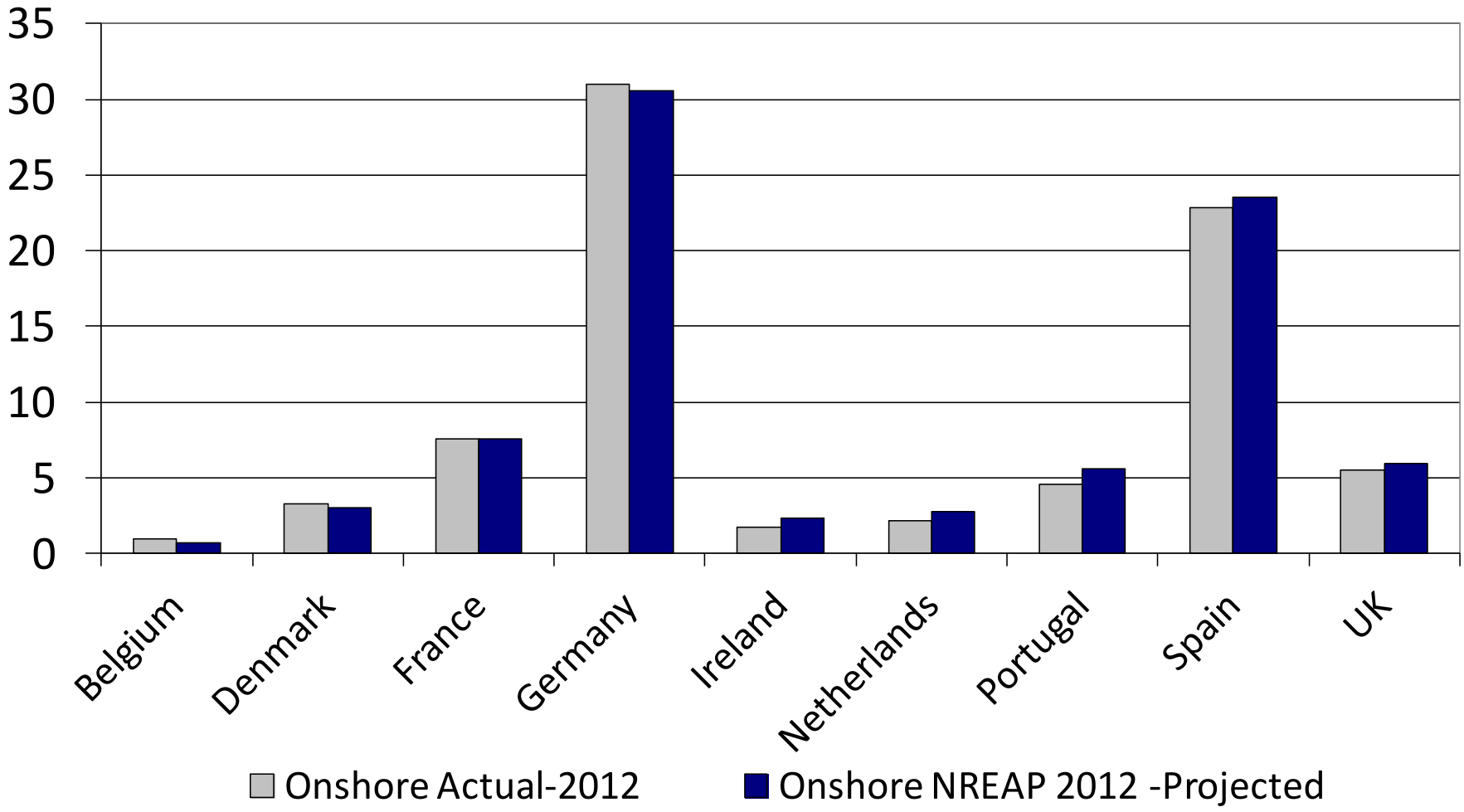
- Article 4 of the renewable energy Directive (2009/28/EC) – regarding National Renewable Energy Action Plans (NREAPs)

- ……*they set out how each Member State expects to reach its legally binding 2020 target for the share of renewable energy in their final energy consumption.*

Wind as % of Gross Electricity Demand 2020



Onshore Wind 2012 (installed Capacity GW)



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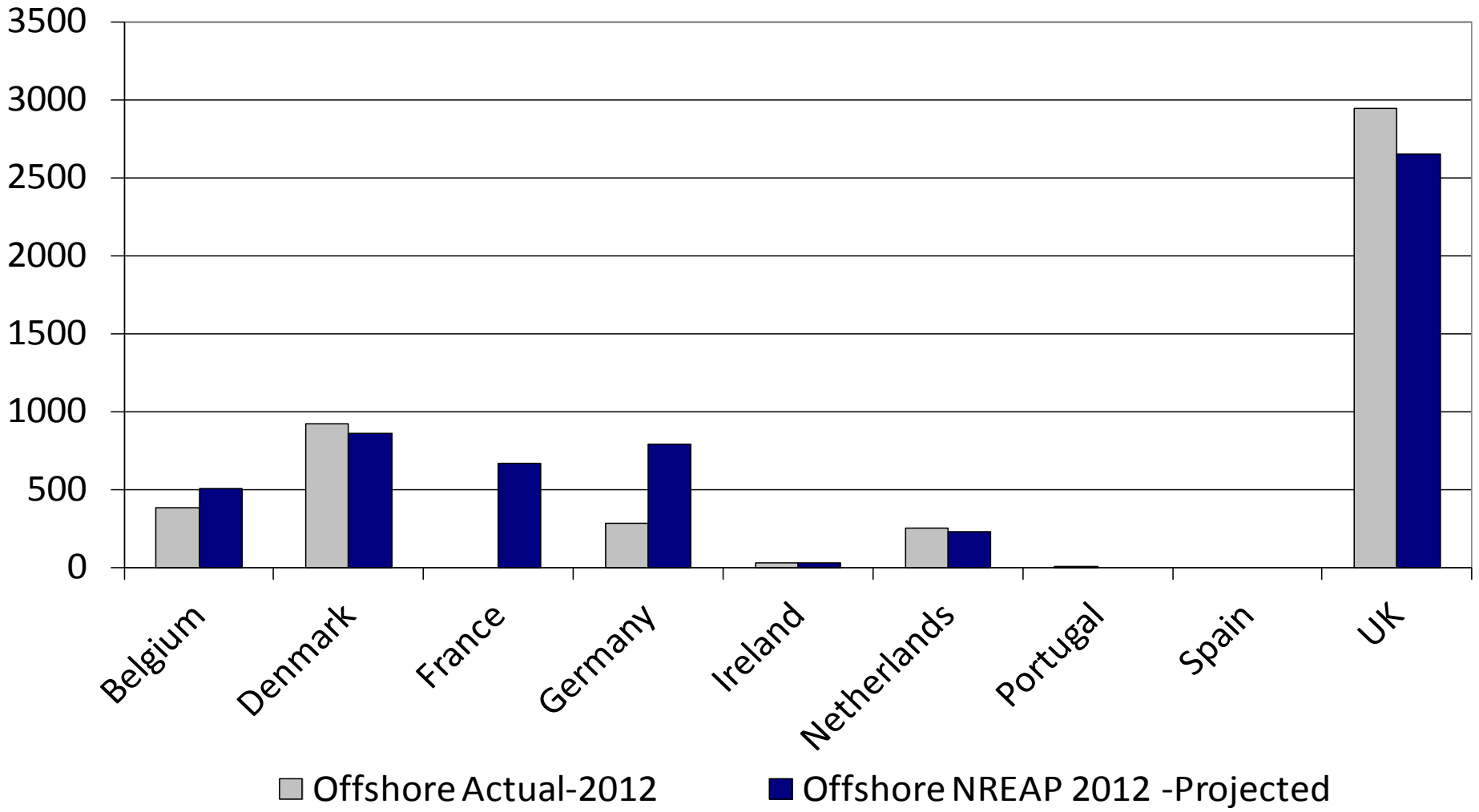
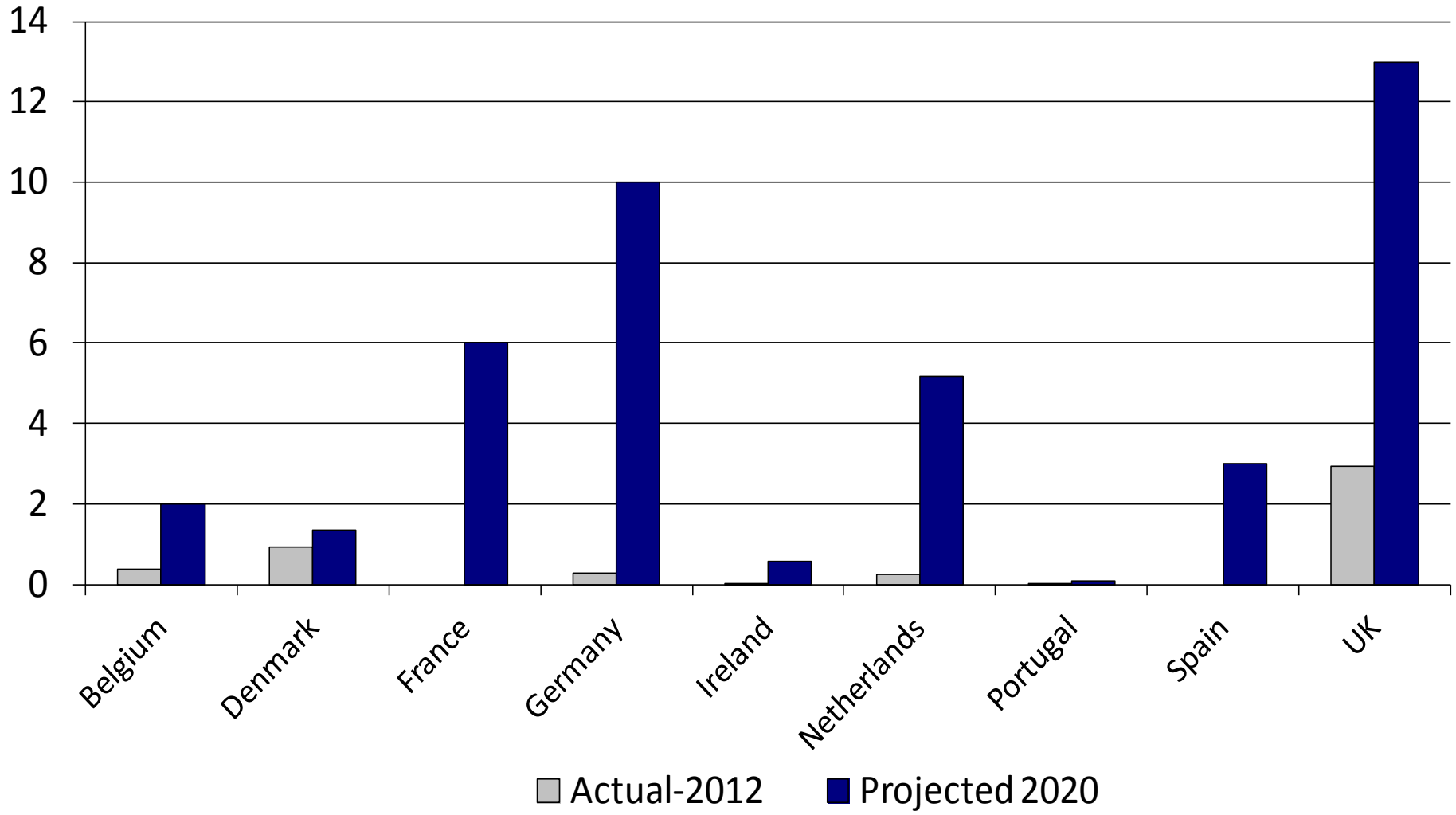
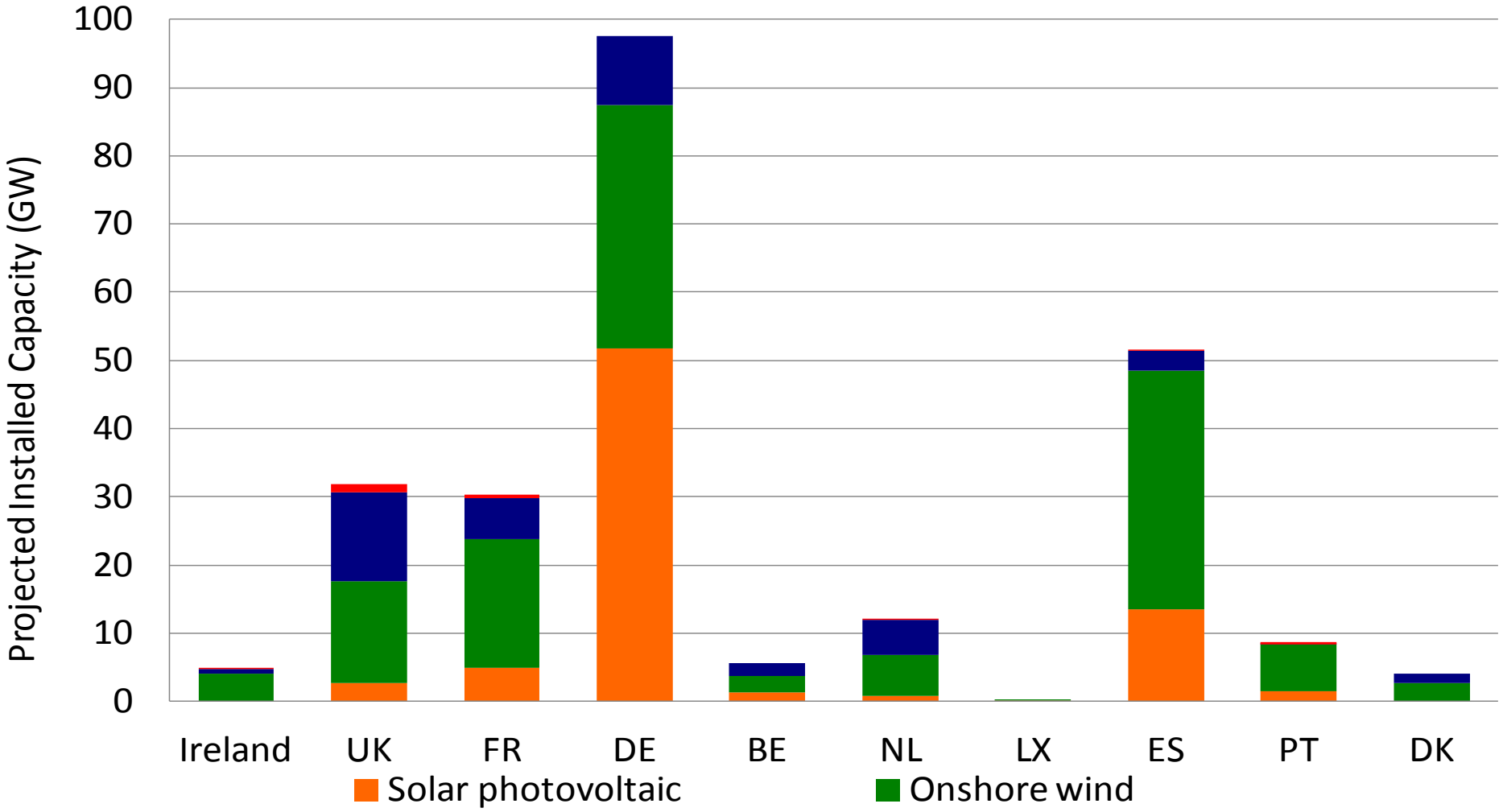


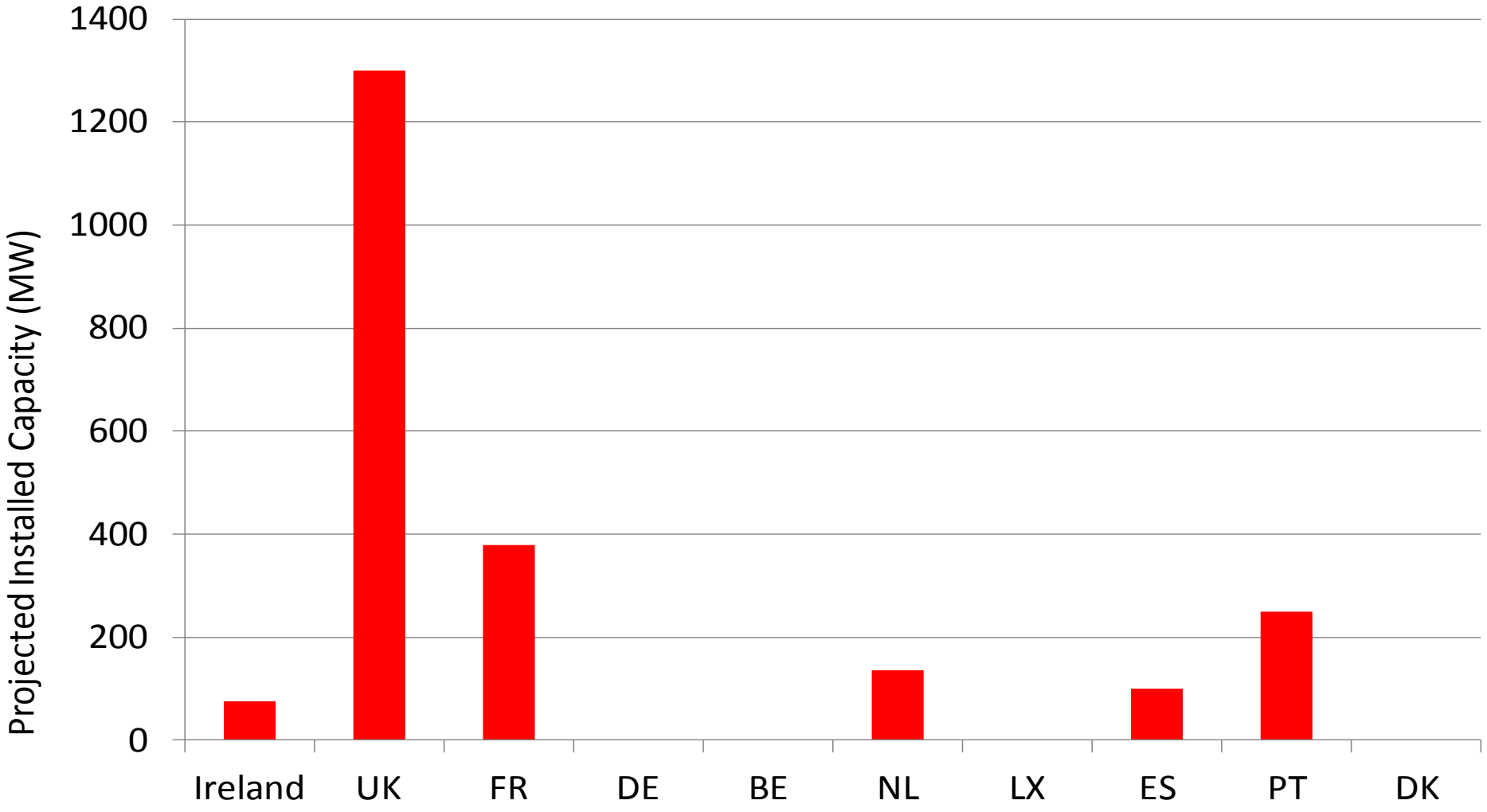
Offshore Wind 2012 vs 2020 (installed Capacity GW)



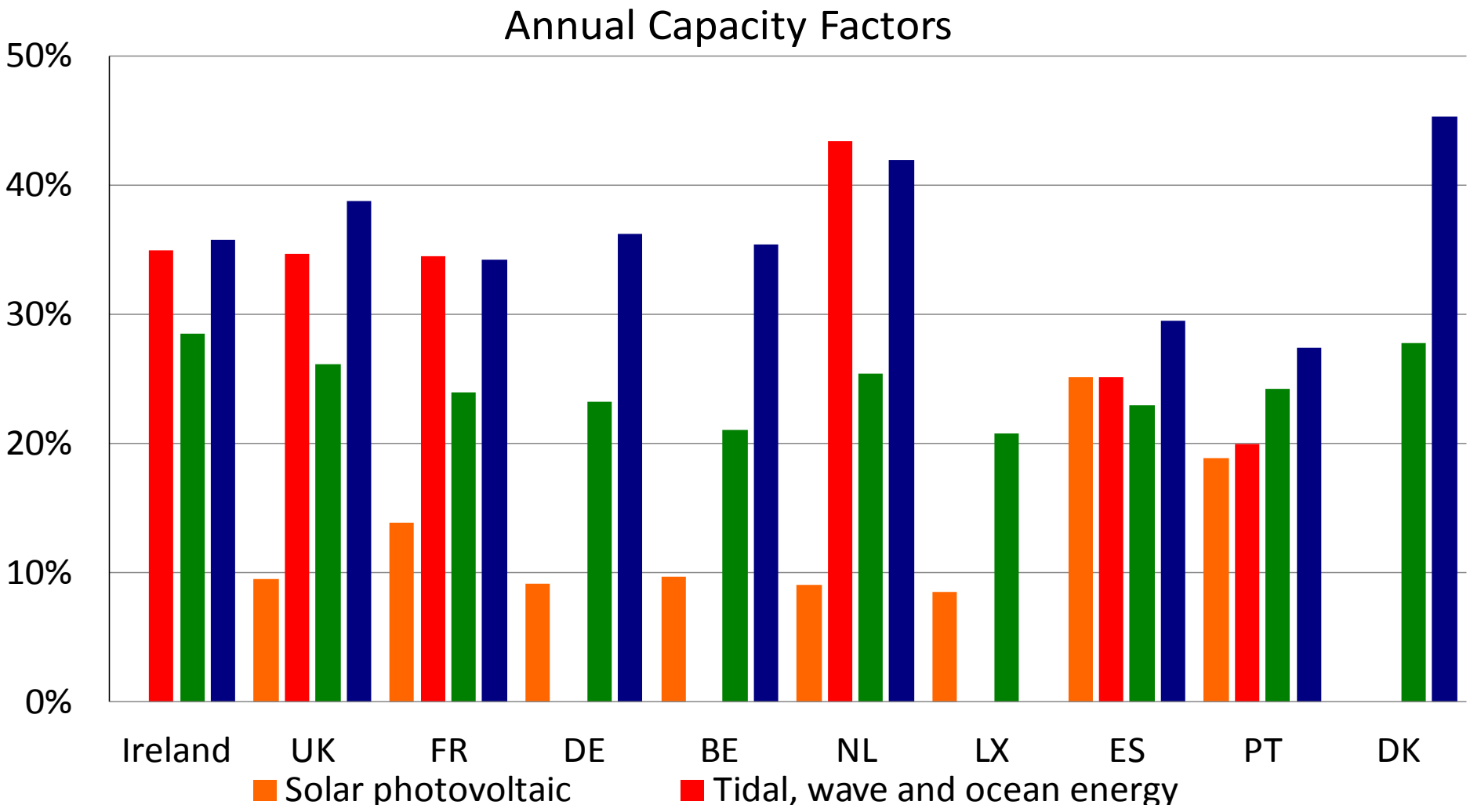
Selected NREAP 2020 RE Capacity (GW) Targets



NREAP 2020 Ocean Energy (MW) Targets



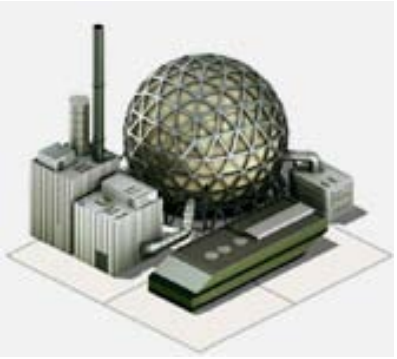
NREAP Annual Capacity Factors

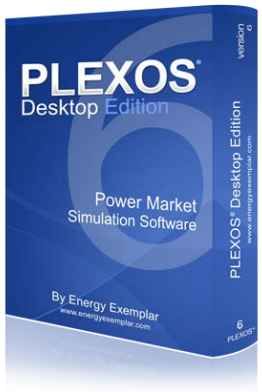


Putting all this together

Modelling Inputs

European Commission





WORLD ENERGY OUTLOOK 2012

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PLEXOS for power systems

Application	Horizon	Users	Frequency
Capacity Expansion Planning	10-30 years	Generator ISO	annual
Transmission Planning	months – years	ISO	monthly – annual
Market Analysis	months – years	Generator Regulator Load	quarterly – annual
Operational Modelling	days – months	ISO IMO Generator	5 min. – daily
Portfolio Optimisation	days – years	Generator	daily – annual

What data are required?

Component	Data
Generation	Capacity, fuel costs, efficiency, other costs, operational constraints
Transmission	Topography (nodes and lines), electrical properties of transmission elements (resistance, reactance), constraints
Load	Load profiles of customers (industrial, residential, *etc*), financial penalty of "unserved energy"

- The electric demand (load) is served by generators via the transmission network
- We need information on generation, transmission and load.
- The availability of data is highly variable across power markets: often there is little public information on generator efficiency and costs, and the transmission network
- The transmission network is often simplified to "regional" or "zonal" level

Operational Modelling

- Short timeframe (hours to days ahead)
- All market rules and known constraints modelled:
  - Transmission constraints
  - Ancillary services requirements (*i.e.* backup services), *etc*
- Key generation constraints and costs:
  - **Min Stable Level**: the minimum megawatt possible when unit is “on”
  - **Start Cost**: cost of getting a unit from “off” to MSL
  - **Fuel Cost**: cost of operating once “on”
  - **Min Up Time**: hours unit must stay up once committed
  - **Min Down Time**: hours unit must stay down after de-commitment
  - **Ramping**: maximum change in megawatt output
  - **Resource constraints**: fuel, hydro, wind
- Overall objective is maximise welfare (minimise all costs incl. VoLL)

Operational Modelling, continued

- Unit commitment (on/off) decisions are integer *i.e.* you cannot turn on half a generator!
- Accepted solution methods:
  - Lagrangian relaxation (old method)
  - Mixed integer programming (new method)
- Recent advances in algorithm speed for mixed integer programming mean it is the preferred method
- Focus of analysis depends on user/market:
  - **IMO** interested in generation commitment/dispatch schedules and prices for energy and ancillary services
  - **Generator** wants to know best self-commitment schedule (for self-commitment markets where Generators decide on/off schedules)

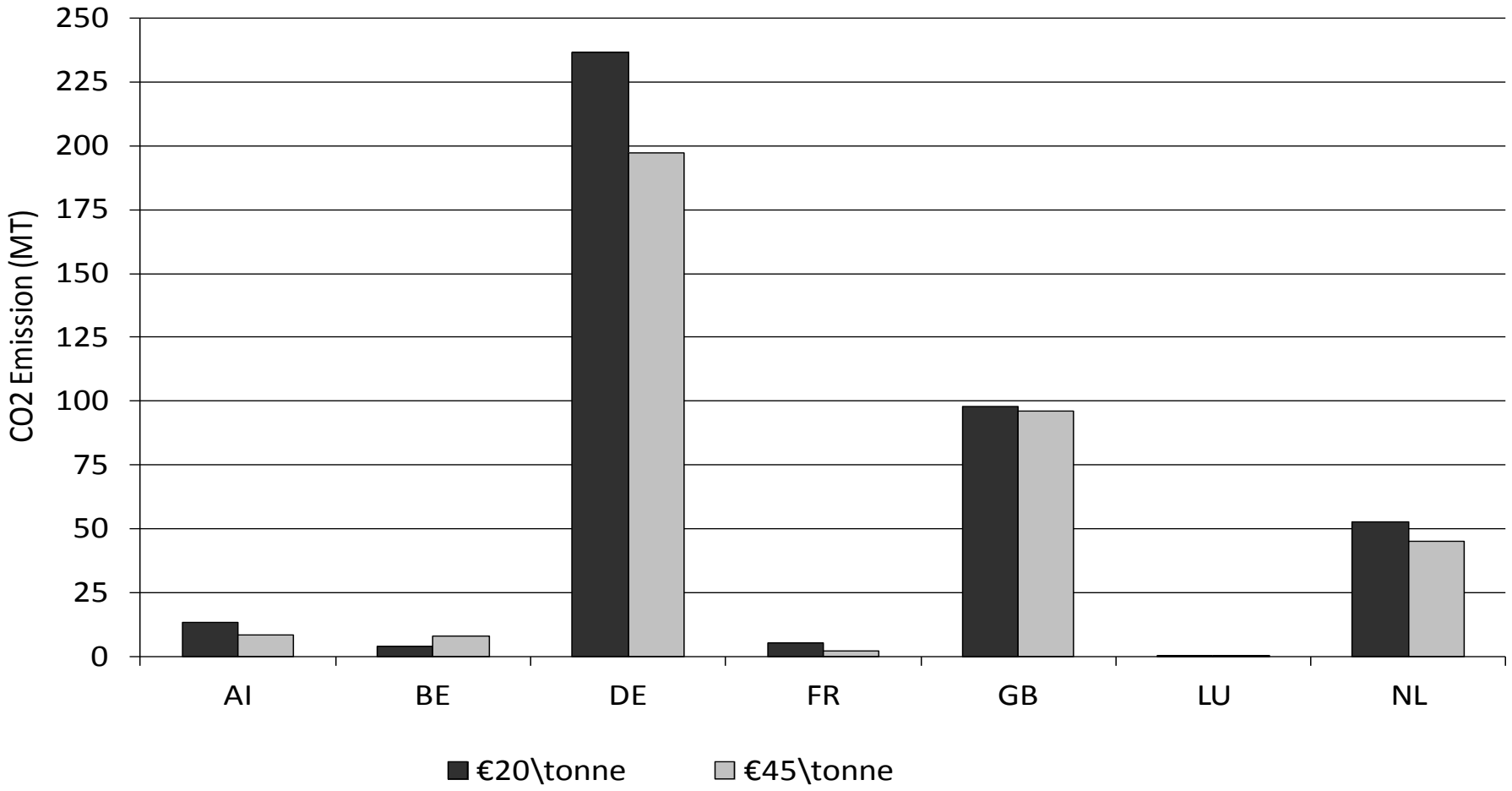

Skagerrak
Kattegat
North Sea
Vesterhavet
Denmark
Copenhagen
Sylt
Isle of Man
Dublin
Irish Sea
Ireland
United Kingdom
Muir Cheilteach
St George's Channel
Amsterdam
Netherlands
Berlin
Poland
London
Brussel
Brussels
Belgium
Germany
Prague
English Channel
Czech Republic
Guernsey
Jersey
Celtic Sea
Luxembourg
Luxembourg
Paris
Vienna
Austria
Liechtenstein
Berne
Switzerland
France
Alps
Slovenia
Zagreb
Croatia
Bay of Biscay
Bosnia and Herzegovina
San Marino
Monaco
Italy
Isola d'Elba
Adriatic Sea
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Projected New Intercnonnection 2020

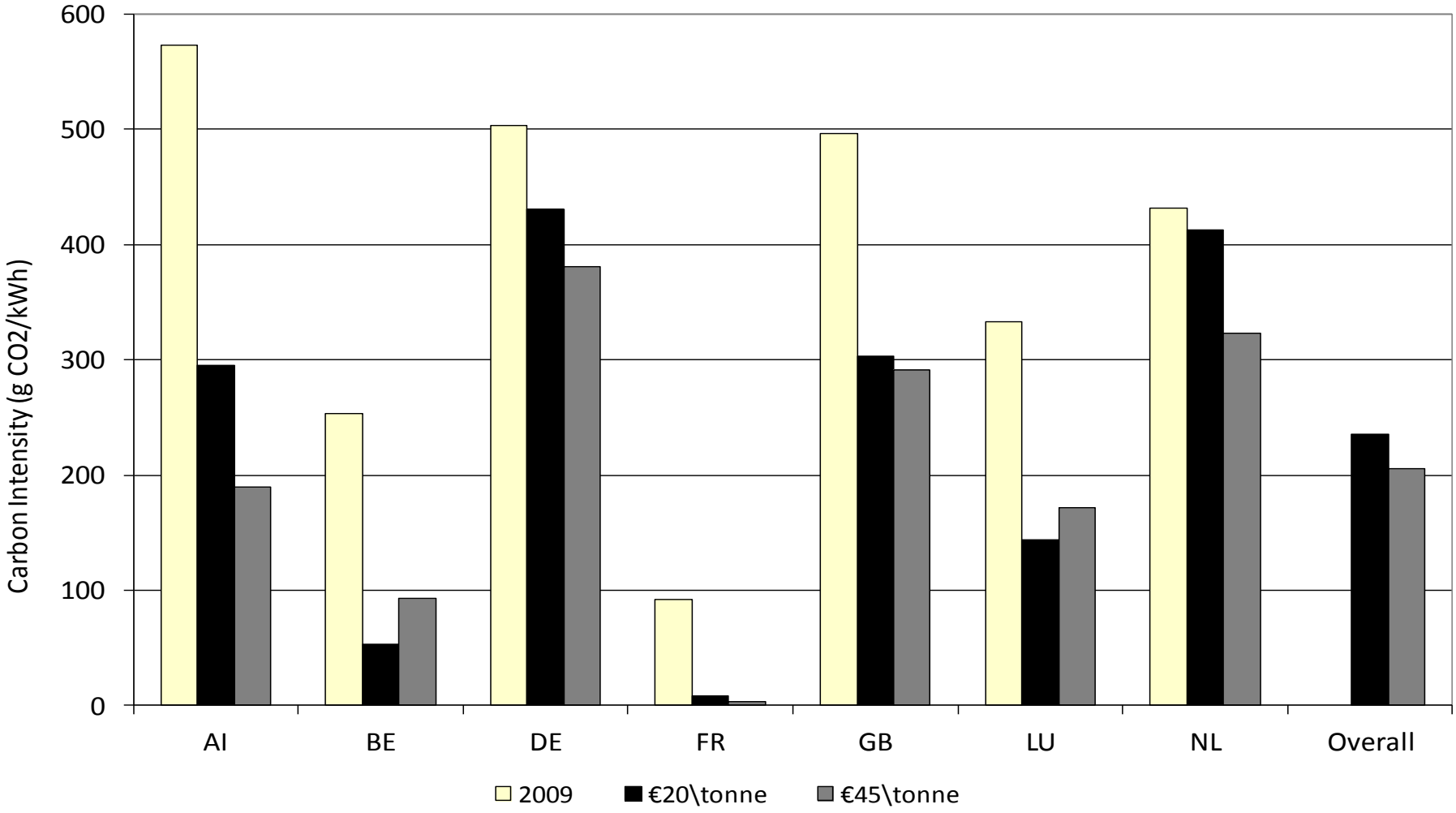
Results

- Emissions
- Flows
- Congestion
- Prices

CO_2 Emissions (Mt)



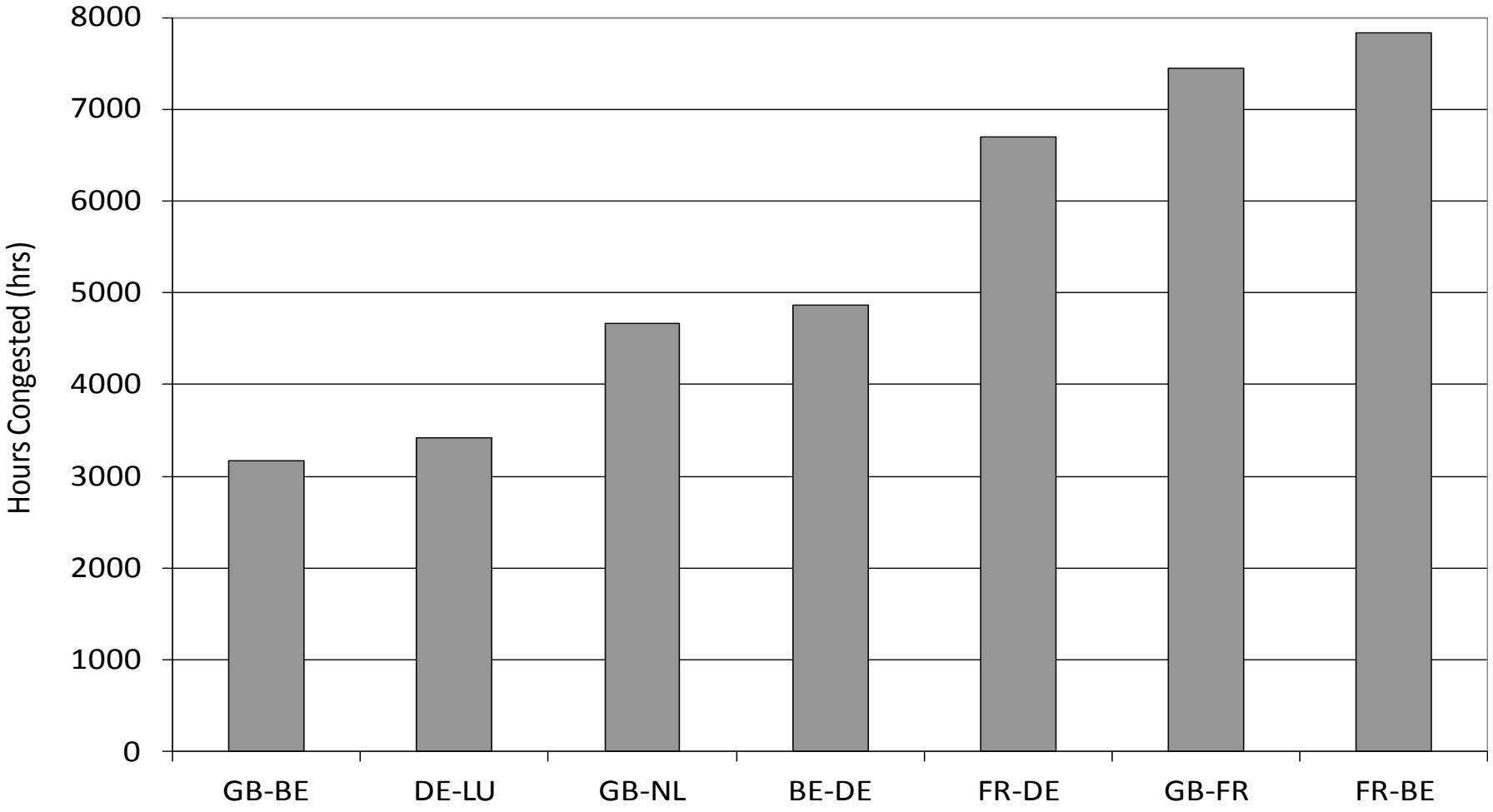
Emissions Intensity (gCO_2/kWh) 2009 vs 2020



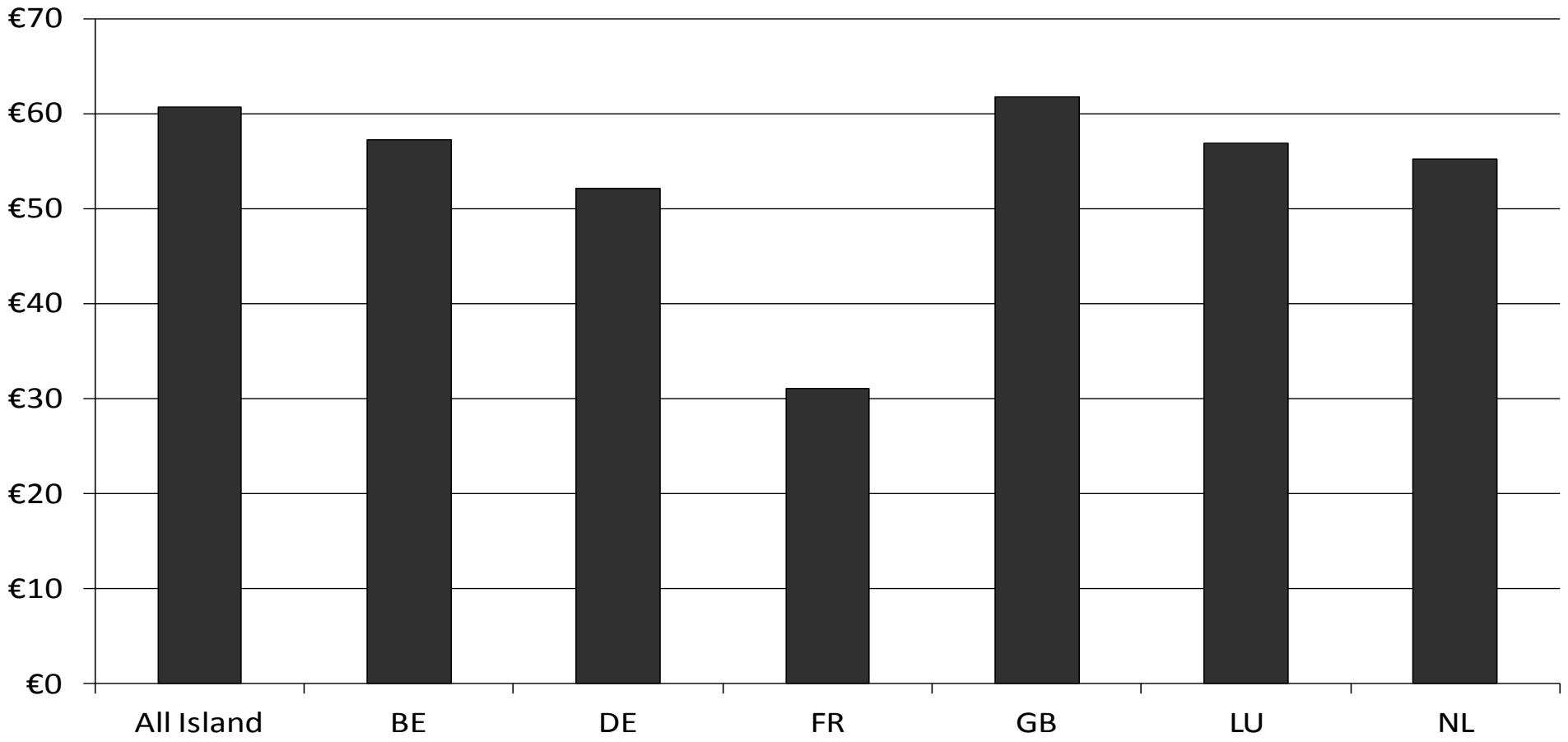
Imports/Exports

	Imports	Exports	Net Interchange	unit
All Island	1541	2483	942	GWh
BE	39284	5474	-33810	GWh
DE	26821	28004	1183	GWh
FR	2311	98086	95776	GWh
GB	34450	4907	-29543	GWh
LU	6647	1238	-5409	GWh
NL	16873	14255	-2618	GWh

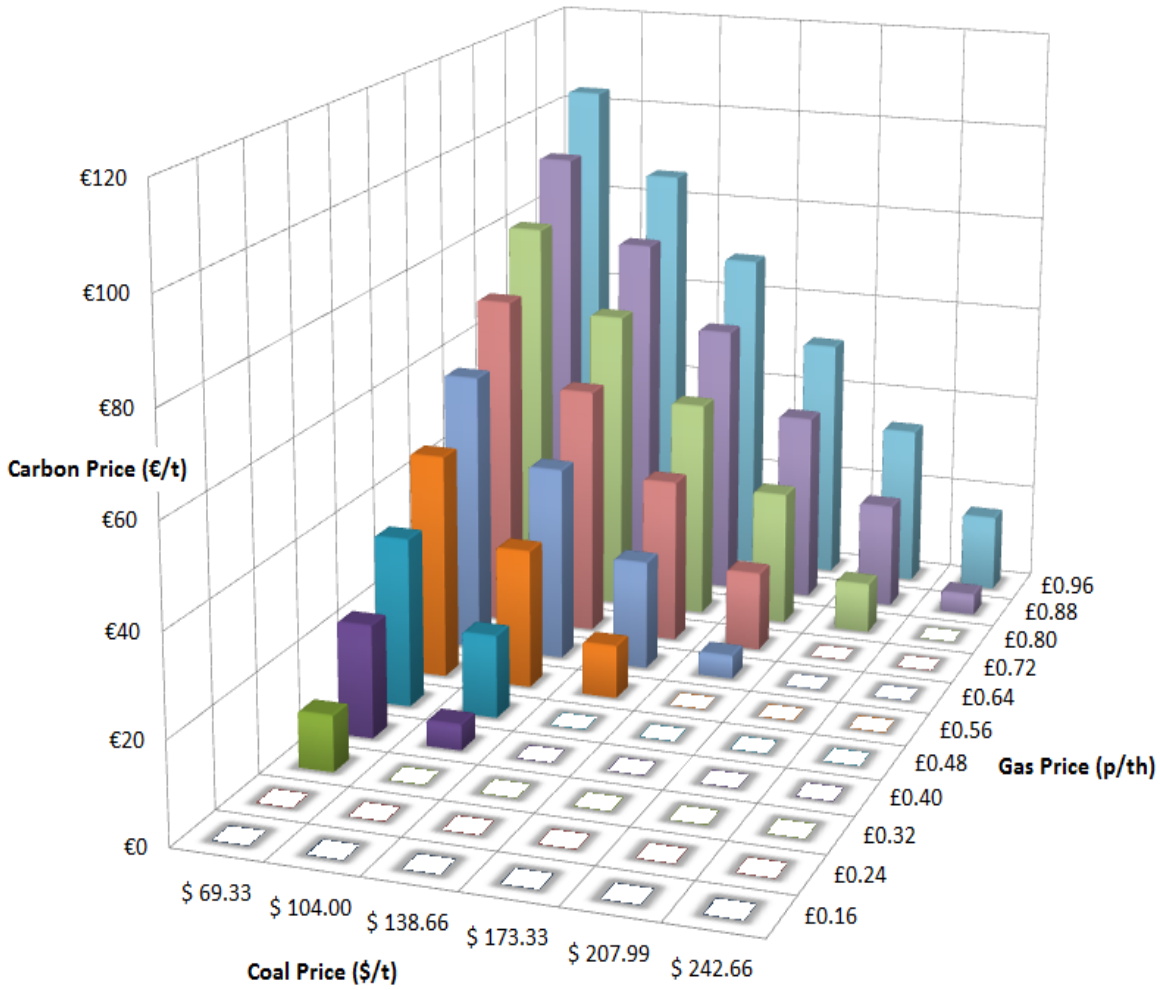
Hours of Congestion on IC between Regions



System Marginal Price (€/MWh) @ €20/tCO_2



Carbon Prices?



Carbon price required to make cost of electricity production (SRMC) (€/MWh) from Coal and Gas equal for varying gas and coal prices.

Conclusion

- Strong value in targeted power systems modelling to reveal insights that at challenging to capture in energy system models
- Congestion on mainland Europe will limit the movement of power
- Increased carbon tax in near term may have only limited impact. Higher coal prices or lower coal-gas difference is required to drive emissions down
- Coal still a strong player in the Mix (DE)

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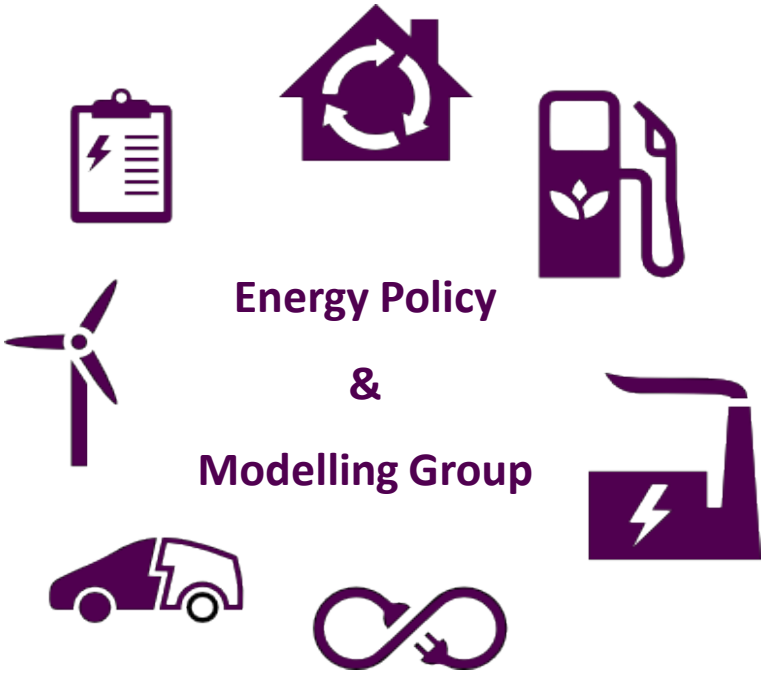

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