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The EU Power System in 2030:
Investigating Electricity Sector Challenges

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International Energy Workshop

Abu Dhabi | 5th June 2015

Agenda

ENERGY

- Overview
- Objectives
- Methodology
- Model Structure
  - Multi model approach
  - Development of Generation Portfolios
  - Variable Renewable Generation Modelling
- Results

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Overview

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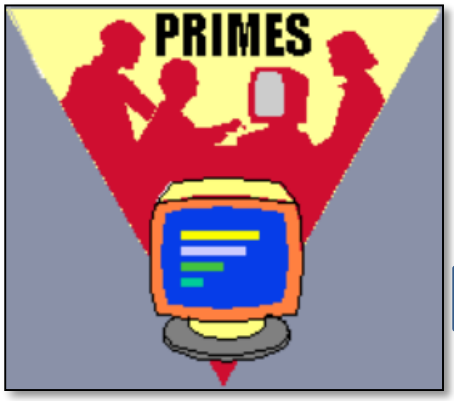
- Adds value and tests power sector results from PRIMES
- Done using a dedicated power system model (PLEXOS).
- Model simulates the operation of the EU power system at high temporal and technical resolution for a target year (2030).



PLEXOS®
Integrated Energy Model

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Objectives

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- Test the technical appropriateness and robustness of PRIMES 2030 Reference Scenario results for the electricity sector using a soft linking methodology.

- Added value of this analysis for scrutinization of:
  - Renewable curtailment
  - Pricing
  - Flexibility of the power system to absorb variable renewables
  - Congestion on interconnector lines

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Multi-model soft-linking methodology

Deane J.P., Chiodi A., Gargiulo M. and Ó Gallachóir B.P. 2012 *Soft-linking of a power systems model to and energy systems model.* **Energy** Vol 42, Pages 303-312

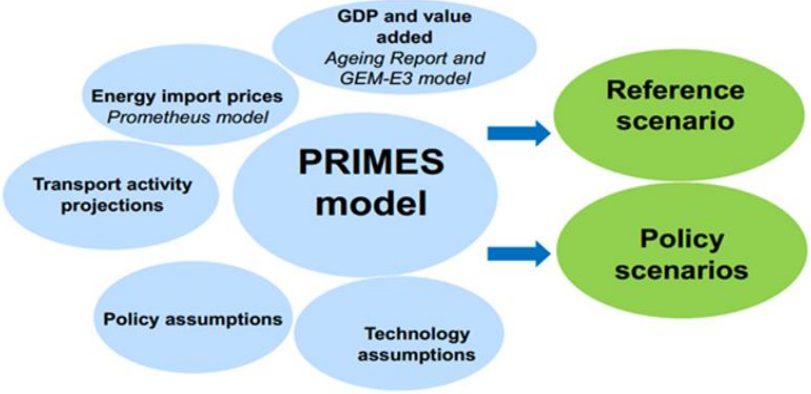
Deane J.P., Gracceva F.; Chiodi A.; Gargiulo M., and Ó Gallachóir B.P. 2015 *Assessing Power System Security. A framework and a multi model approach.* **International Journal of Electrical Power and Energy Systems** 73 Pages 283-297

Deane, J.P., Dineen, D., Chiodi, A., Gargiulo, M., Gallagher, P., Ó Gallachóir, B.P., 2015. *The electrification of residential heating in Ireland as a pathway to reduced CO_2 emission - good idea or bad idea?* **Applied Energy** (In review)

Deane J.P, Gracceva F, Chiodi A, Gargiulo M and Ó Gallachóir B.P. 2015 *Soft-Linking Exercises Between TIMES, Power System Models and Housing Stock Models.* Chapter in **Springer Book** Informing energy and climate policies using energy systems models pp 315-331

PRIMES (whose results we're adding value to)

- Energy systems model for EU-28 developed by the National Technical University of Athens
- 2030 Reference Scenario includes full implementation of policies adopted by late spring 2012
- Results of PRIMES REF include installed generation capacities, Gross & Net Electrical Generation by plant type and indicators for electricity generation among other results



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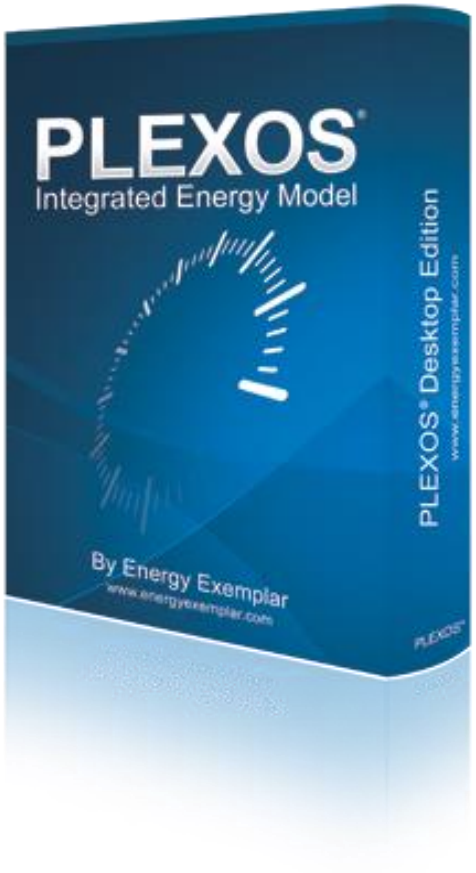
PLEXOS (the modelling tool we're using)



- Academic License
- Transparent and auditable
- Strong commercial user base
- Strong R&D focus
- Production Cost Simulation
- Electric and Gas modelling
- Capacity Expansion Capability
- Market Analysis and Market Design
- Transmission Analysis
- Stochastic Optimisation
- Hydro Resource Management

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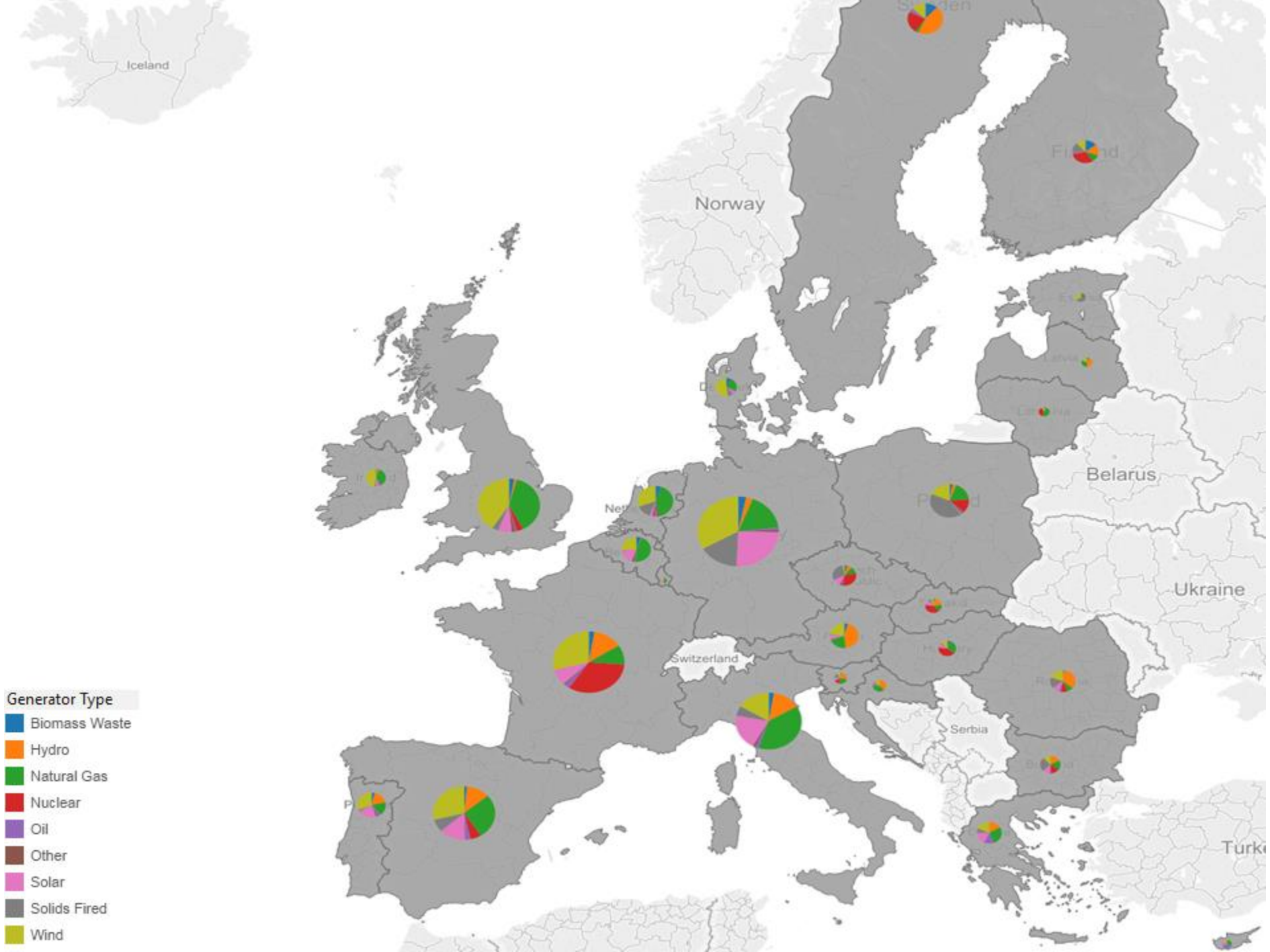
PRIMES → PLEXOS

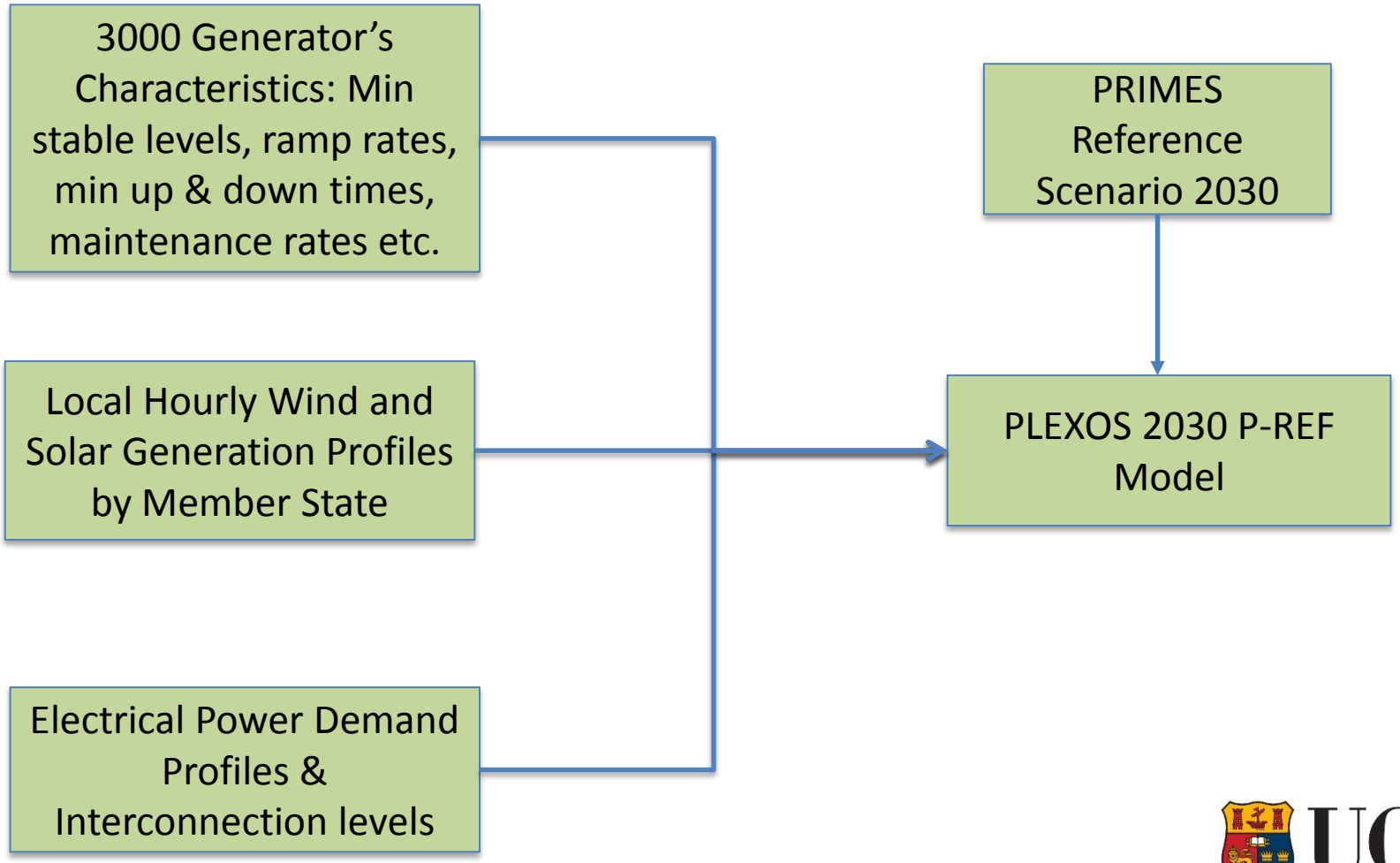
- Energy system model
- **Low temporal resolution (Day/Night/Peak)**
- **Long term time horizon (2030/2050)**
- Focus on technology pathways
- Rich in sectoral disaggregation

PLEXOS®
Integrated Energy Model

- Dedicated power system model
- **High temporal resolution (15min-1 hr)**
- High technical detail, **reserve modelling, hydro modelling, multi-stage stochastic UC**
- **Ramping costs, flexibility metrics**


Iceland
Norway
Belarus
Ukraine
Switzerland
Serbia
Generator Type
Biomass Waste
Hydro
Natural Gas
Nuclear
Oil
Other
Solar
Solids Fired
Wind

Process



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PLEXOS 2030 P-REF Model Structure

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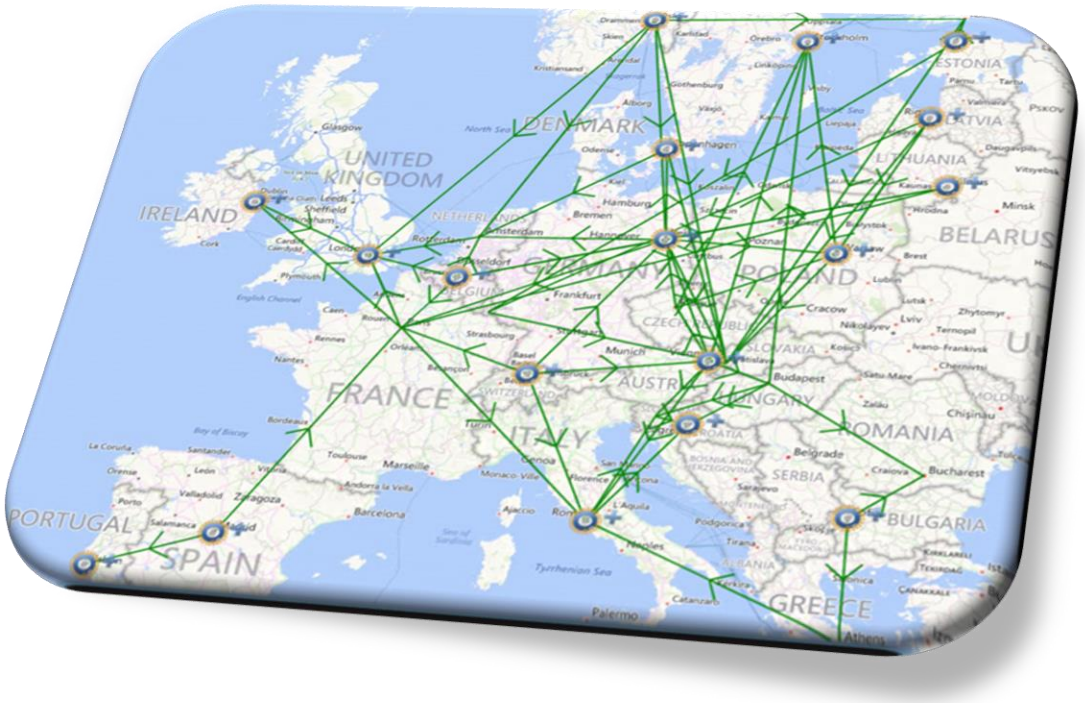
Generation Portfolio

- Take PRIMES REF power sector results and disaggregate
- Standard generation units for all modes of generation
- Heat Rates for generators taken from PRIMES Results

Interconnection

- Considered between Member States
- Aligned with ENTSO-E 10 yr network development plan



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Variable Renewable Generation Profiles

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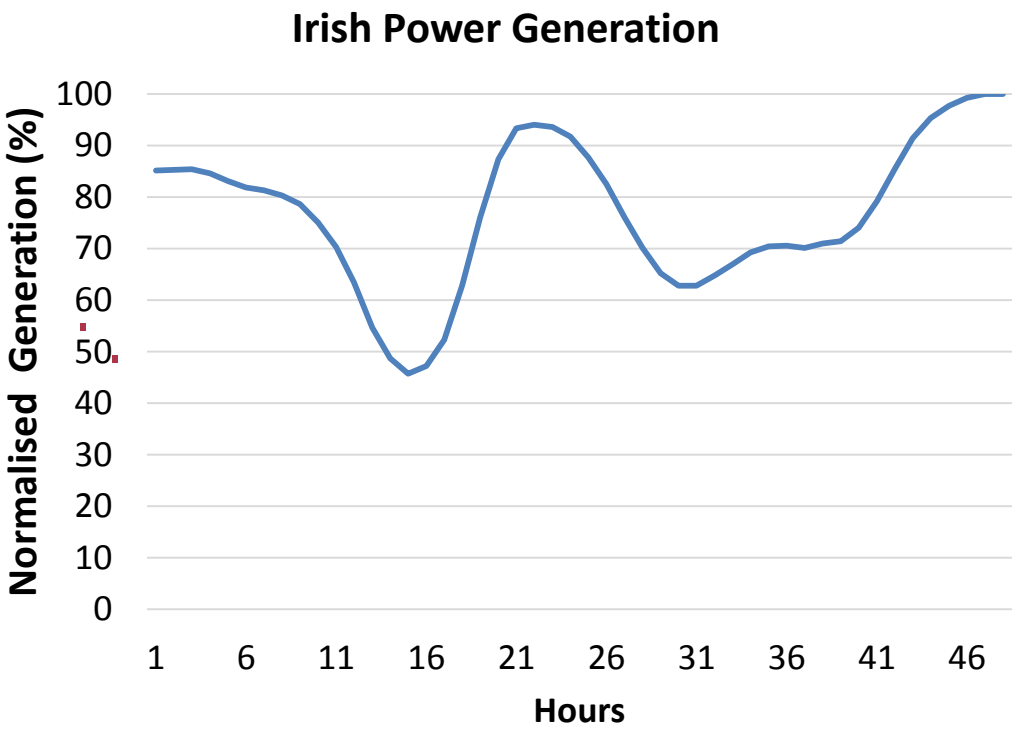
Wind Generation Data (Hourly)

- Based on NASA MERRA Data
- MS Wind Profiles in line with PRIMES REF capacity factors
- Wind profiles from multiple sites aggregated using Python script

Solar Generation Data (Hourly)

- Calculated using NREL's PV Watts online package
- Solar profiles based on local solar irradiation data
- Normalised Profiles created for PLEXOS model



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Inertia Considerations

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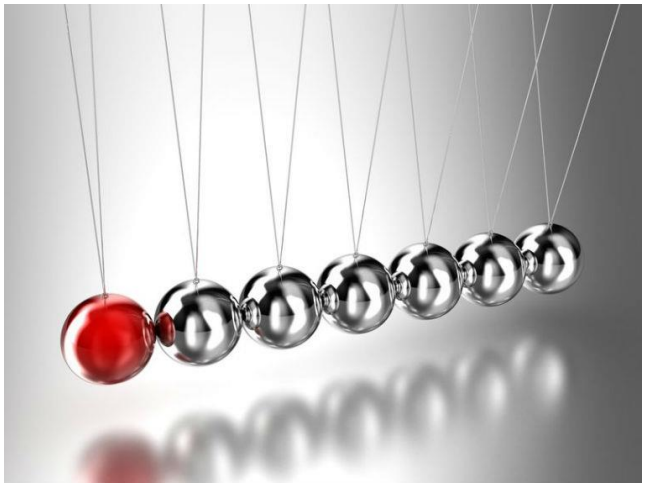
- Important for Rate of Change of Frequency limits

$$\frac{df}{dt} = \frac{f_0 P}{2H_{\text{system}} S_b}$$

- Essential considering the amount of renewables replacing conventional generation



- Currently being incorporated into the model

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Results - Electrical Emissions Intensity

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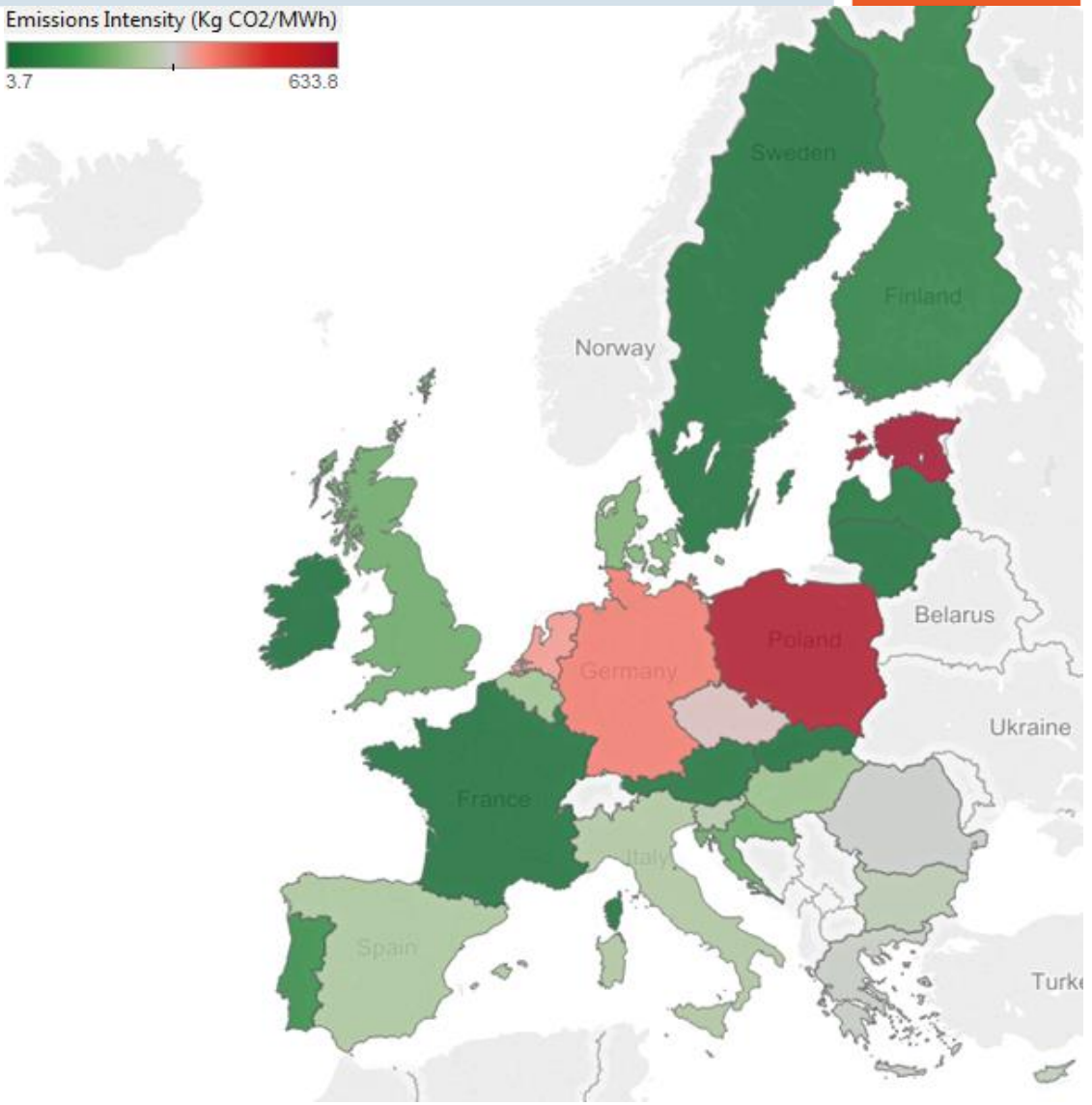
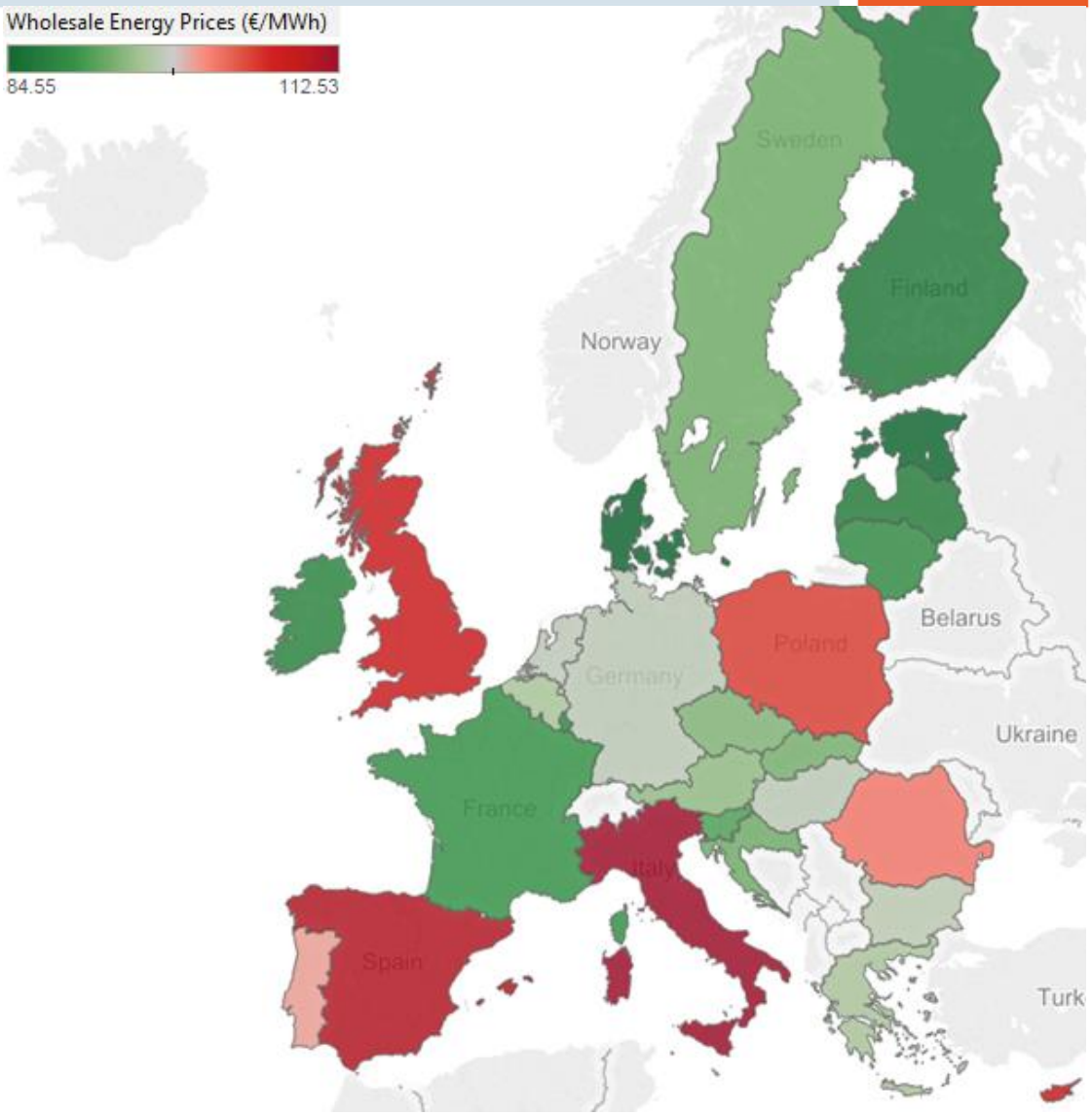
Electricity emissions intensity ($kgCO_2/MWh$) developed using PRIMES 2030 REF scenario results



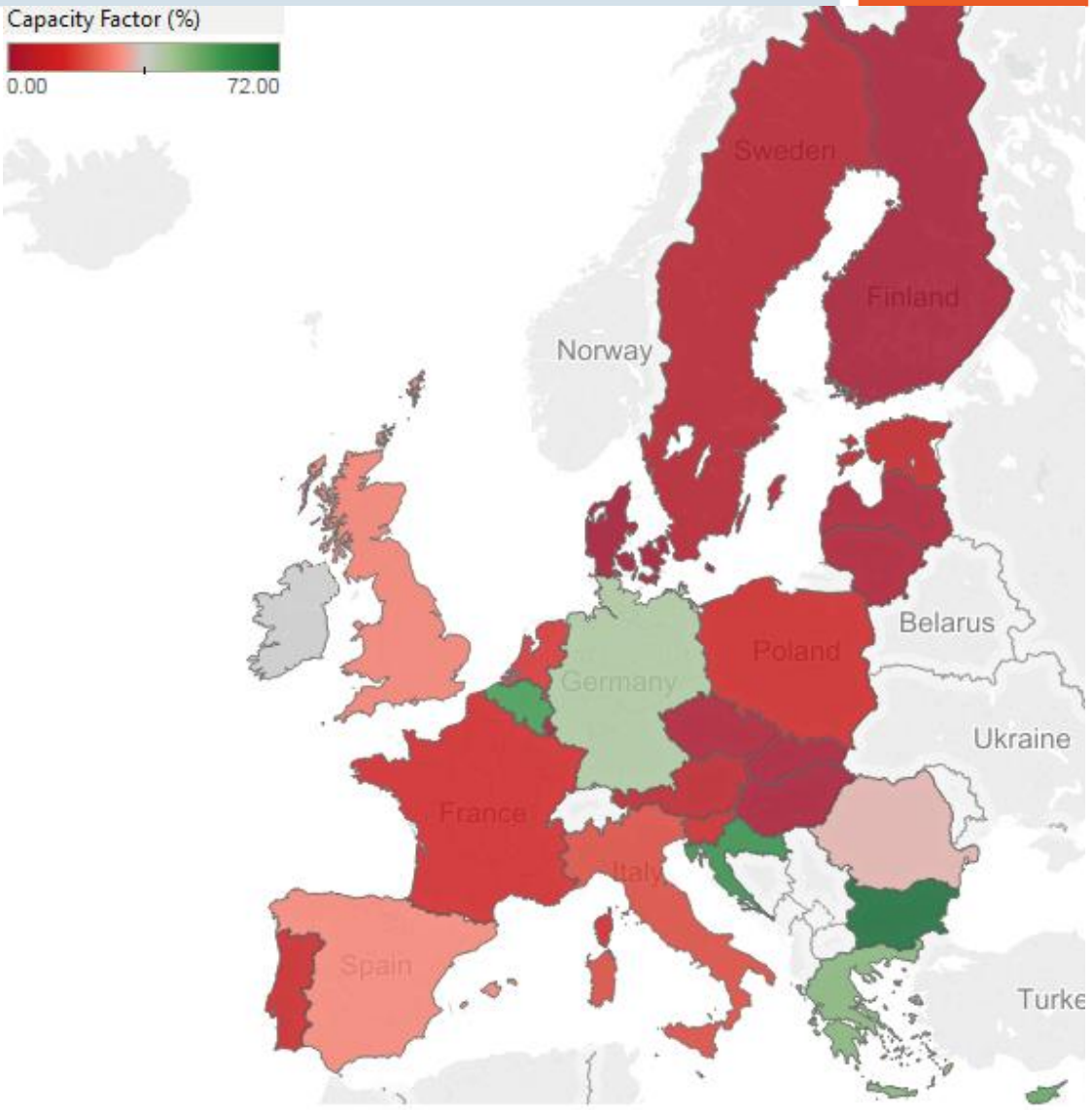
Wholesale Electricity Prices

- Added results not available from PRIMES
- Renewables causing a shift in the merit order curve
- Affects revenues of conventional power plants



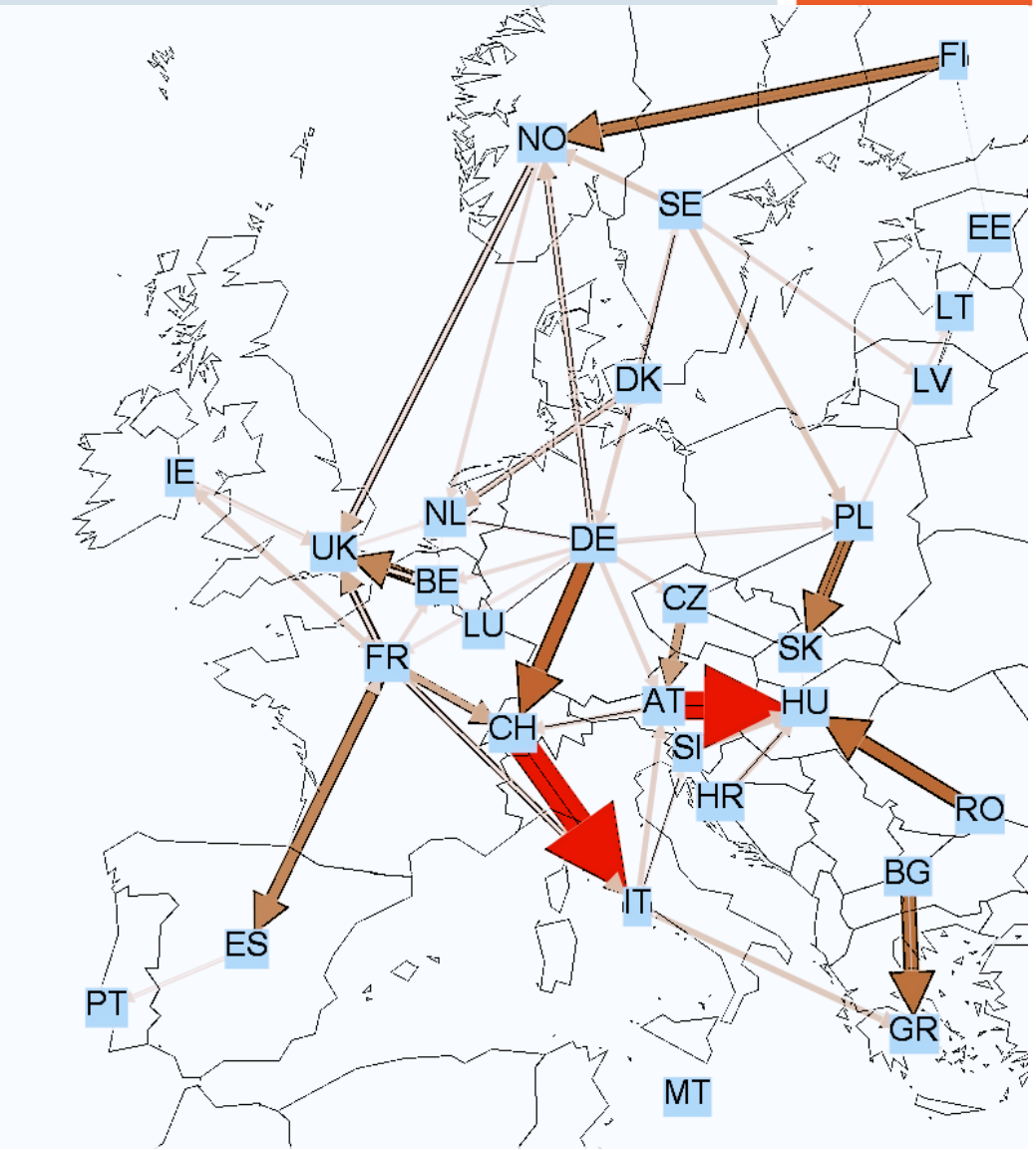
Natural Gas Generation Capacity Factors

- In Europe today, current market prices are not sufficient to cover the fixed costs of all plants operating on the system
- Natural gas fired plant may still struggle to achieve sufficient financial remuneration



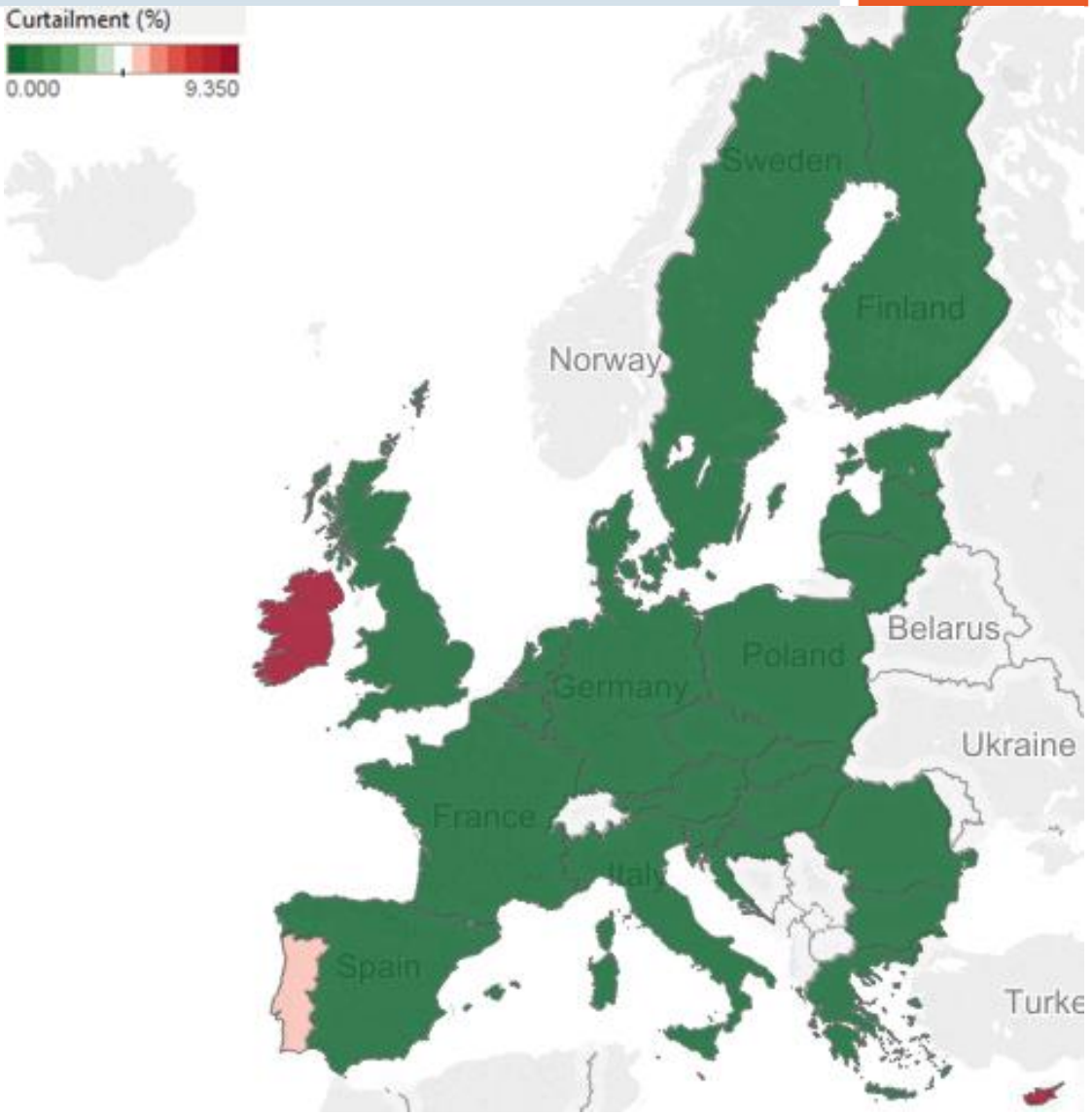
Interconnector Congestion

- Limits the efficient movement of electricity particularly in Central and Eastern Europe lines
- Raises concerns over the flexibility of the power systems within these member states



Variable Renewable Curtailment

- Raises concerns regarding the ability of the power system to absorb the variable renewables
- Well interconnected states within the model run experiencing curtailment are concerned about power system flexibility



Conclusions

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- Approach tests the appropriateness of PRIMES using 2030 scenario results
- Adds value to PRIMES with new insights on key issues: Curtailment, Interconnector Congestion, Inertia Power system flexibility
- Next step – engagement with NTUA to provide feedback

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Thank You

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