A large wind turbine stands in the center of the frame, its blades blurred from motion. The background features rolling green hills and mountains under a sky with soft, golden light from a setting or rising sun. The overall scene is serene and natural.

Benefits to single country modelling?

Comparing 14 interconnected individual country models to a single 14-country model

Jakob Zinck Thellufsen

5th Cnternational Conference on Smart Energy Systems and 4th Generation District Heating

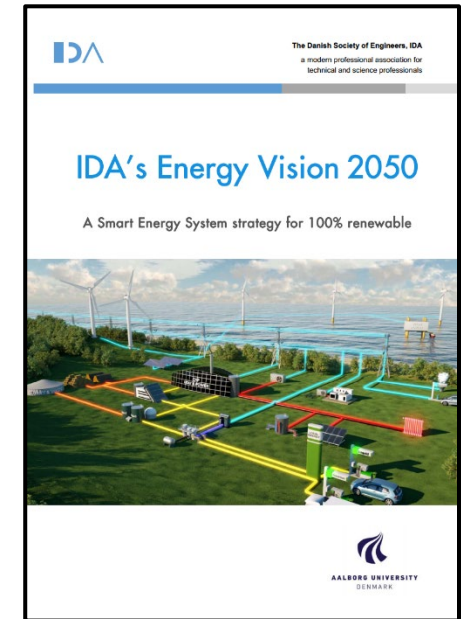
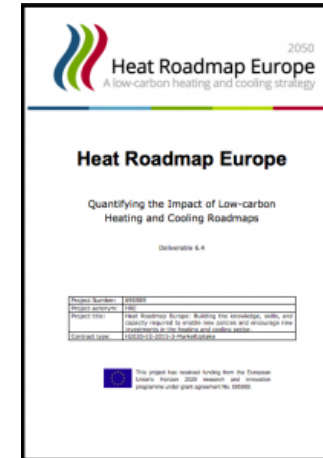


Scope of modelling energy systems

Do we want to say something regarding a country? Or a whole region?

To what extent do we need to country specifics to discuss the regional development?

To what extent do we need to see that country in the context of the region?



What do I need to model?

1. A region as a whole single model
2. Each country individually in the region
3. Each country in the region, but interconnected

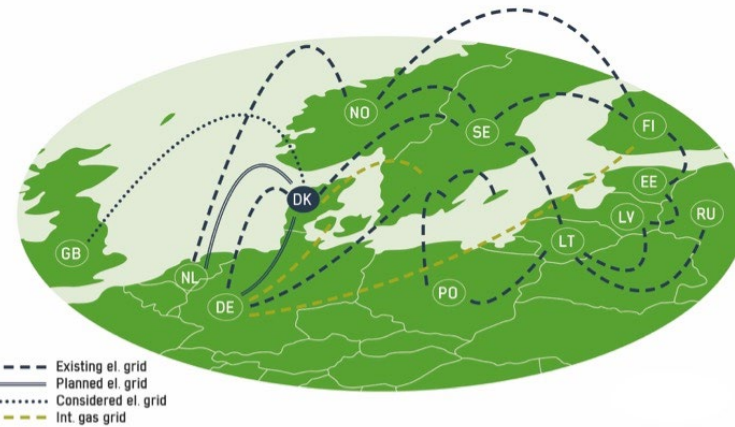
I will do this on the case of the 14 HRE4 countries

1. All 14 countries as a single model
2. All 14 countries modelled individually without interconnection
3. All 14 countries modelled individually with interconnection



Two dimensional modelling approach

System interconnection



TWO-DIMENSIONAL APPROACH

System integration



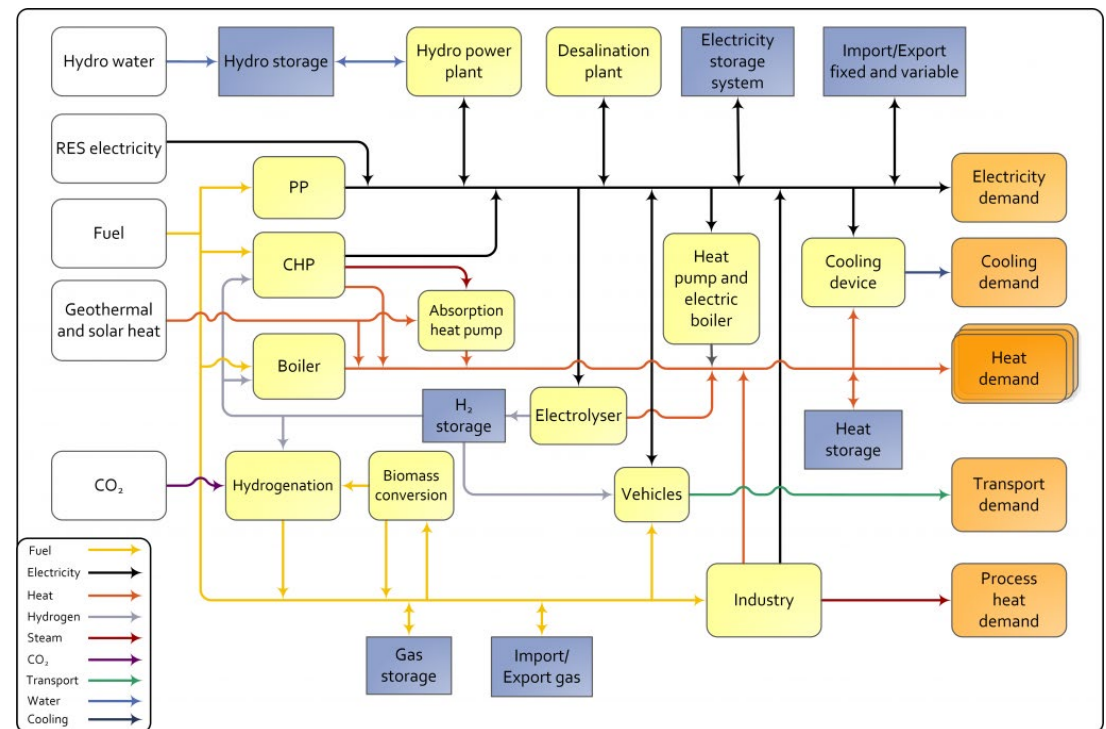
The EPlanFlow Tool

- Combines EnergyPLAN with PowerFLOW
- EnergyPLAN is a tool that models single energy systems
- PowerFLOW can balance the electricity grid
- It works in three steps



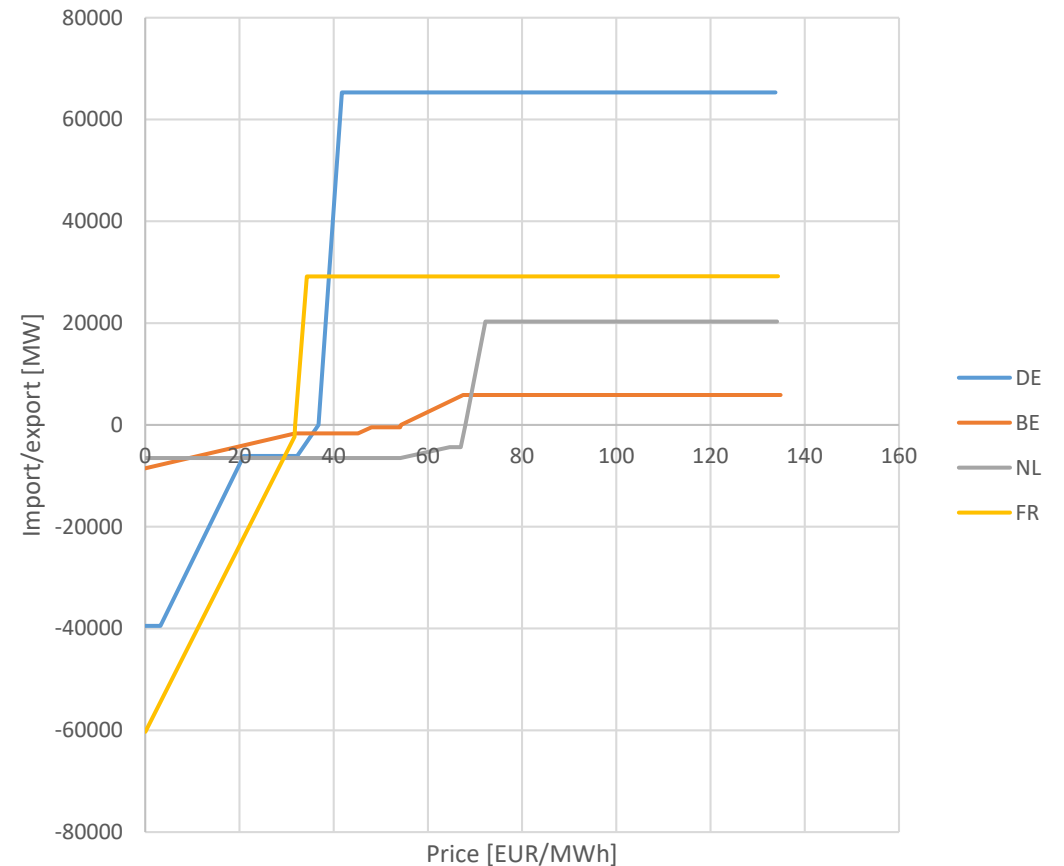
EPlanFlow (Step 1)

- EnergyPLAN simulation of each individual country
- Operates the entire energy system based on different market prices
 - Identifies import/export curves for every hour



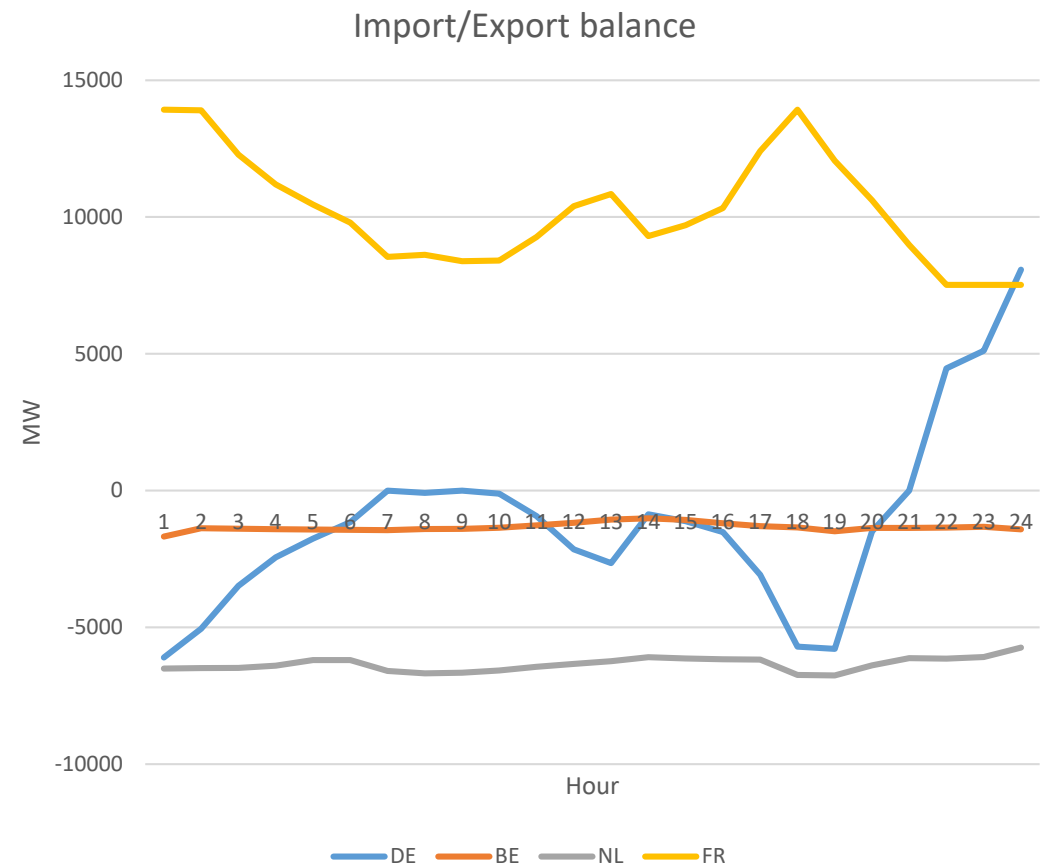
EPlanFlow (Step 2)

- PowerFLOW balances the import/export every hour between every country
- Uses Python and Gurobi
- The results are an import/export curve for each country



EPlanFlow (Step 3)

- The import/export curve is fixed in EnergyPLAN
- EnergyPLAN makes a technical simulation to identify the operation of the countries energy system given the transmission constraints.



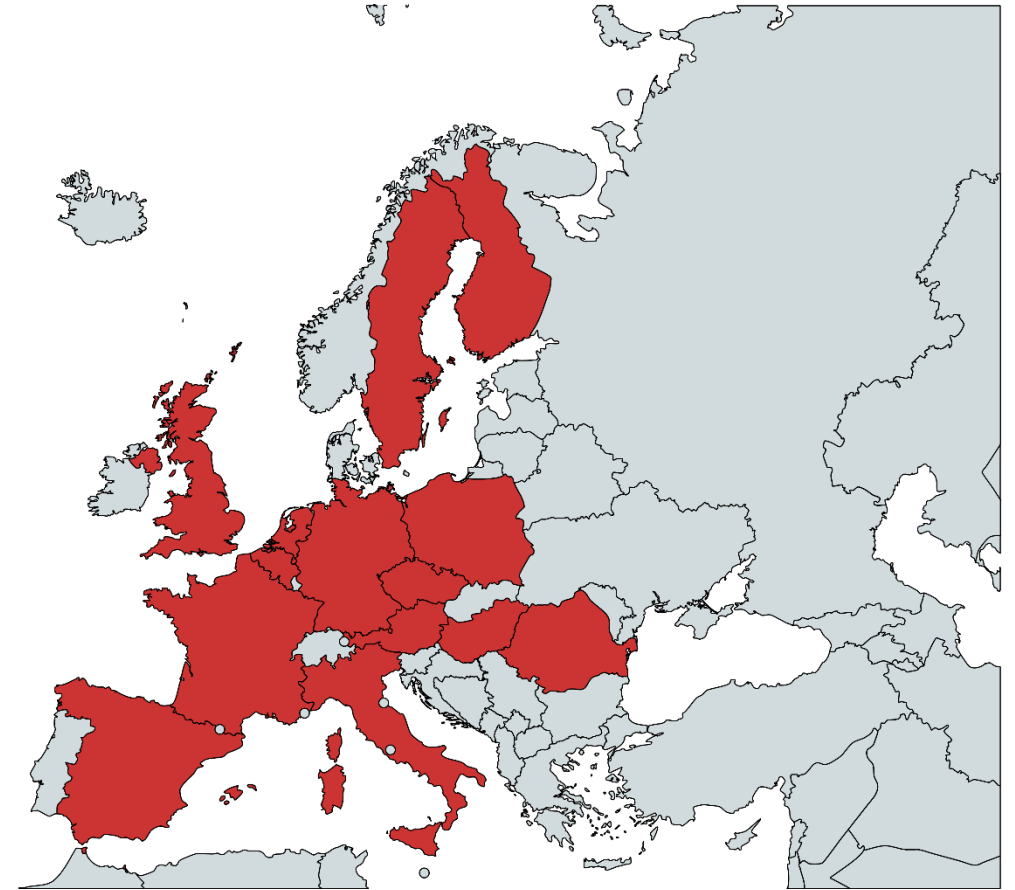
Heat Roadmap Europe as a case

14 HRE4 countries

2015 Baseline scenarios

- Basically the current energy systems

	AT	BE	CZ	DE	ES	FI	FR	HU	IT	NL	PL	RO	SE	UK
AT	-	0	1908	2519	0	0	0	1474	285	0	0	0	0	0
BE	0	-	0	0	0	0	3400	0	0	2400	0	0	0	0
CZ	1908	0	-	2745	0	0	0	0	0	0	1881	0	0	0
DE	2519	0	2745	-	0	0	3200	0	0	3850	2424	0	610	0
ES	0	0	0	0	-	0	2997	0	0	0	0	0	0	0
FI	0	0	0	0	0	-	0	0	0	0	0	0	2050	0
FR	0	3400	0	3200	2997	0	-	0	2324	0	0	0	0	2000
HU	1474	0	0	0	0	0	0	-	0	0	0	1102	0	0
IT	285	0	0	0	0	0	2324	0	-	0	0	0	0	0
NL	0	2400	0	3850	0	0	0	0	0	-	0	0	0	1000
PL	0	0	1881	2424	0	0	0	0	0	0	-	0	600	0
RO	0	0	0	0	0	0	0	1102	0	0	0	-	0	0
SE	0	0	0	610	0	2050	0	0	0	0	600	0	-	0
UK	0	0	0	0	0	0	2000	0	0	1000	0	0	0	-



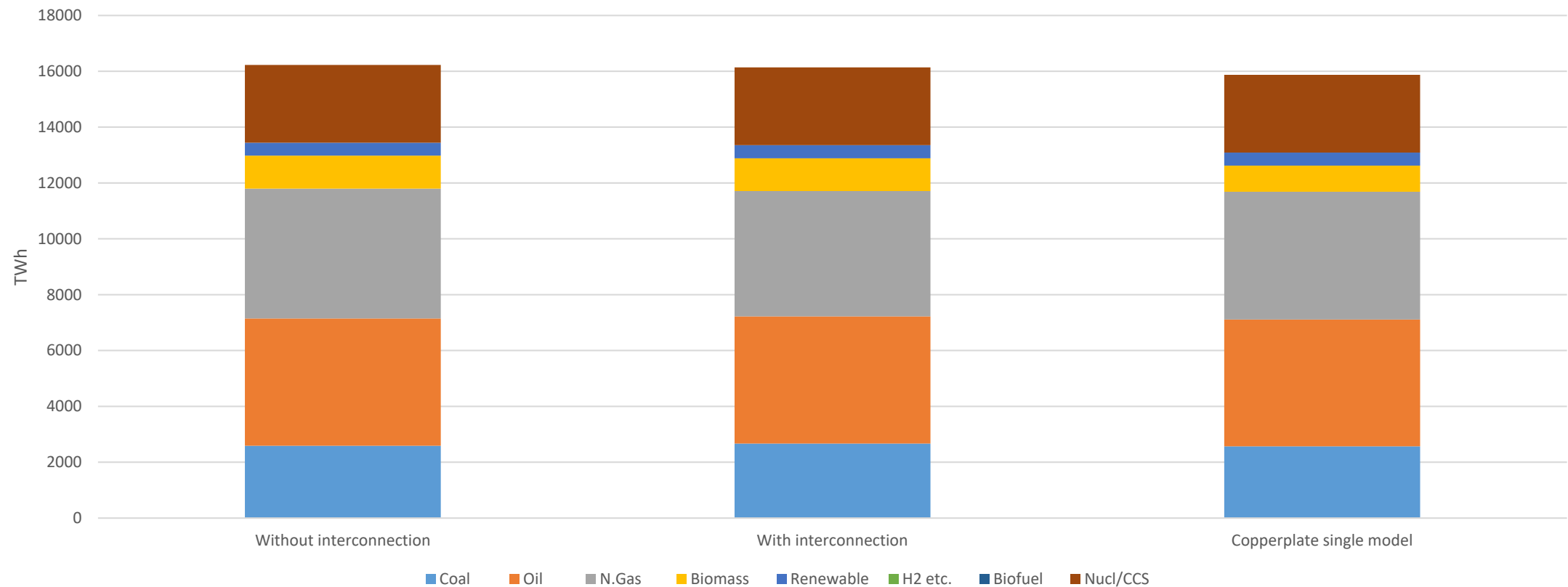
Scenarios and comparisons

- Heat Roadmap Europe 14 2015 Baseline
 - Current energy systems modelled in EnergyPLAN
 - Calibrated compared to JRC TIMES and Eurostat
- 2050 Baseline
 - Not analysed
- 2050 HRE4 scenario
 - Not analysed

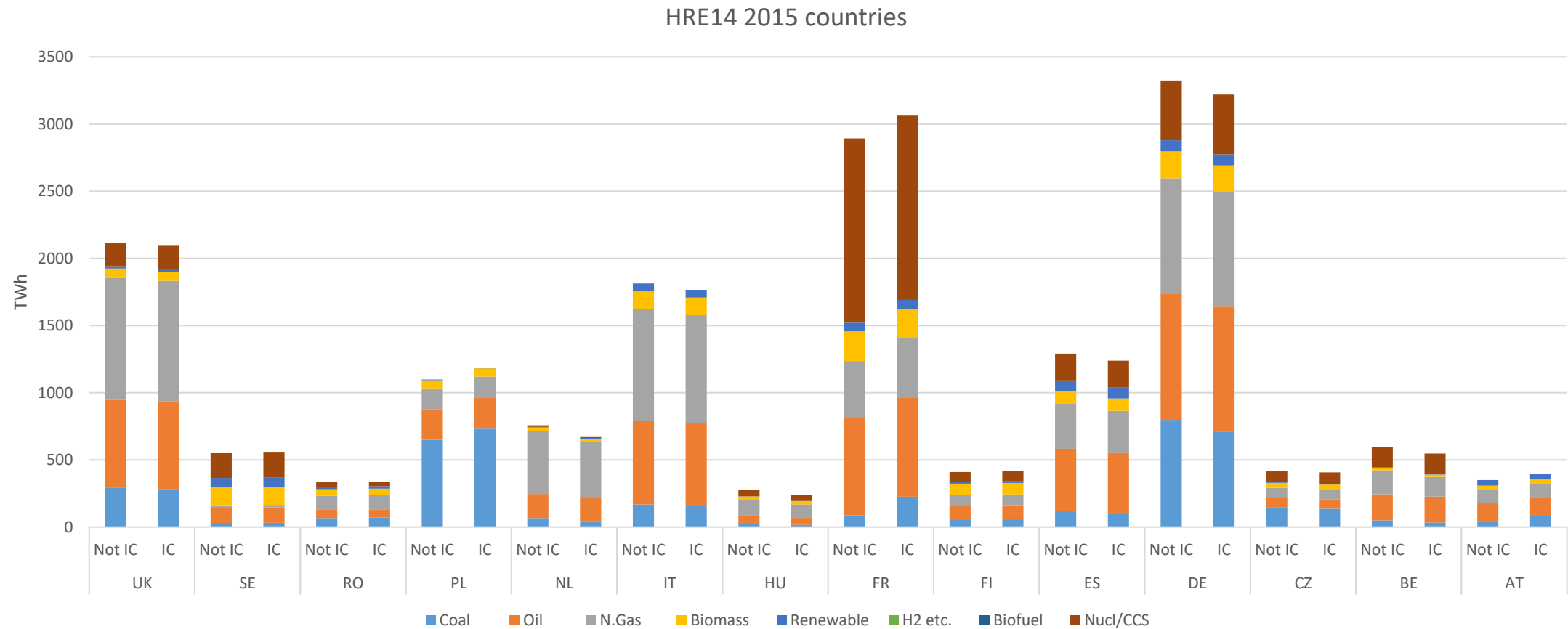


Results: Comparing common Europe to interconnected single country modelling

Primary energy consumption HRE14 2015



Results: Individual country models. With and without interconnection



Conclusions

- The difference between one single national model and interconnected single model is not that big.
- The operation of the single country do change. But depends on technologies
 - With little interconnection, not too big of difference
 - With excess electricity from wind and nuclear, it is possible to export and replace fossil fuel



Next steps

- Test for impact in other scenarios
 - Higher share of renewable energy
 - Higher electrification rate / little system integration
 - Higher degree of system integration
- Baseline 2050 and HRE 2050 scenario



Questions?

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