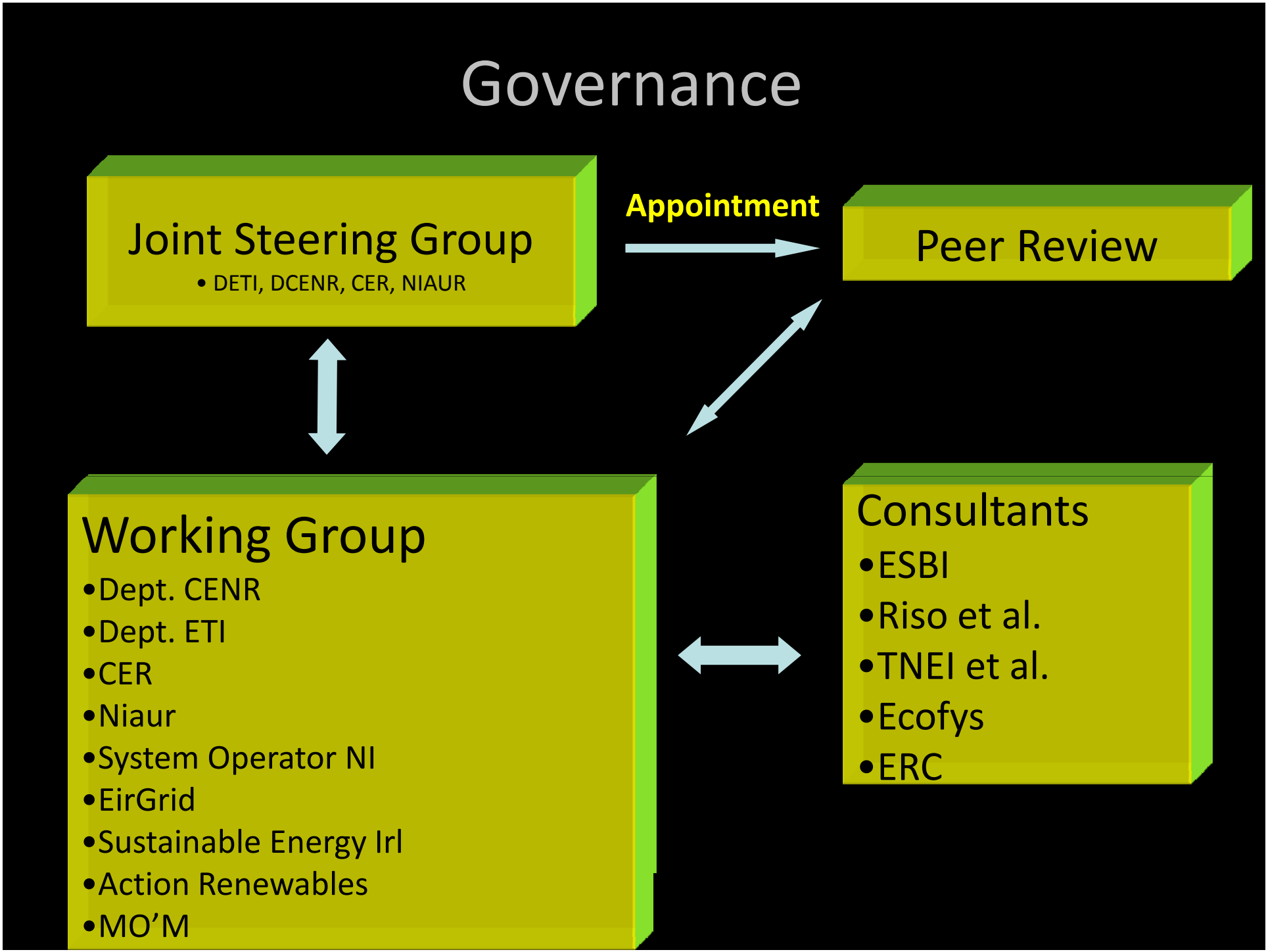
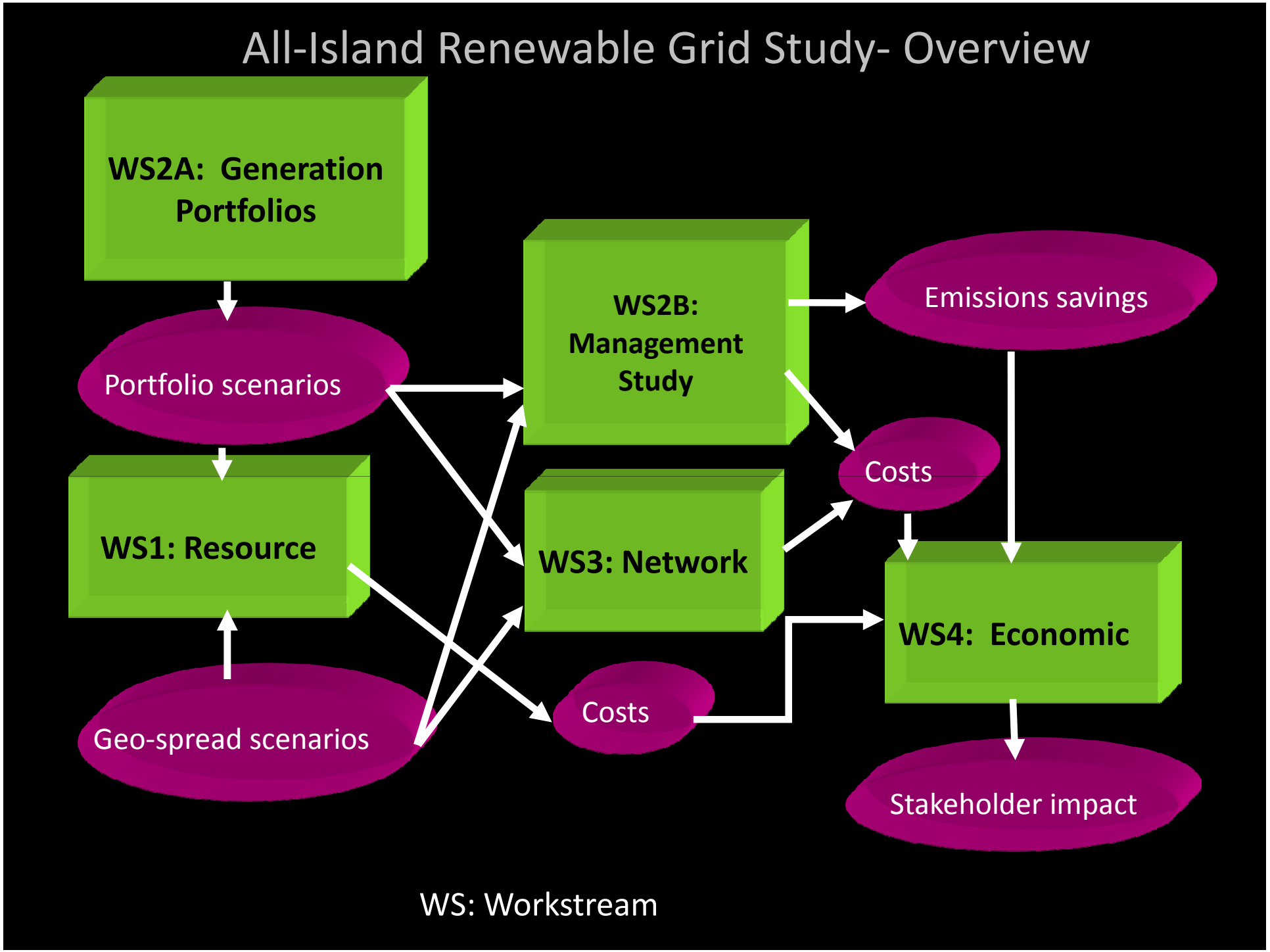
ALL-ISLAND GRID STUDY

Mark O'Malley

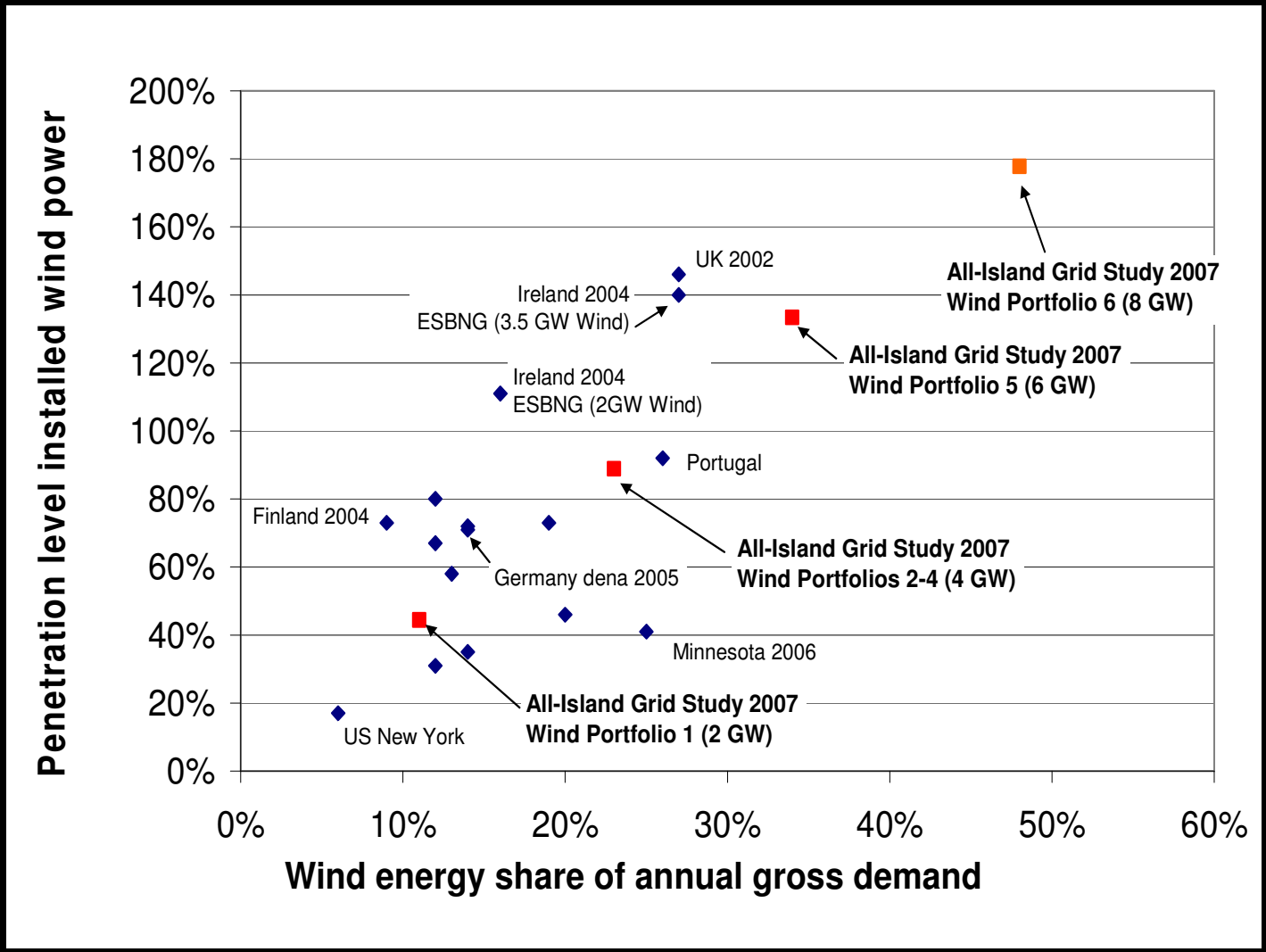
Cambridge May 16th 2008

Governance


Joint Steering Group
• DETI, DCENR, CER, NIAUR
Appointment
Peer Review
Working Group
•Dept. CENR
•Dept. ETI
•CER
•Niaur
•System Operator NI
•EirGrid
•Sustainable Energy Irl
•Action Renewables
•MO'M
Consultants
•ESBI
•Riso et al.
•TNEI et al.
•Ecofys
•ERC


All-Island Renewable Grid Study- Overview
WS2A: Generation Portfolios
Portfolio scenarios
WS1: Resource
Geo-spread scenarios
WS2B: Management Study
WS3: Network
Costs
Emissions savings
Costs
WS4: Economic
Stakeholder impact
WS: Workstream

Contrast to other studies



High level assumptions

- Modelling exercise
  - One hour resolution
- Cost base study – simple view of the world !
- Market
  - Not Single Electricity Market & perfect
- Snap shot study – 2020 – based on scaled wind and load data

WS2A: High level assessment of suitable generation portfolios for the All-Island System in 2020

Consultant: ERC

Role of WS2A

- To identify range of optimal portfolios for further study
  - Grid Study lite!

- Doherty, R. and O'Malley, M.J., "Establishing the role that wind generation may have in future generation portfolios", *IEEE Transactions on Power Systems*, Vol. 21, pp. 1415 – 1422 (2006)

Portfolio Diversification: Plant mix

**Non-Grid Study information

Examples of results

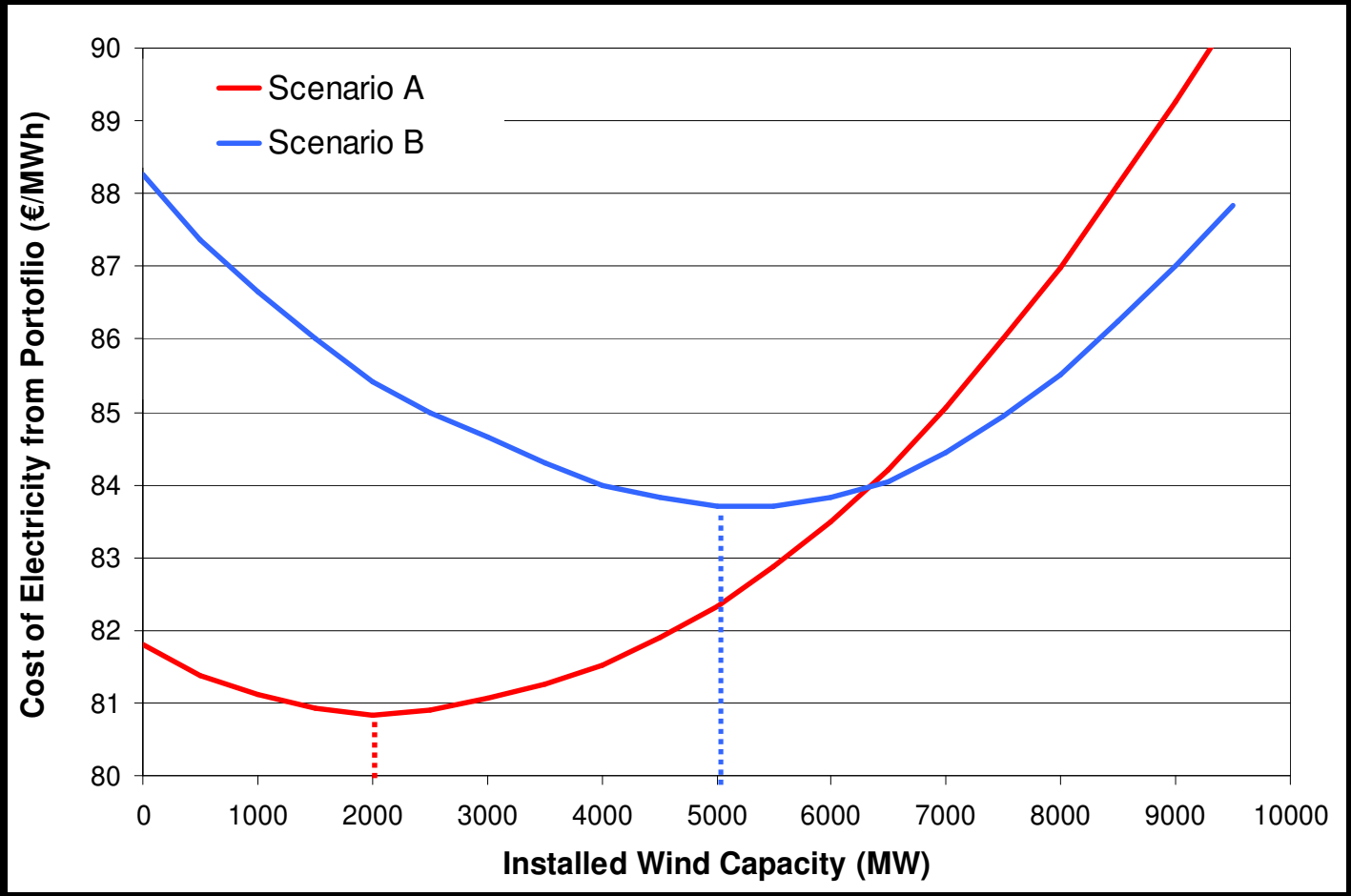
Portfolio A, low gas price

Portfolio A	MW Installed
Coal 1	0
Coal 2	0
Lignite	0
Peat	0
CCGT	694
OCGT	1761
ADGT	89
Base Load Renewables	370
Variable Renewables	70
Wind	2000
Co-fired Capacity (of peat)	104
Resultant Energy Mix	**%**
Coal/Lignite Energy	17.09
Peat Energy	3.40
Gas Energy	51.89
Interconnection	8.24
Hydro	1.64
Base Load Renewables	5.10
Variable Renewables	0.35
Wind Energy	10.83
Co-fired Capacity (of peat)	1.46
Total Renewables	**19.38**

Portfolio B, high gas price

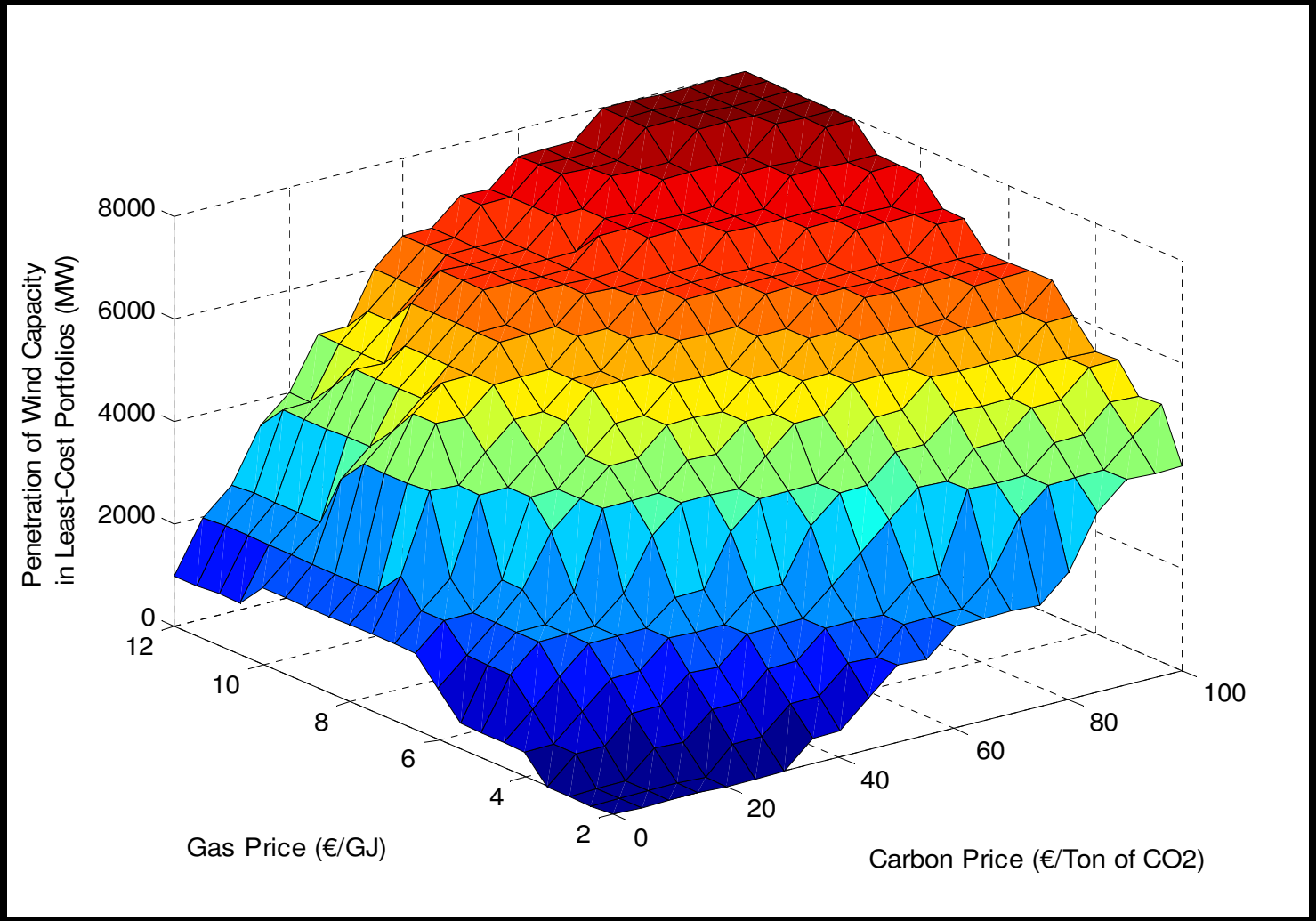
Portfolio B	MW Installed
Coal 1	1550
Coal 2	0
Lignite	0
Peat	0
CCGT	0
OCGT	681
ADGT	0
Base Load Renewables	370
Variable Renewables	70
Wind	5000
Co-fired Capacity (of peat)	104
Resultant Energy Mix	**%**
Coal/Lignite Energy	38.28
Peat Energy	3.40
Gas Energy	23.91
Interconnection	0.14
Hydro	1.64
Base Load Renewables	5.10
Variable Renewables	0.35
Wind Energy	25.73
Co-fired Capacity (of peat)	1.46
Total Renewables	**34.28**

Sensitivity to installed wind capacity

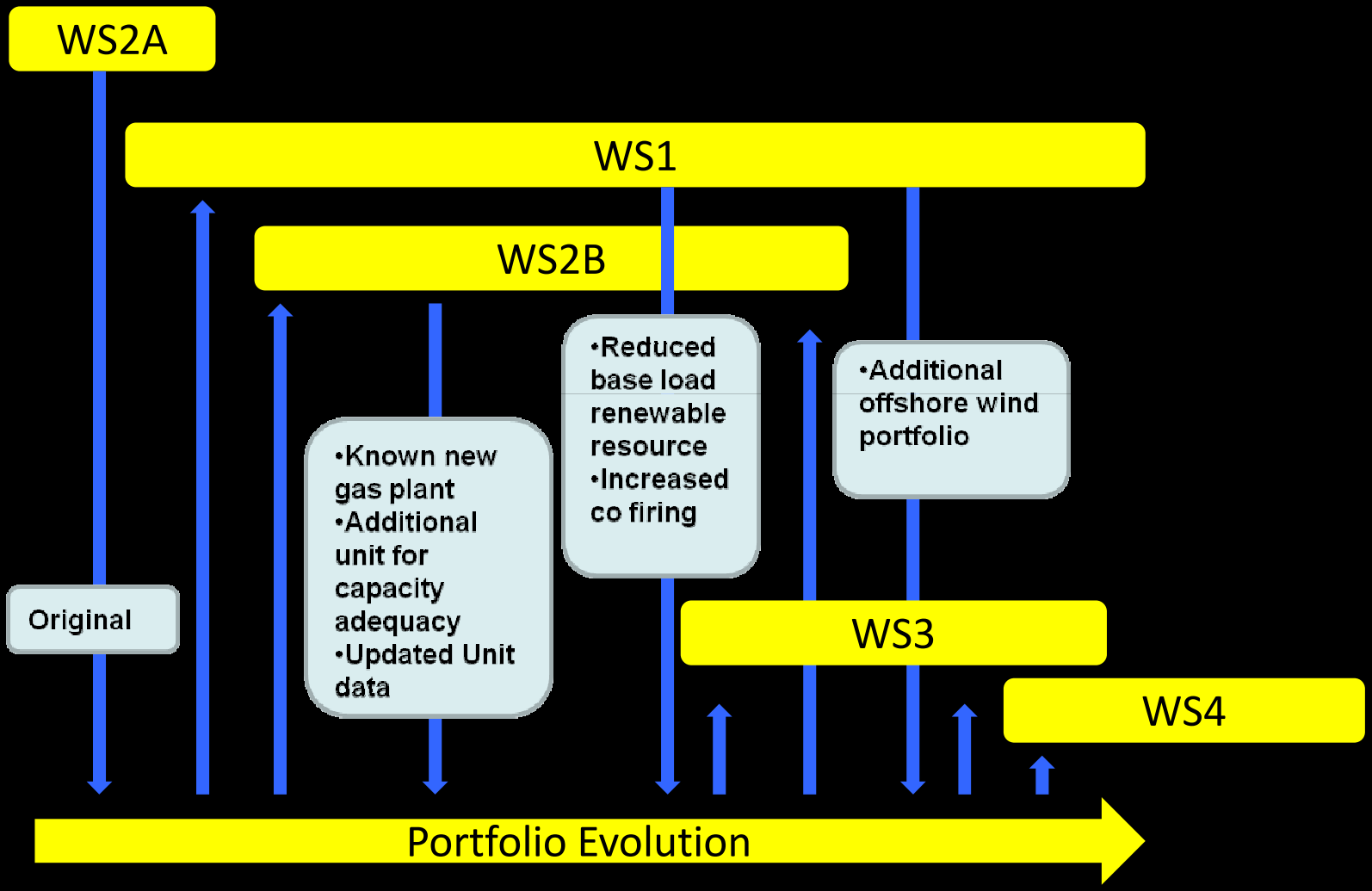


Gas and carbon price impacts

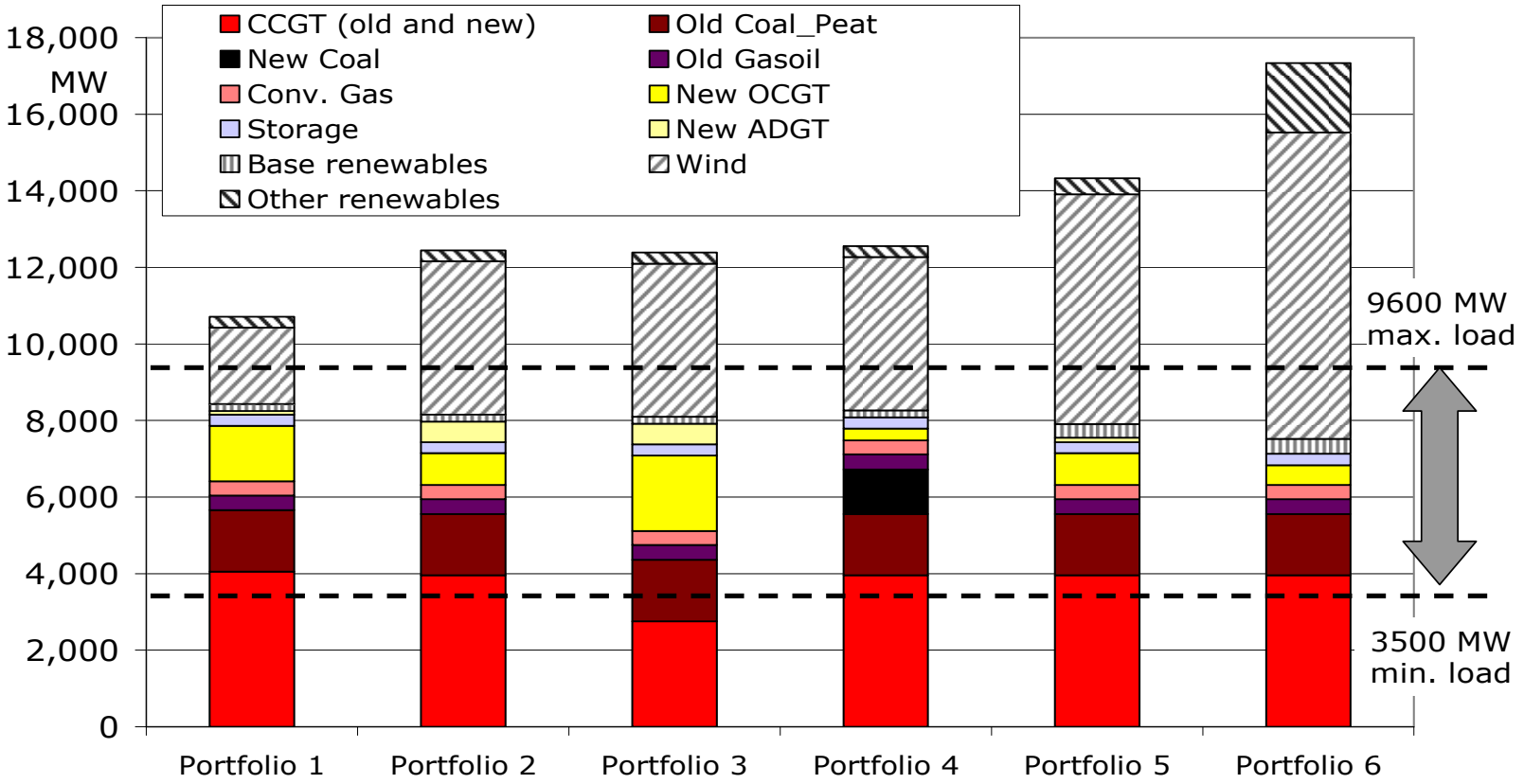
On wind capacity



Portfolio Evolution



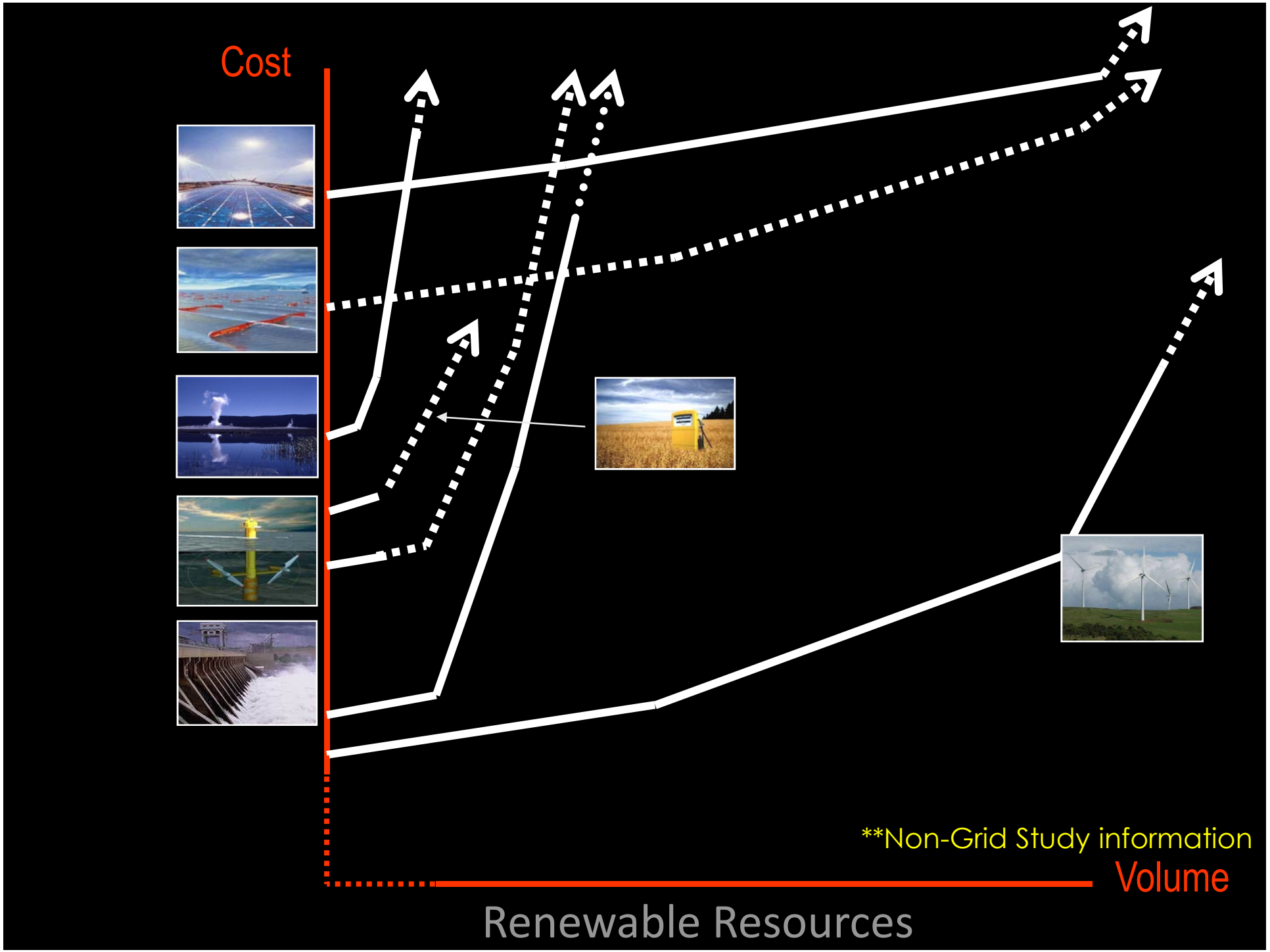
Portfolios



Share of Renewables						
Capacity	23 %	36 %	36 %	36 %	47 %	59 %
Energy	16 %	27 %	27 %	27 %	42 %	59 %

WS1: Renewable energy resource assessment

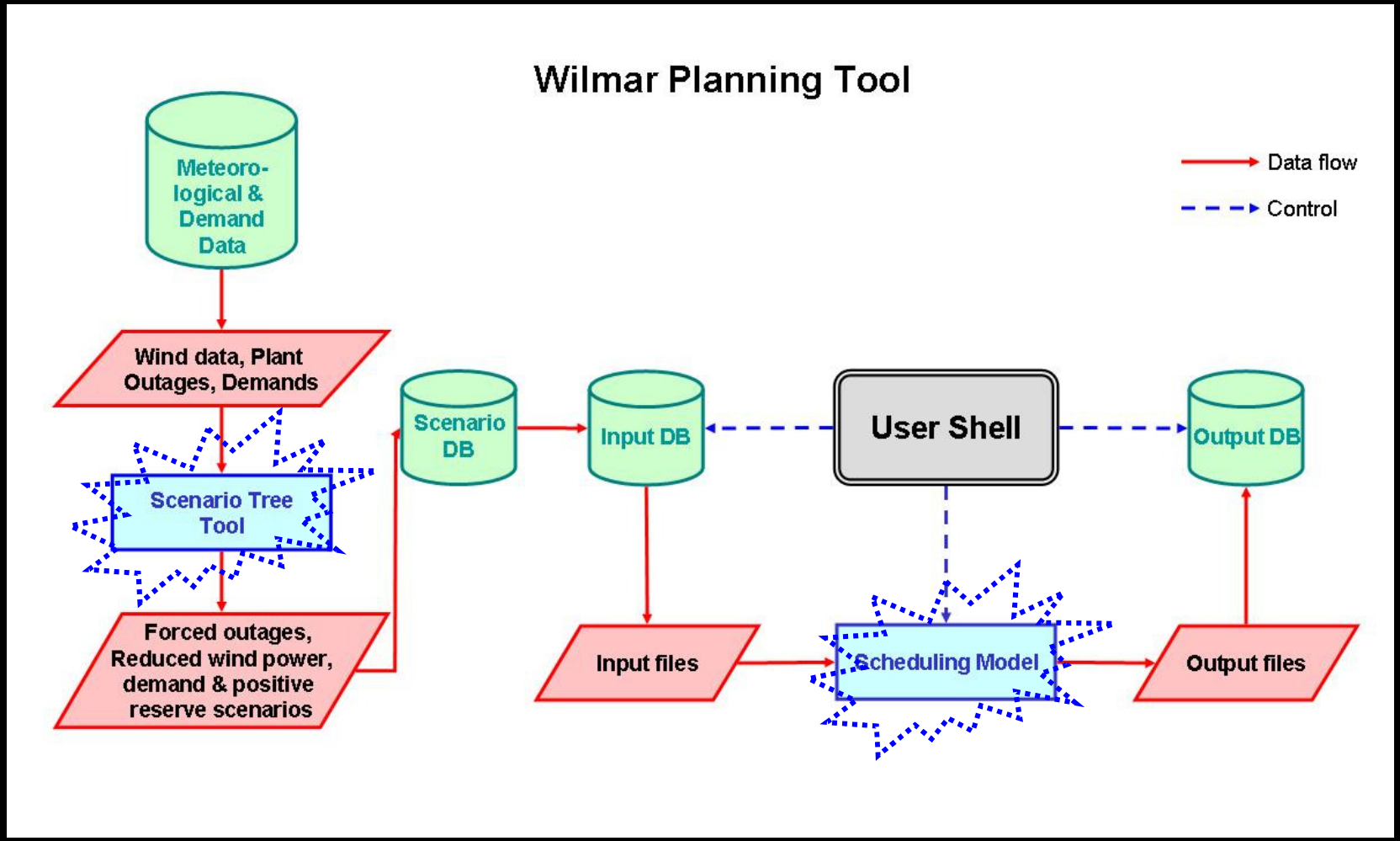
Consultant: ESBI


Cost
**Non-Grid Study information
Volume
Renewable Resources

WS2B: Wind variability management study

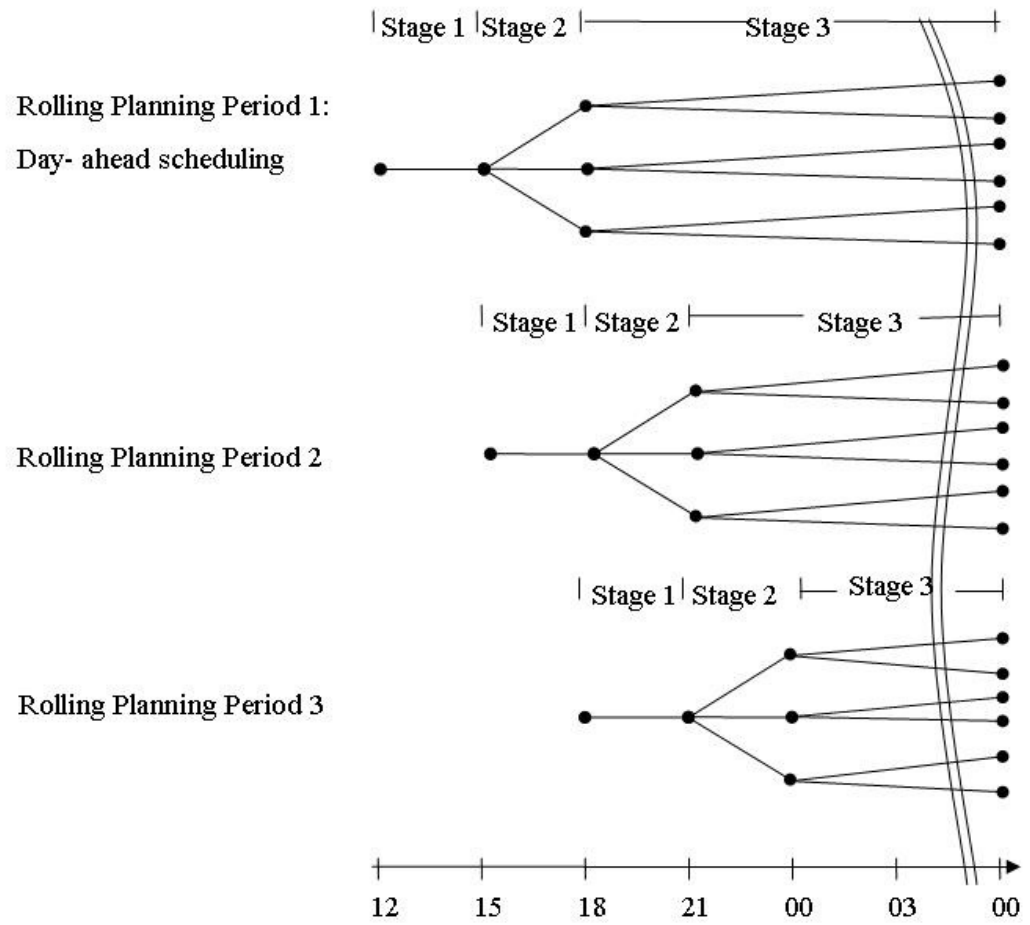
Consultant: RISO *et al.*

Overview of Wilmar

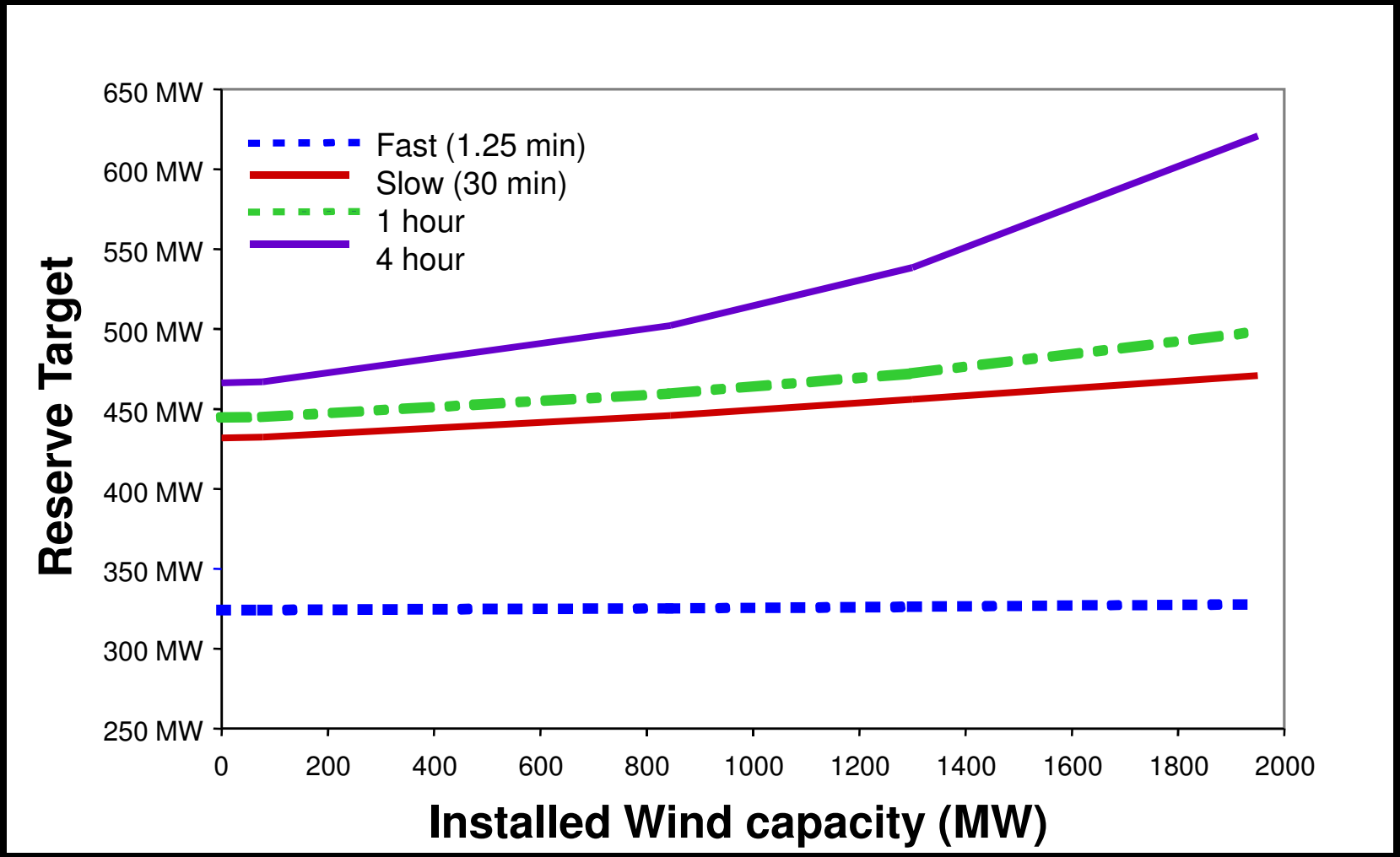


= main model functionality

Functionality Scheduling Model (SM)



Reserve targets



ILEX Energy, UCD, QUB and UMIST, "Operating reserve requirements as wind power penetration increases in the Irish electricity system", Sustainable Energy Ireland (2004)

**Non-Grid study information

Modelling of GB

- 7 Yr Statement (GB National Grid 2006)
- 2012 portfolio used as the basis for power generation portfolio in GB in 2020

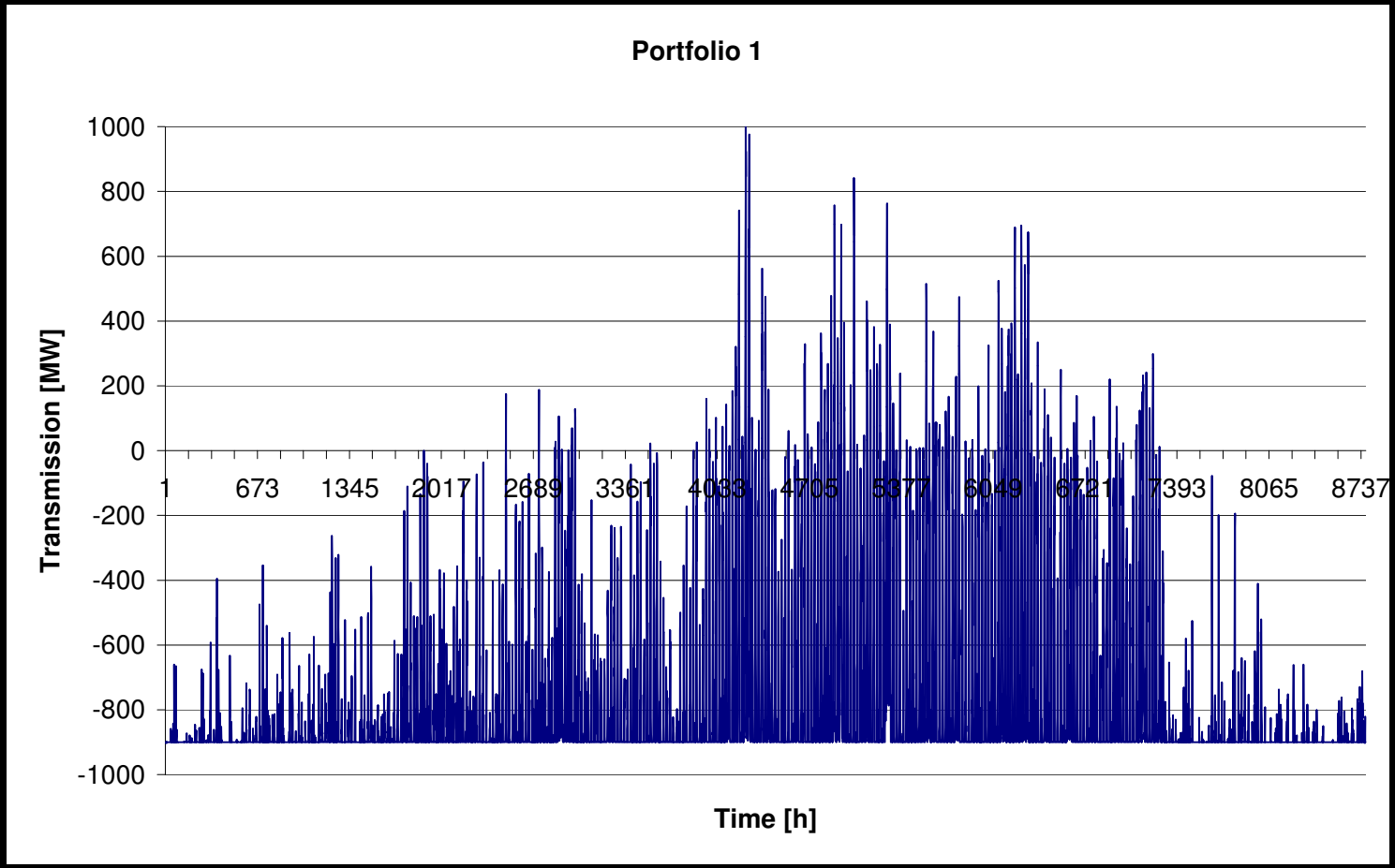
Plant Type	2006	2012
Biomass	45	45
CCGT	23762	33466
CHP	1713	2314
CHP/Steam	19.5	19.5
Hydro	1066	1166
Interconnector	1988	3308
Large Unit Coal	4413	4413
Large Unit Coal + AGT	21306	21441
Medium Unit Coal	1152	1152
Medium Unit Coal + AGT	1076	1076
Nuclear AGR	8366	8366
Nuclear Magnox	2348	0
Nuclear PWR	1190	1190
OCGT	589	589
Offshore Wind	140	3445
Oil + AGT	2990	2990
Pumped Storage	2290	2744
Small Unit Coal	783	783
Tidal	7	7
Waste	8.3	8.3
Wind	1034	5952
Total	76286	94474

Reliance on import and renewables

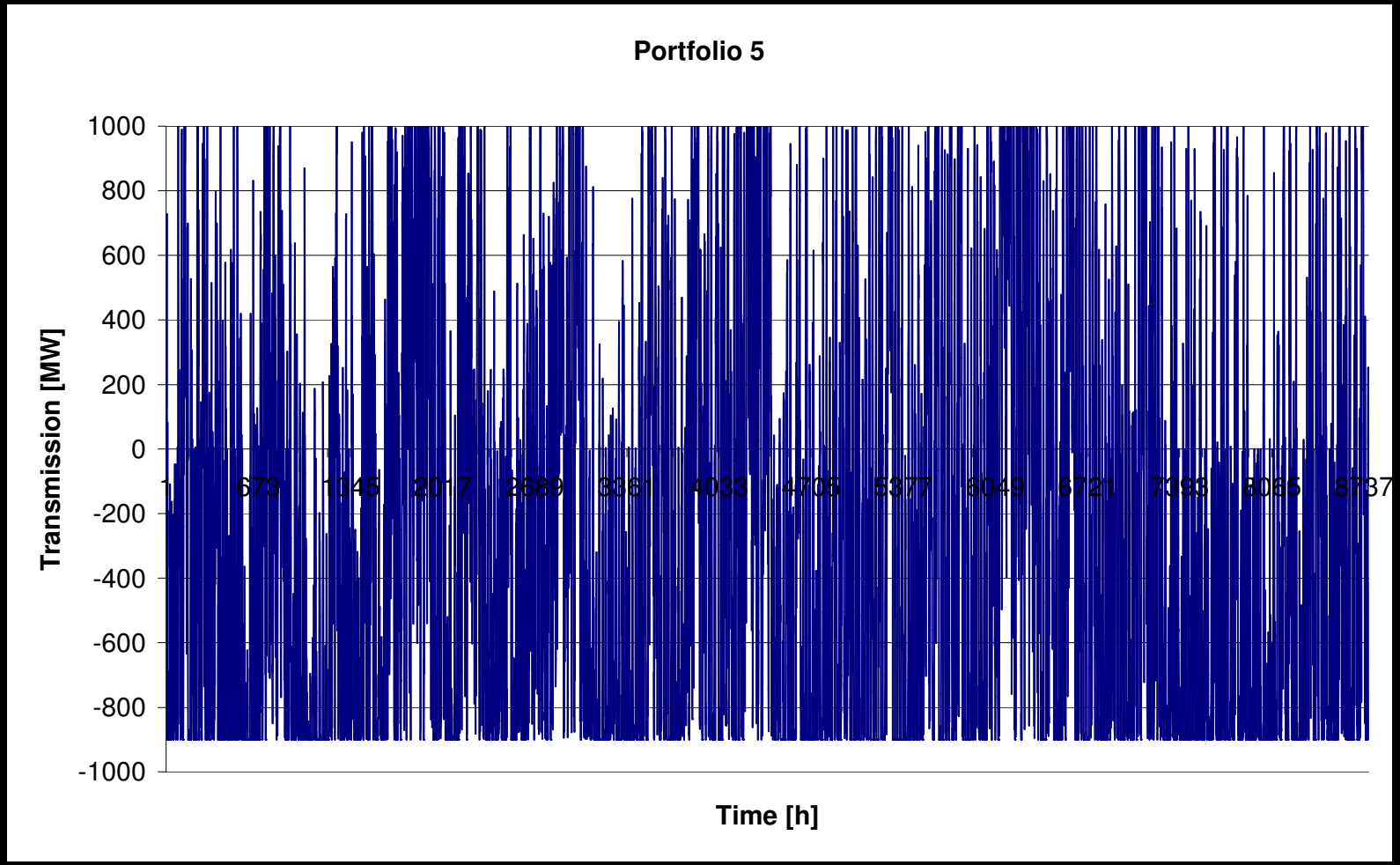
	P1 [MW]	P2 [MW]	P3 [MW]	P4 [MW]	P5 [MW]	P6 [MW]
Total installed capacity excluding wind, tidal and wave power	8644	8374	8314	8484	8128	7739
Peak load	9619	9619	9619	9619	9619	9619

Comparison of the total installed capacity excluding wind, tidal and wave power with the peak load in MW

Import/export GB (portfolio 1)



Import/export GB (portfolio 5)

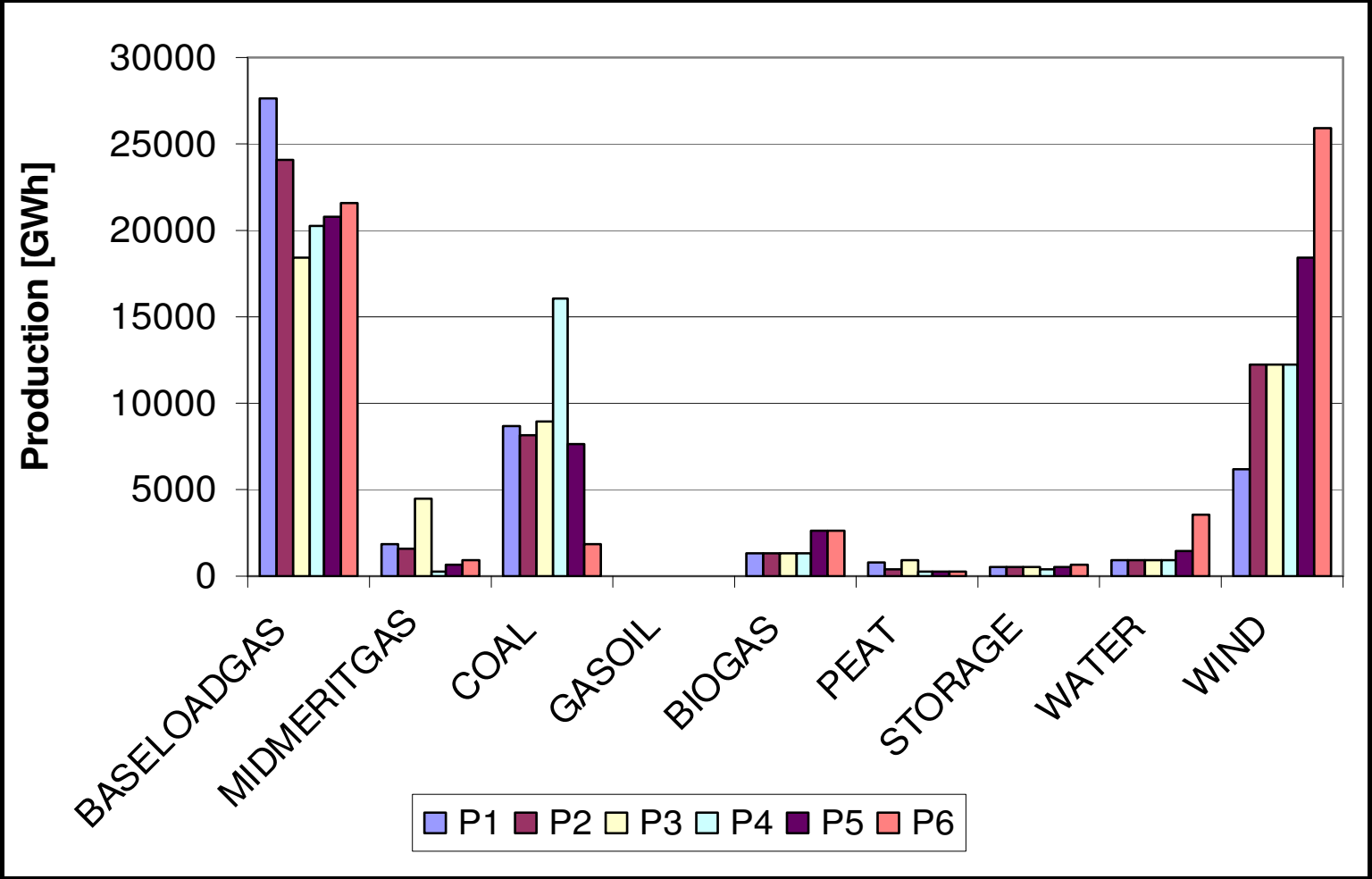


Reliability in model runs

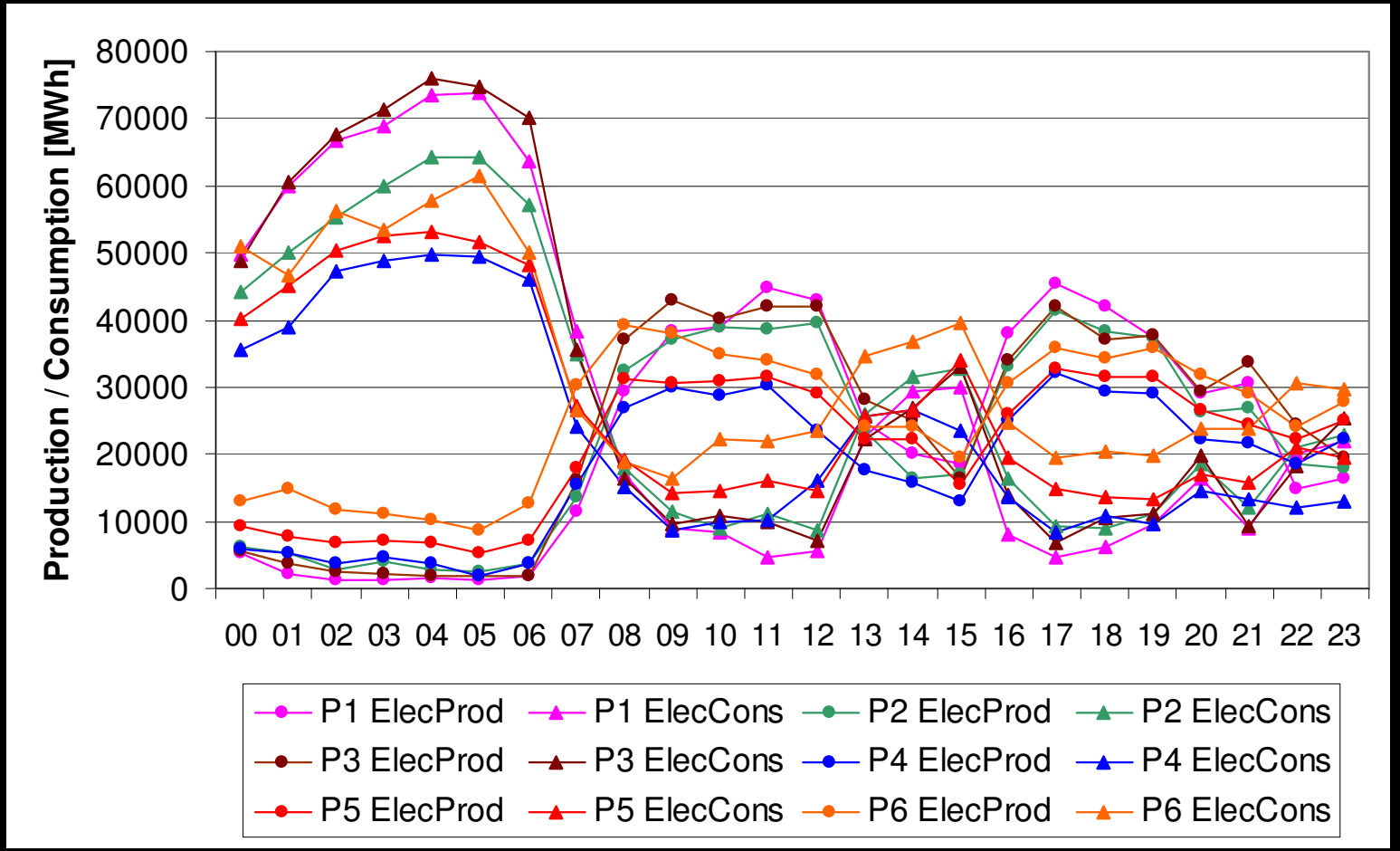
Portfolio	Hours where load is not met	Hours where demand spinning reserve is not met	Hours where demand for replacement reserve is not met due to lack of capacity
P1	0	4	96
P2	3	6	101
P3	0	1	98
P4	1	5	115
P5	0	3	88
P6	23	77	544

Number of hours where load, demand for spinning reserve and replacement reserves is not met. The logic in the model ensures that load is met before the demand for spinning reserves, and the demand for spinning reserve is met before the demand for replacement reserves

Production from fuel source



Pump storage utilisation



The yearly electricity production and electricity consumption of Turlough Hill distributed on the hours during a day in MWh

Improved forecasting

	P1	P2	P3	P4	P5	P6
Absolute cost reductions due to perfect forecast [MEuro]	1.2	8.0	4.8	13.6	18.5	65.0
Relative cost reductions due to perfect forecast [%]	0.05	0.4	0.2	0.7	1.2	3.6

WS3: Networks

Extent and cost of engineering implications including likely network reinforcements to accommodate the specified renewable generation

Consultant: TNEI

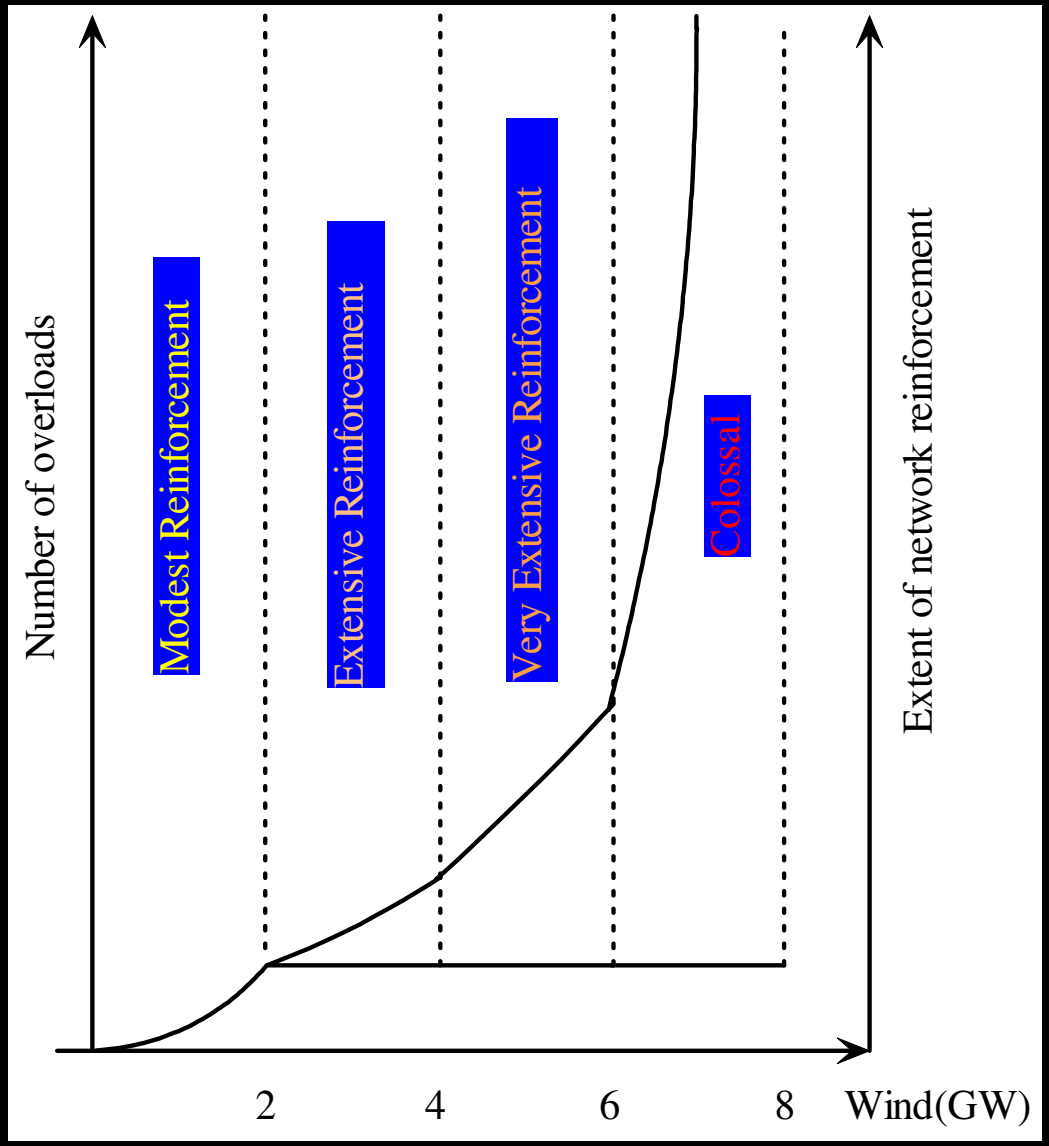
Network protests

**Non-Grid Study information

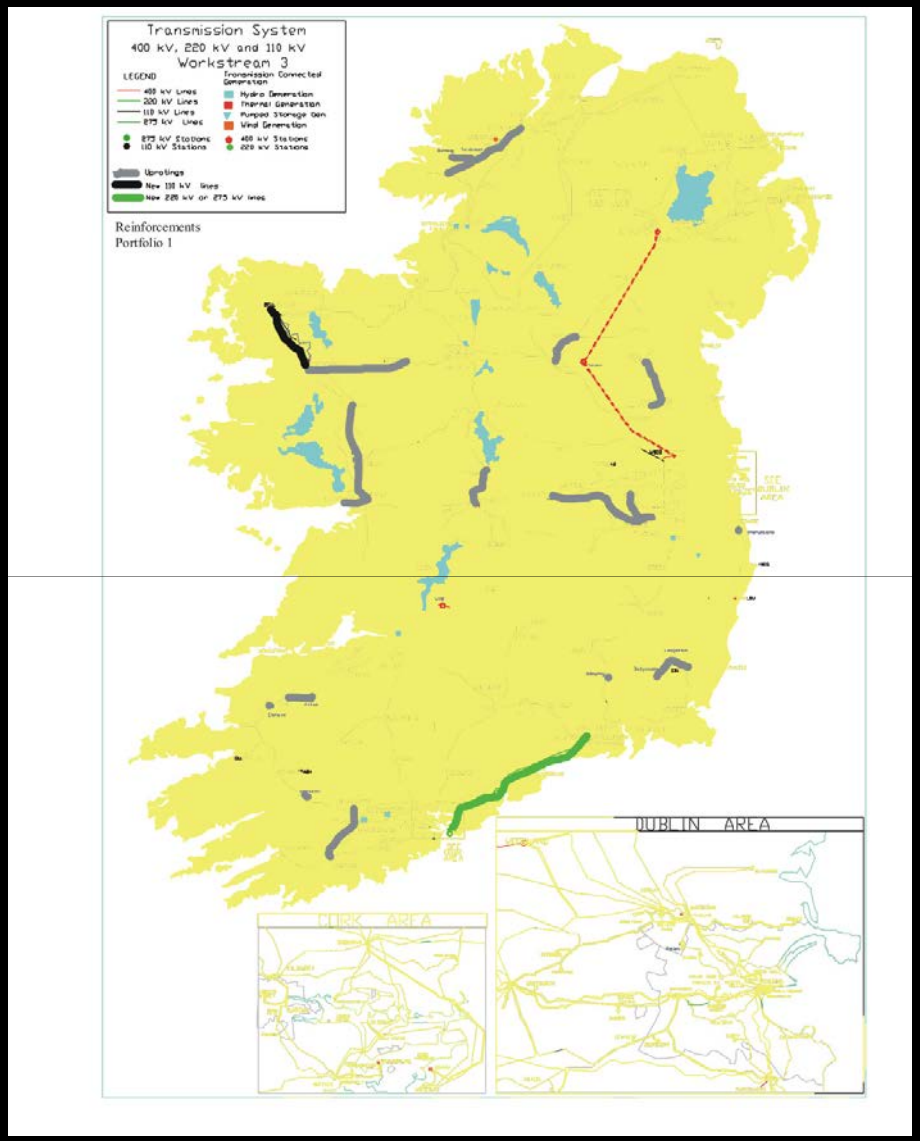
Objectives

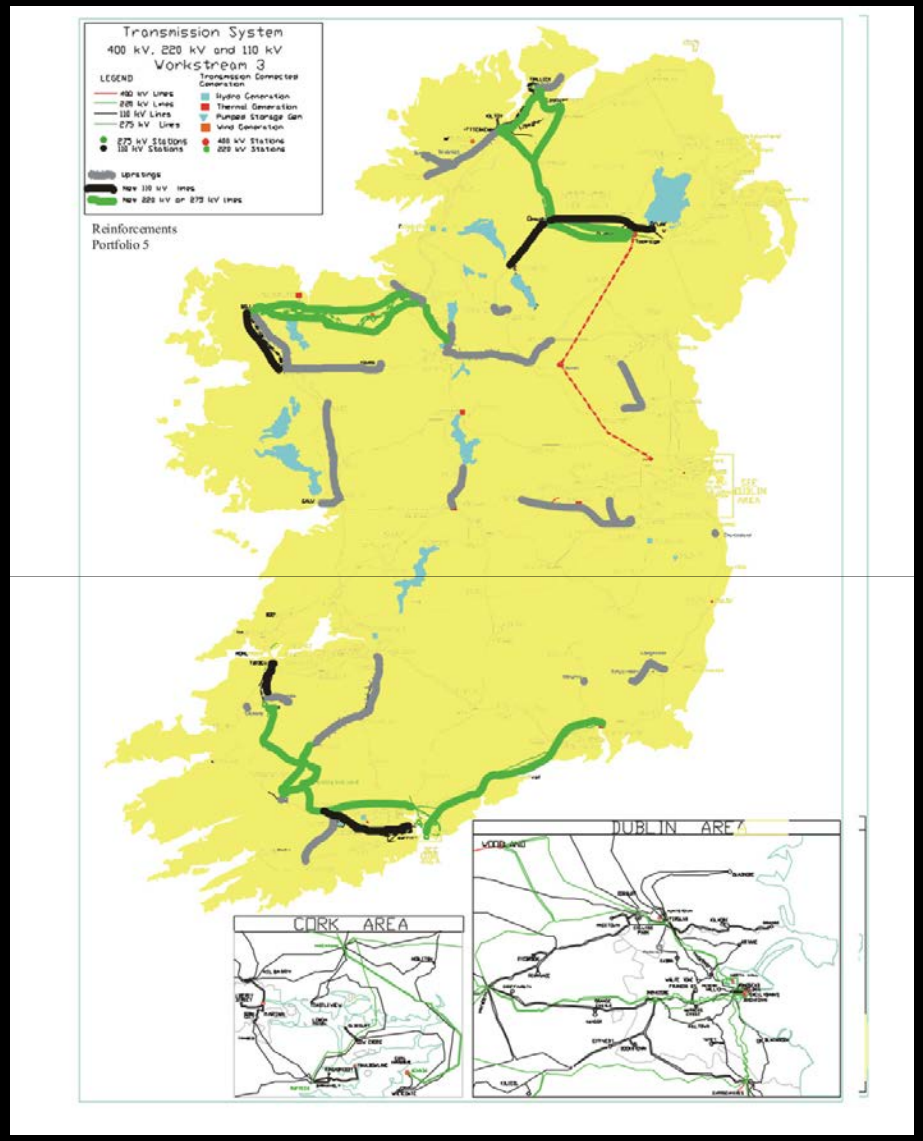
- Identify existing network bottlenecks
- Identify bottlenecks for predicted levels of renewable generation
- Assess reinforcements to reduce bottlenecks
- Analyse the reinforcement capital costs

An Overview


Number of overloads
Modest Reinforcement
Extensive Reinforcement
Very Extensive Reinforcement
Colossal
Extent of network reinforcement
2
4
6
8
Wind(GW)

Upgrades P1 and P5





*Reinterpreted Grid Study information

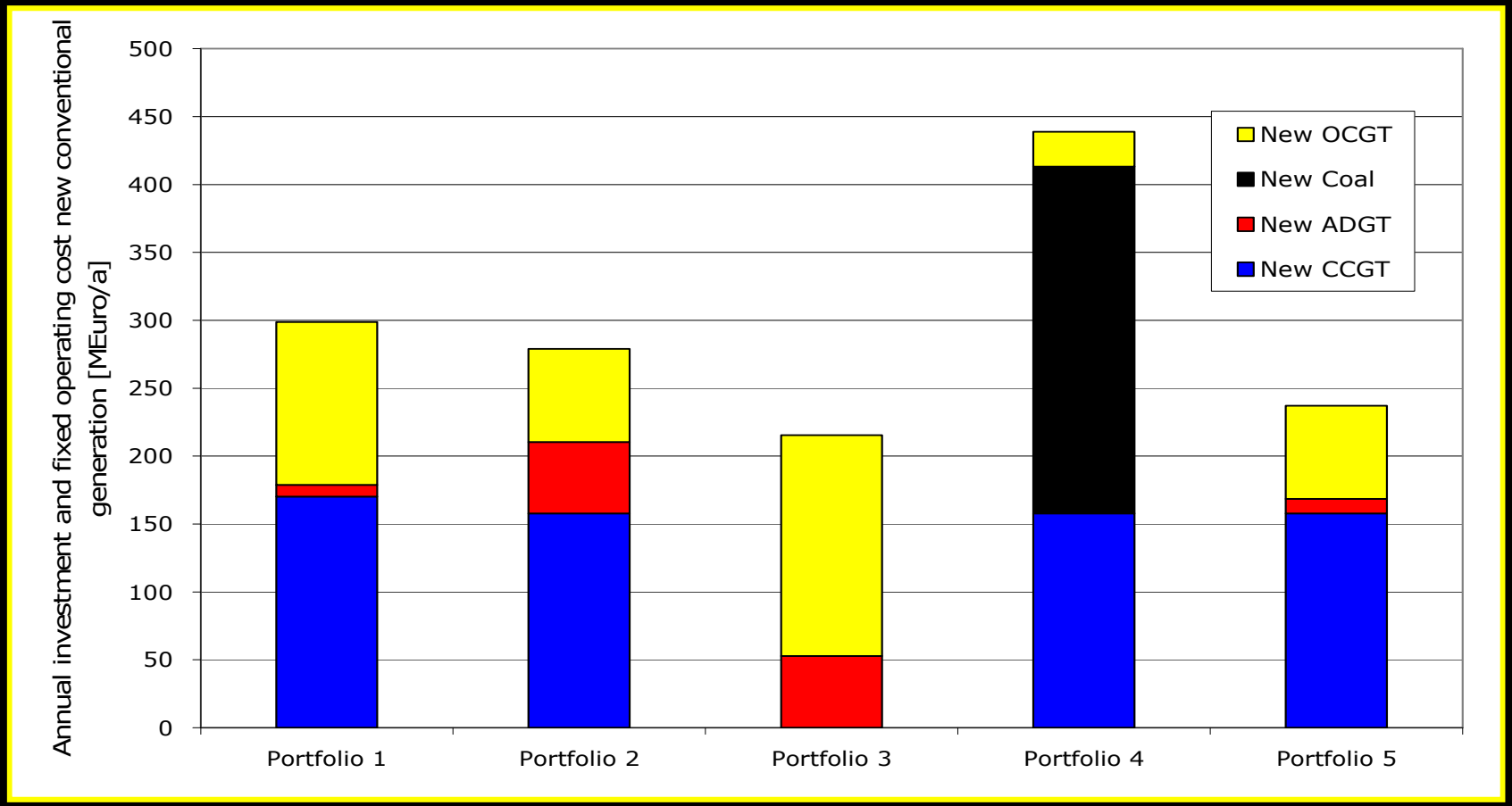
WS 4: Analysis of Impacts and Benefits

Consultant: Ecofys

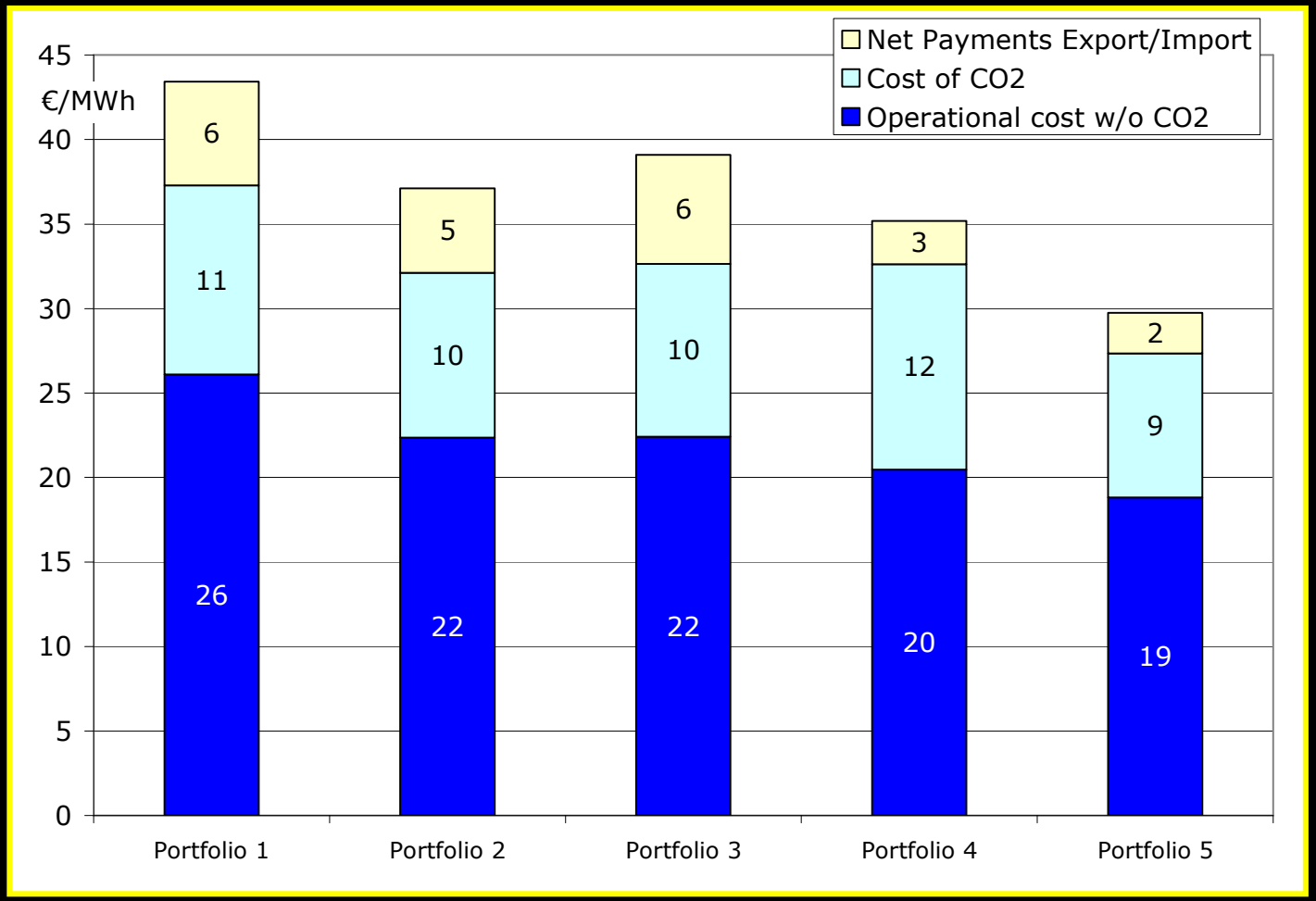
Health warning slide

- Assumptions
- Limitations
- Cautions
- etc.

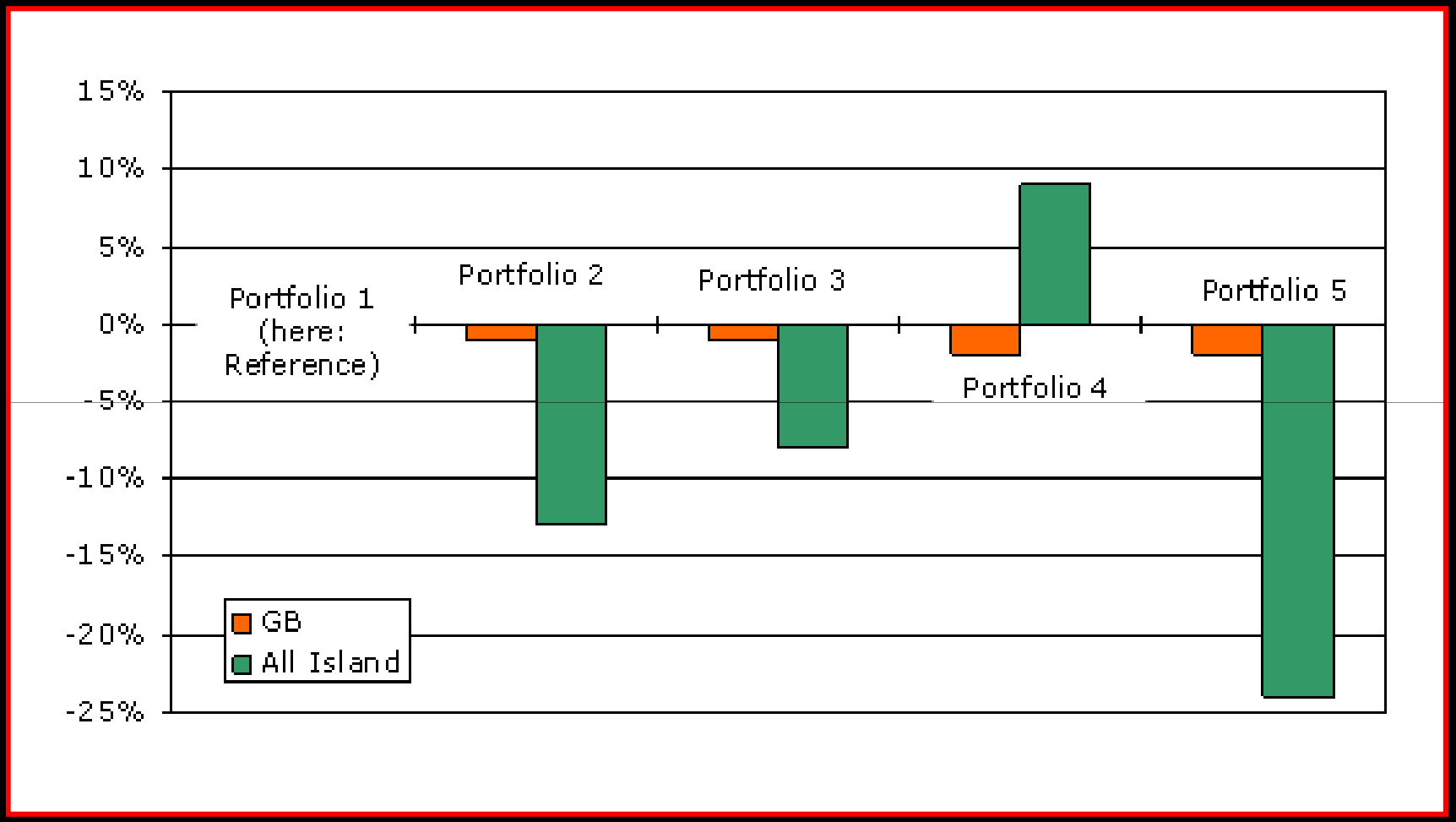
Annual investment and fixed costs for new conventional generation



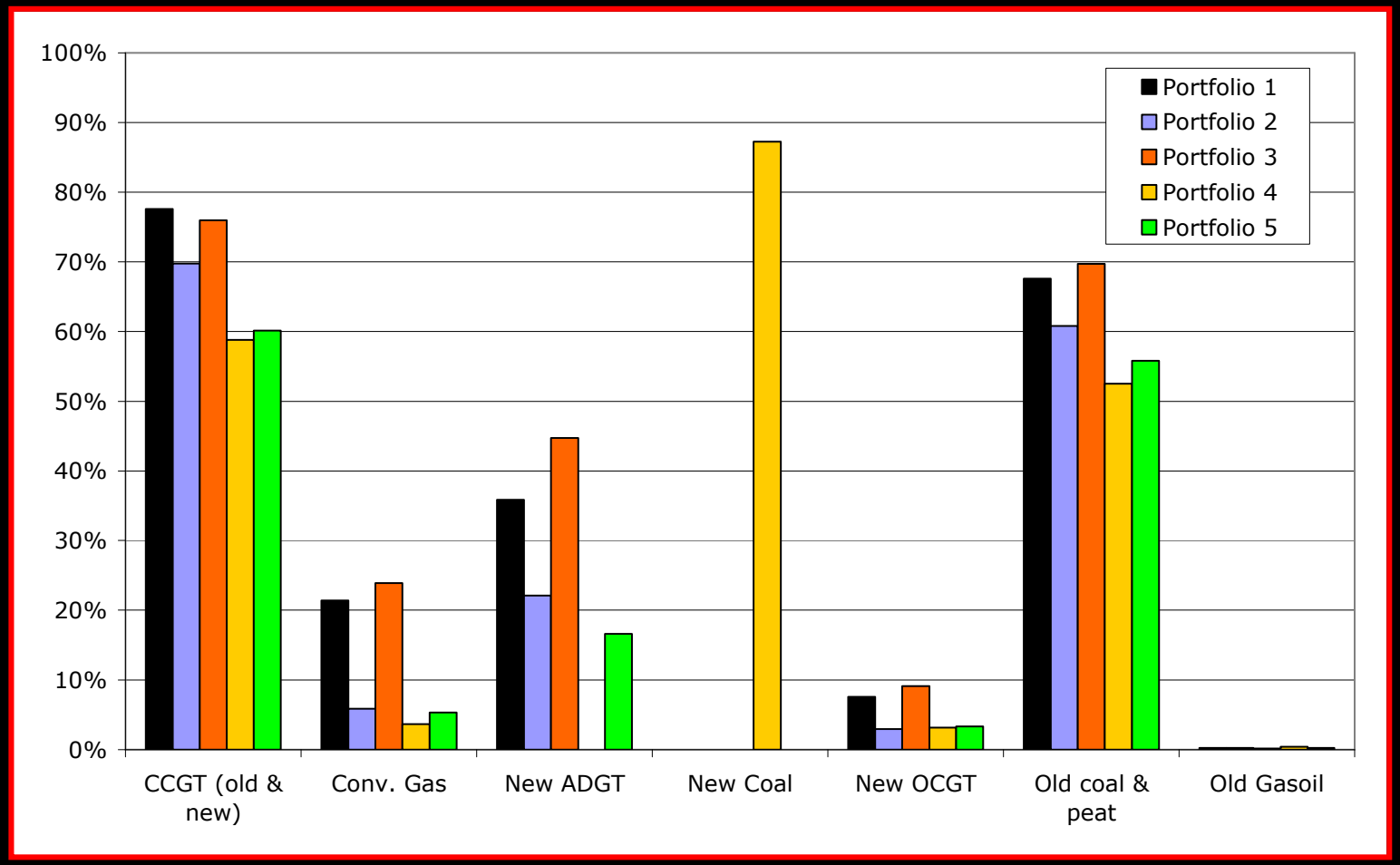
Operational Costs – Conventional Generators



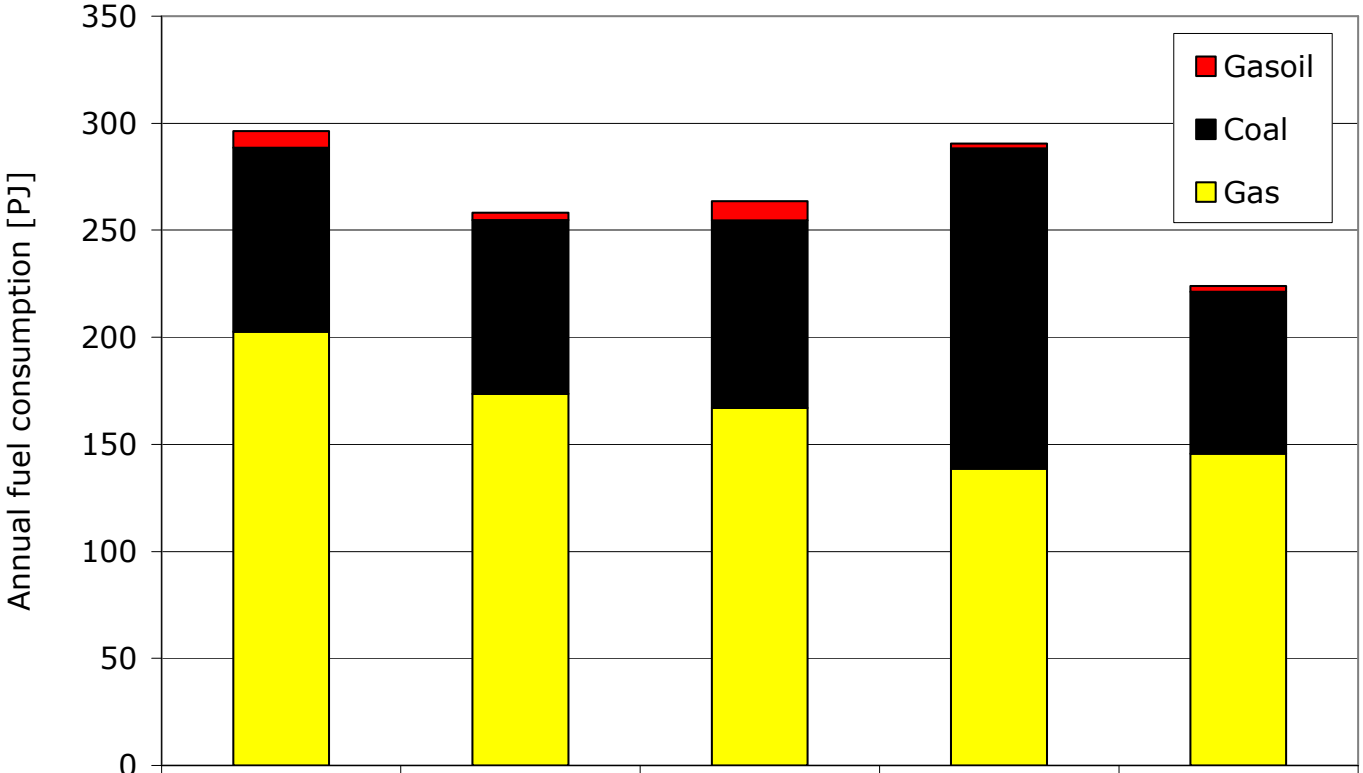
Relative CO_2 Emissions Impact



Impact on thermal generation

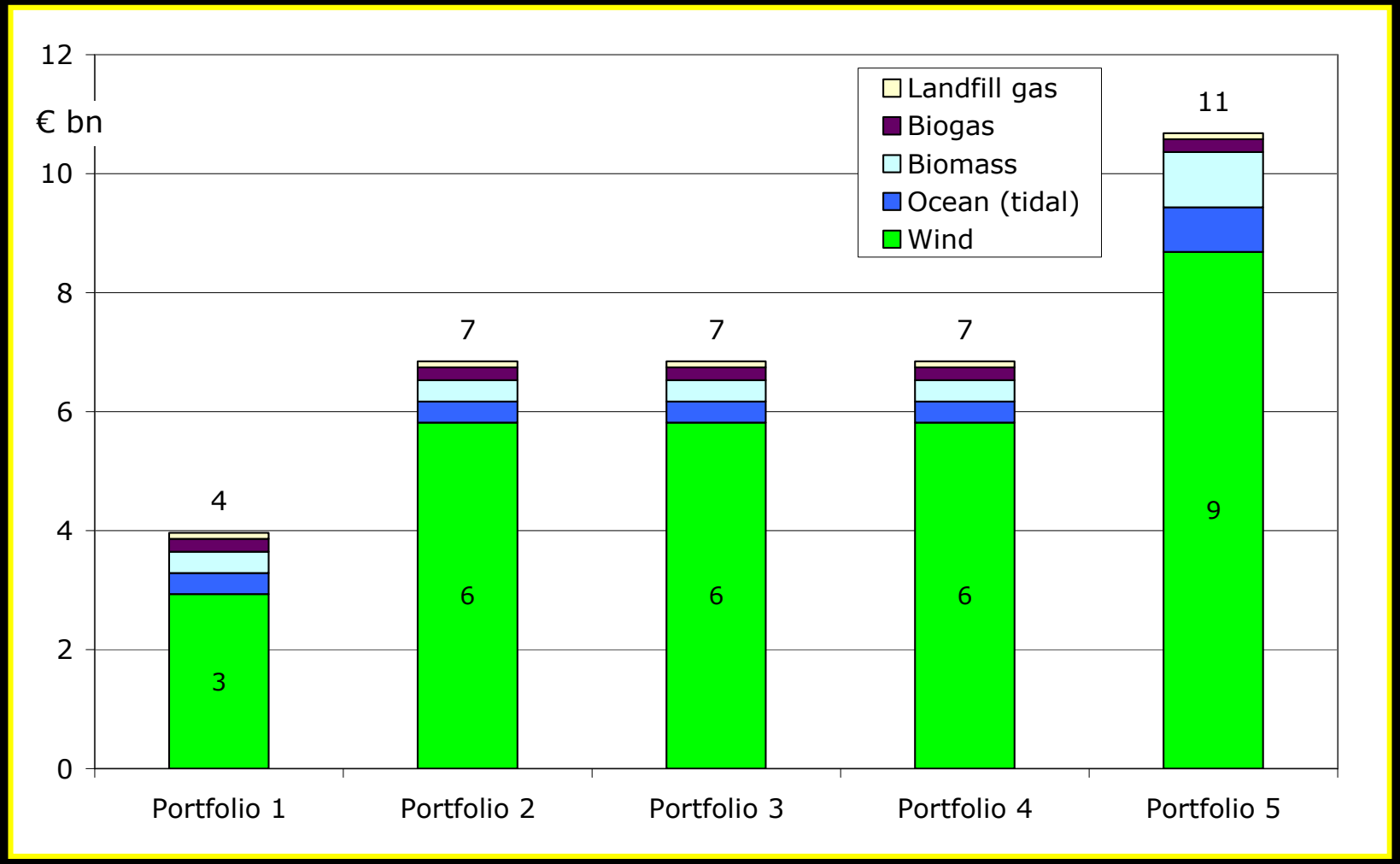


Security of supply

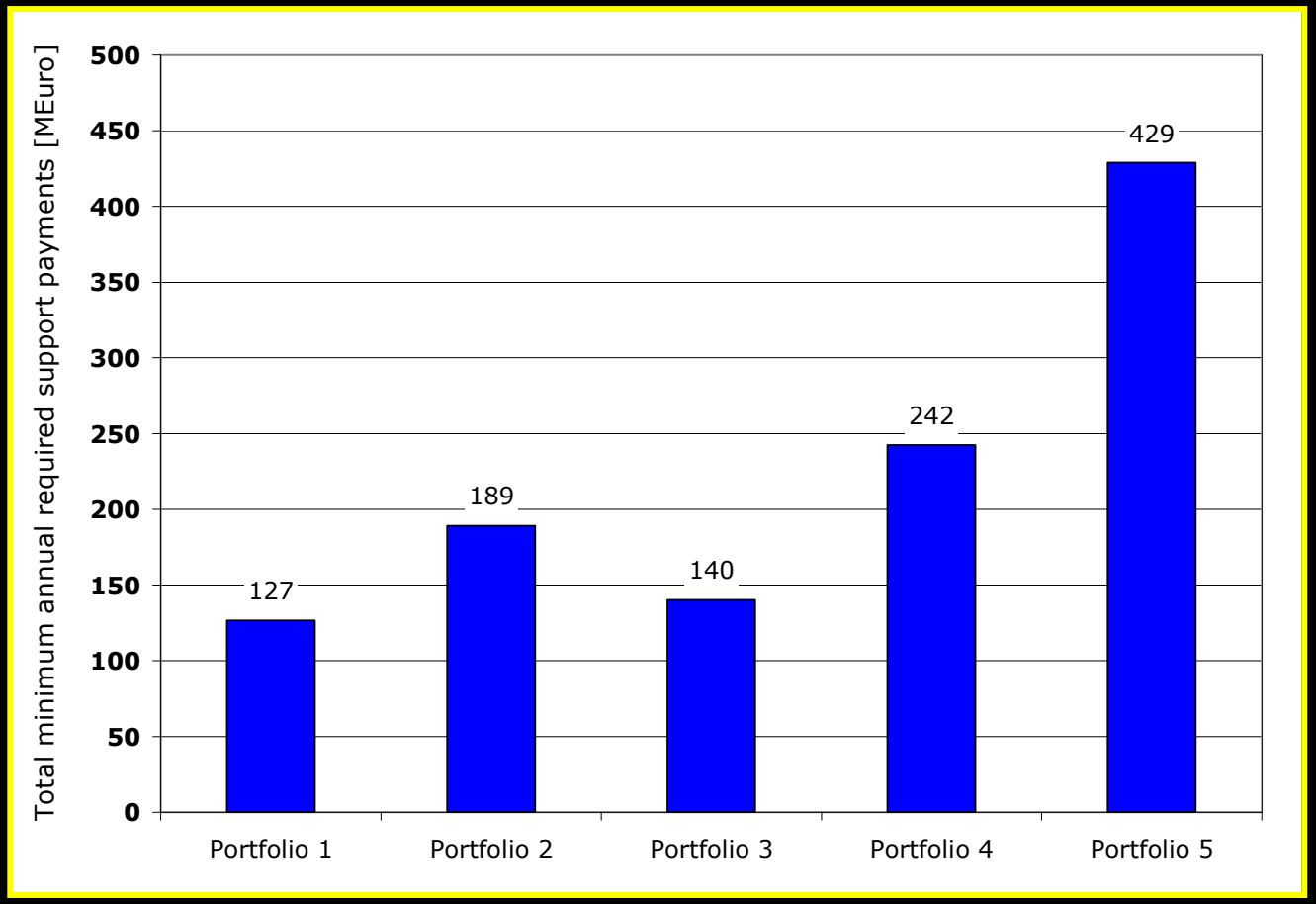


	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5
Gasoil	8	3	9	2	3
Coal	86	81	88	150	75
Gas	203	174	167	139	146

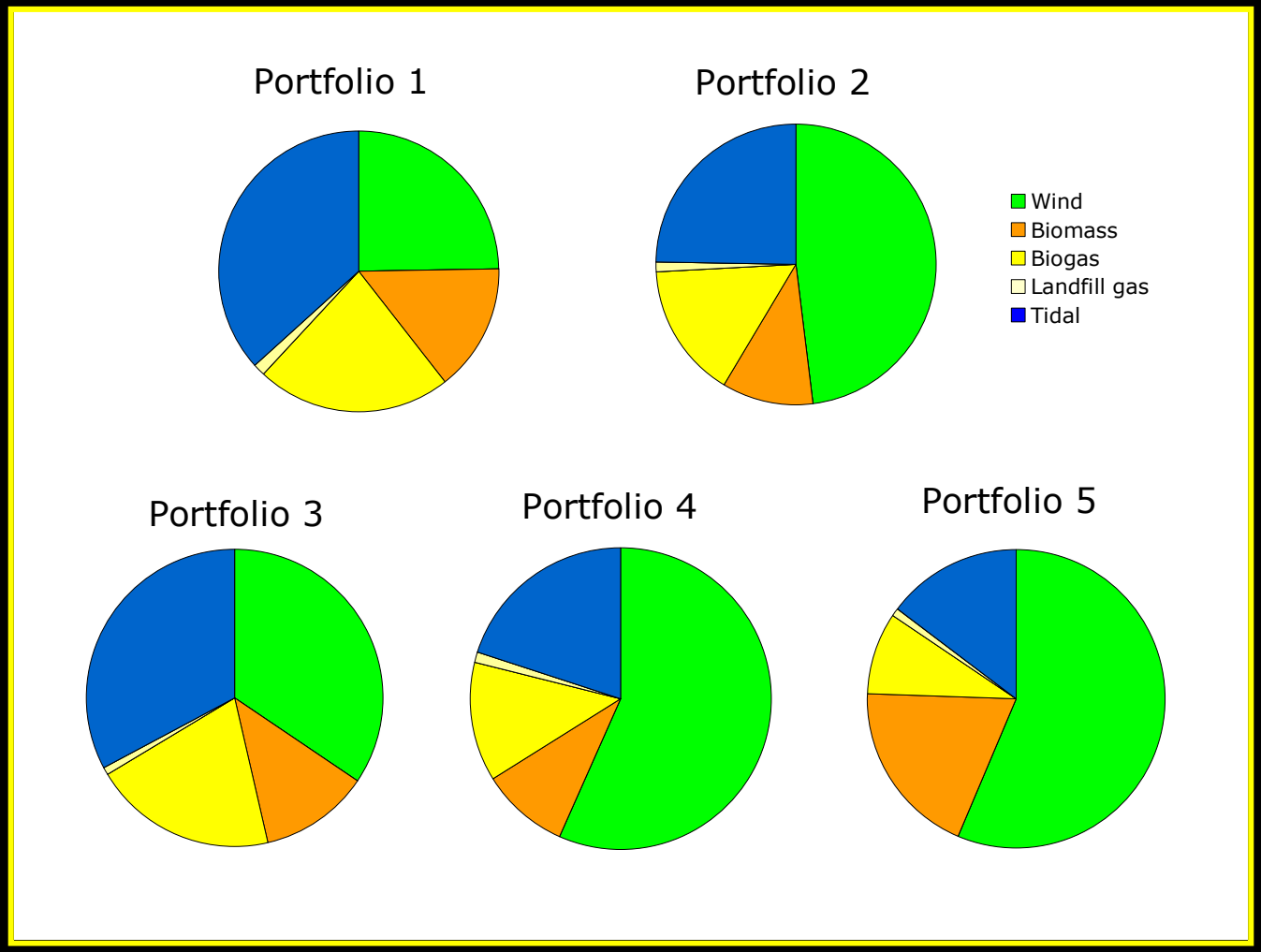
Total investment in Renewables for each Portfolio



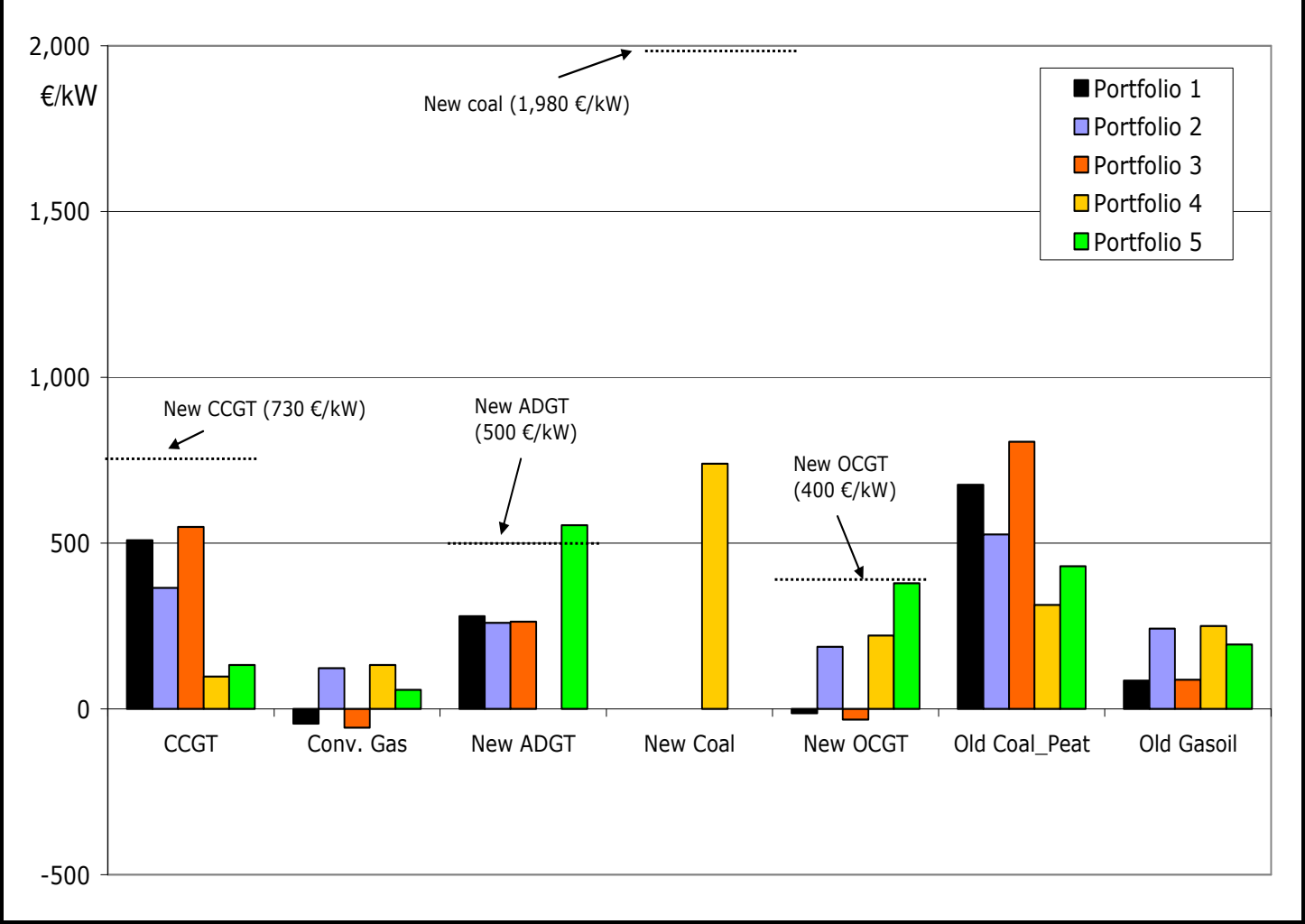
Minimum support for renewables



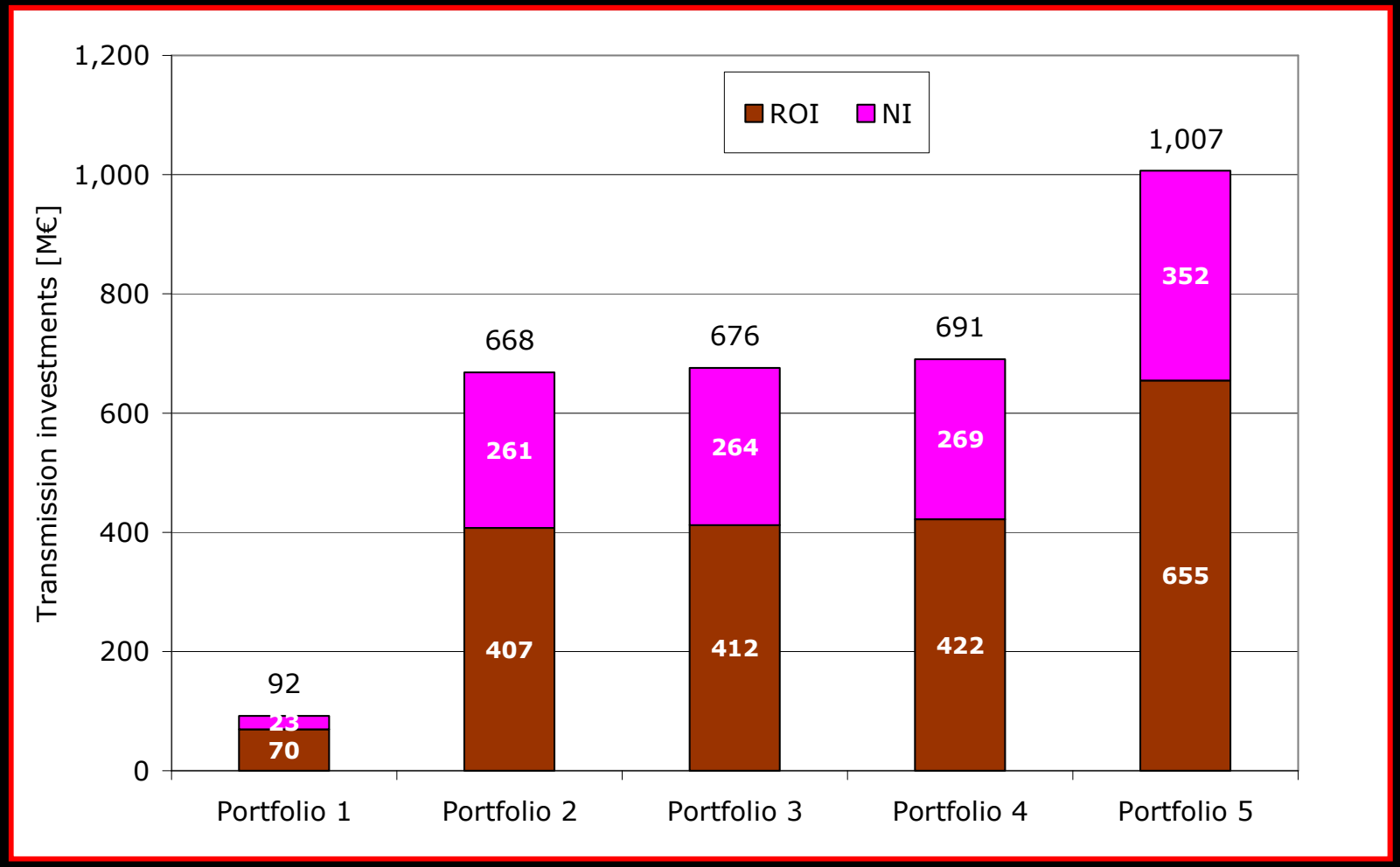
Distribution of renewable support



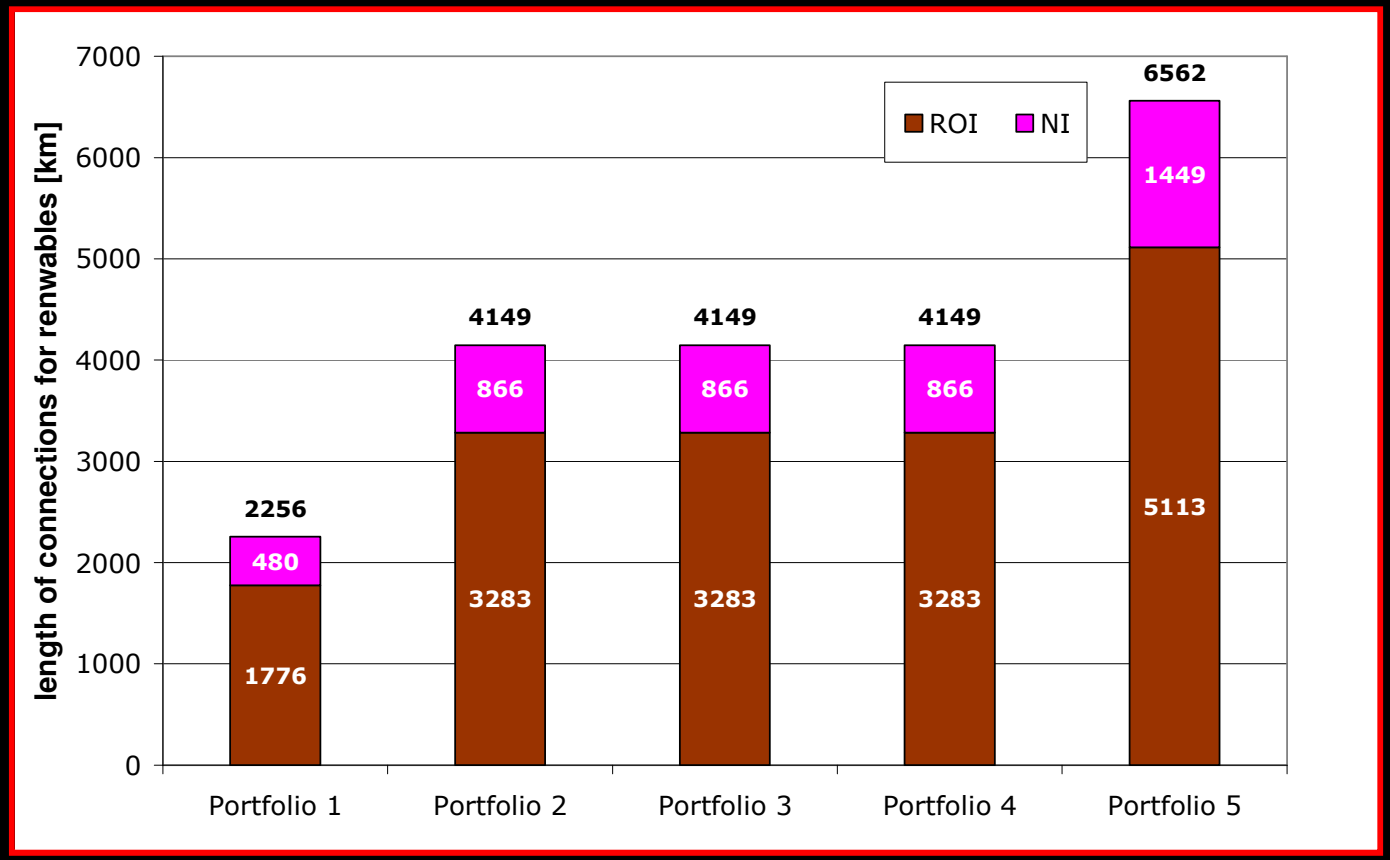
Support for thermal plant



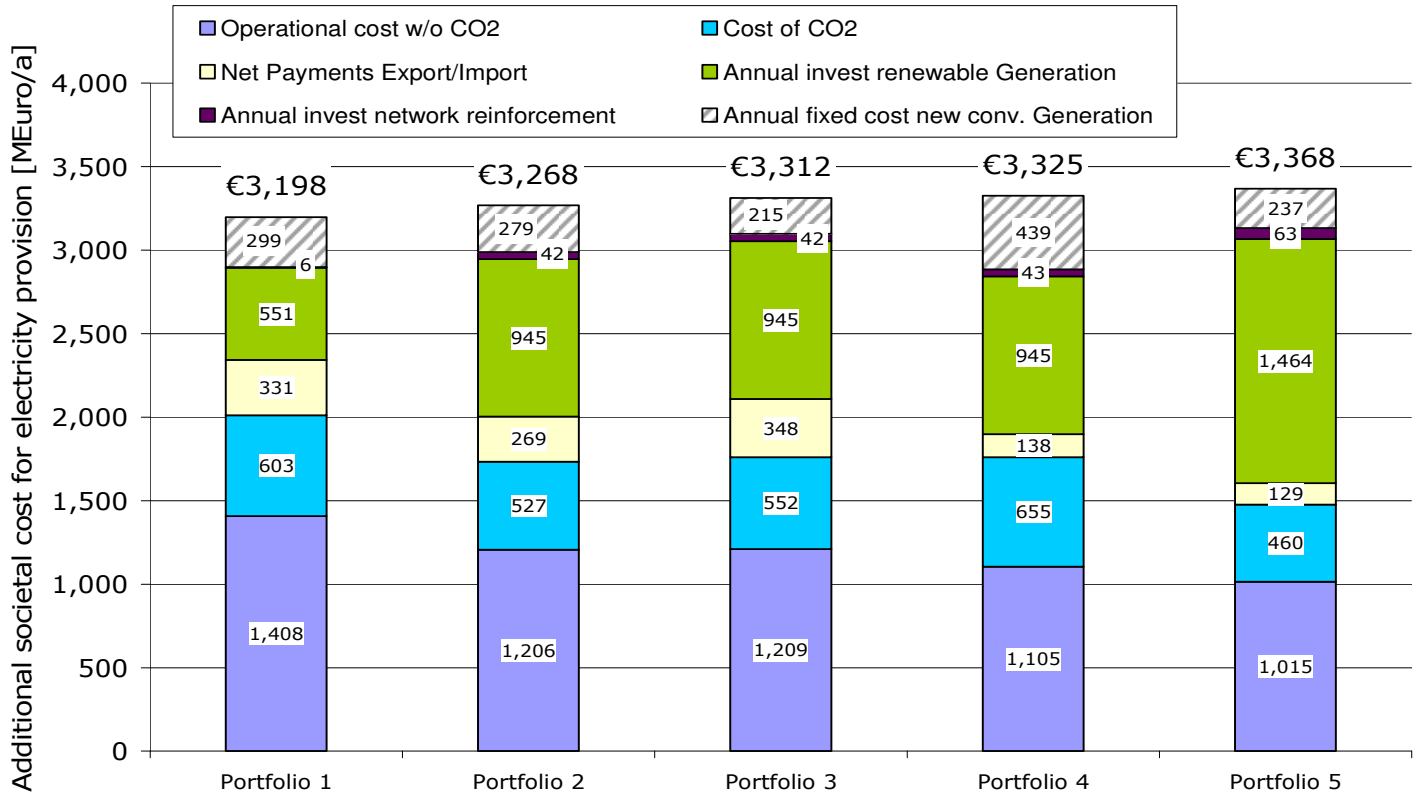
Cost of Transmission System Reinforcement



Other network impacts



Societal Costs of Adopting Portfolios



RE share of demand	16%	27%	27%	27%	42%
CO_2 emissions [Mt/a]	20	18	18	22	15

Conclusions

- Up to 42% renewables is feasible (Portfolio 5), requires less imported fuels, and provides CO_2 saving of 25% compared to Portfolio 1

- Costs to society of additional renewables (7 %, Portfolio 1 to 5)
  - may change for different fuel and carbon prices
  - these costs are probably underestimates

- Principal form of renewable generation will be wind

Conclusions contd.

- Relatively large amount of high voltage transmission required
  - low cost but may be difficult to deploy

- Improved forecasting and additional storage appear not to give significant economic benefit

Limitations etc.

- Interactions
- Market model
- Inefficiency in support mechanism
- Costs not included
- Impact on thermal generation
- Detail transmission network design
- Constraining off
- Sensitivities
- Offshore and wave
- UK system modelling

Further work

- Intra hour operation and dynamics
  - curtailment
- Strategic network planning
  - distribution network
- Operational paradigm
  - forecasting etc.
- Long term data (e.g. wind time series)

Further work

- Plant mix
  - OCGT/CCGT, storage, demand side management, interconnection
- Market study
  - Electricity market SEM
  - Support mechanism
  - Wider market impacts e.g. gas

ALL-ISLAND GRID STUDY

Mark O'Malley

Cambridge May 16th 2008