IEA-ETSAP Technology Collaboration Programme - Ireland's experience

Prof. Brian Ó Gallachóir,
Chair IEA ETSAP Executive Committee
Professor of Energy Policy and Modelling, UCC

IEA ETSAP Workshop on Energy Modelling & Applications
Todai, Tokyo, Dec 14 2016

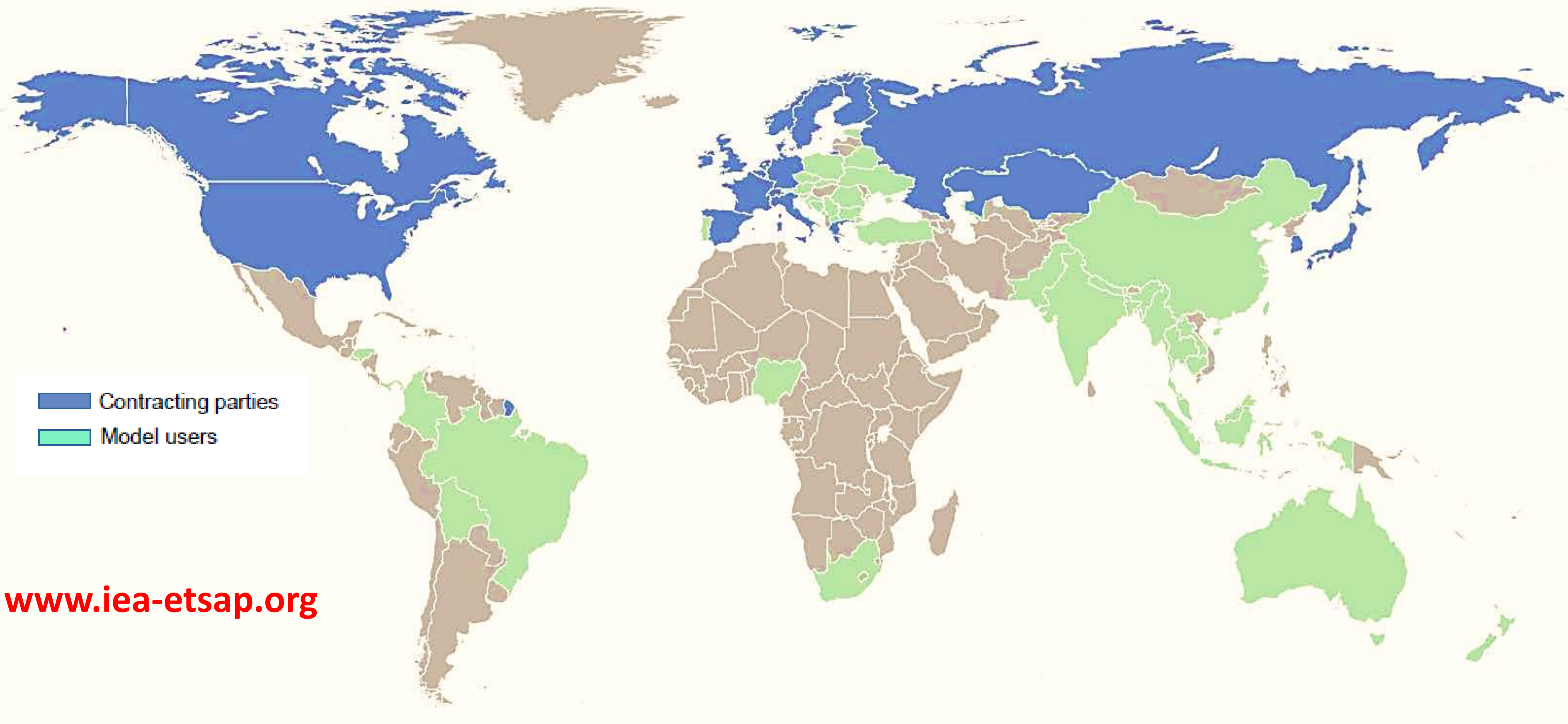
A TRADITION OF INDEPENDENT THINKING

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

What is IEA ETSAP?

- One of 39 **IEA Technology Collaboration Programmes** www.iea.org/tcp/
- 40 years international **cooperation** on energy **systems** modelling (since first oil crisis)
- **Developing and maintaining** (MARKAL and TIMES) tools
- **Assisting policy decisions** by modelling possible future **energy pathways**
- Focus on key role of **technology** to meet goals
- Biannual **workshops** and **training**

>200 Users in 73 countries

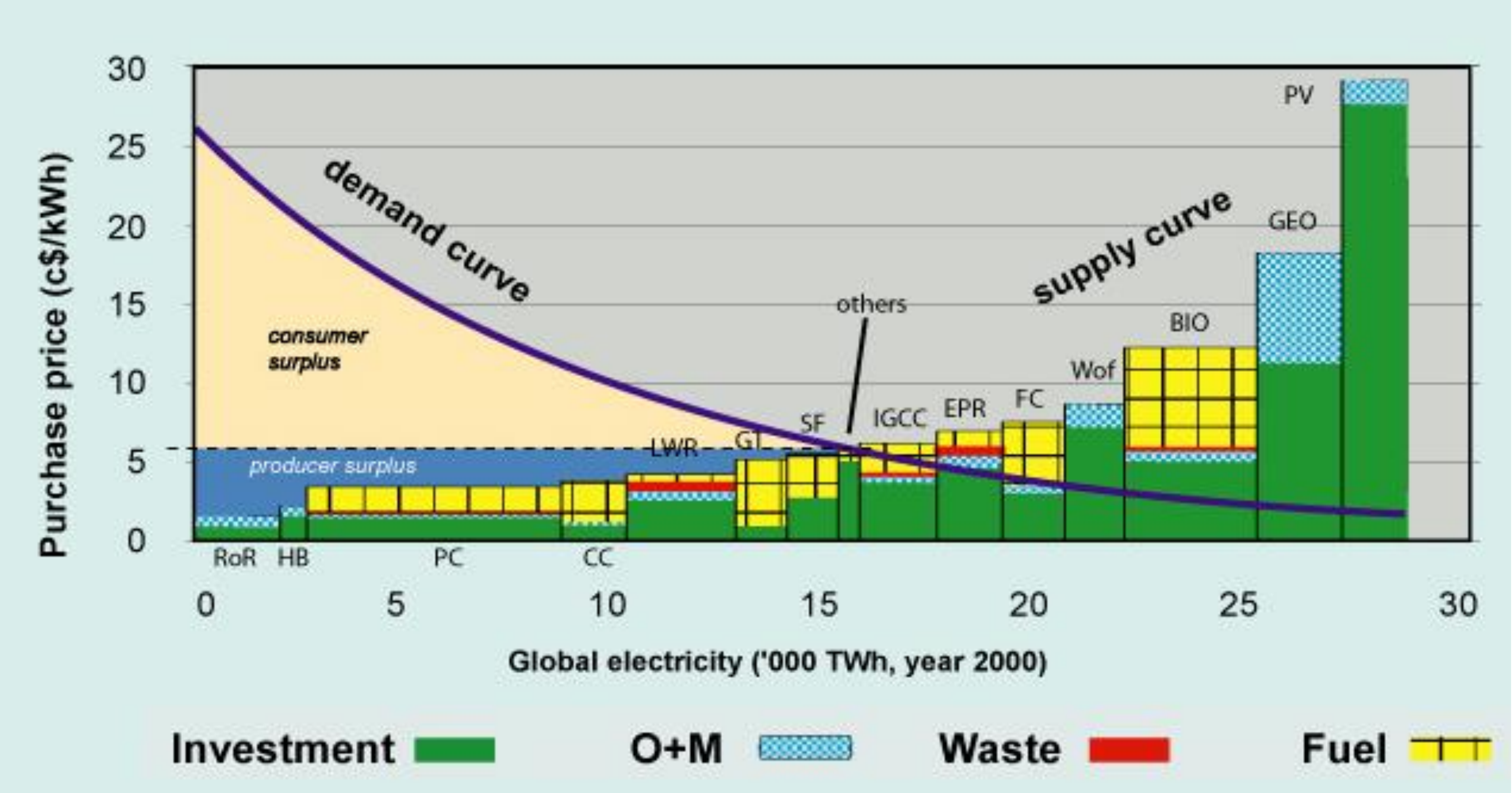


www.iea-etsap.org

TIMES Model

- linear programming bottom-up energy model
- integrated model of the entire energy system
- medium to long term prospective analysis (20 - 50 years)
  - Demand driven (exogenous) in physical units
- partial and dynamic equilibrium (perfect market)
- optimal technology selection
- minimize the total system cost
- environmental constraints
- energy and emission permits trading
- price-elastic demands

Net Social Surplus



Minimise System Costs

$$NPV = \sum_{y \in YEARS} (1 + d_{r,y})^{REFYR - y} \bullet ANNCOST(y)$$

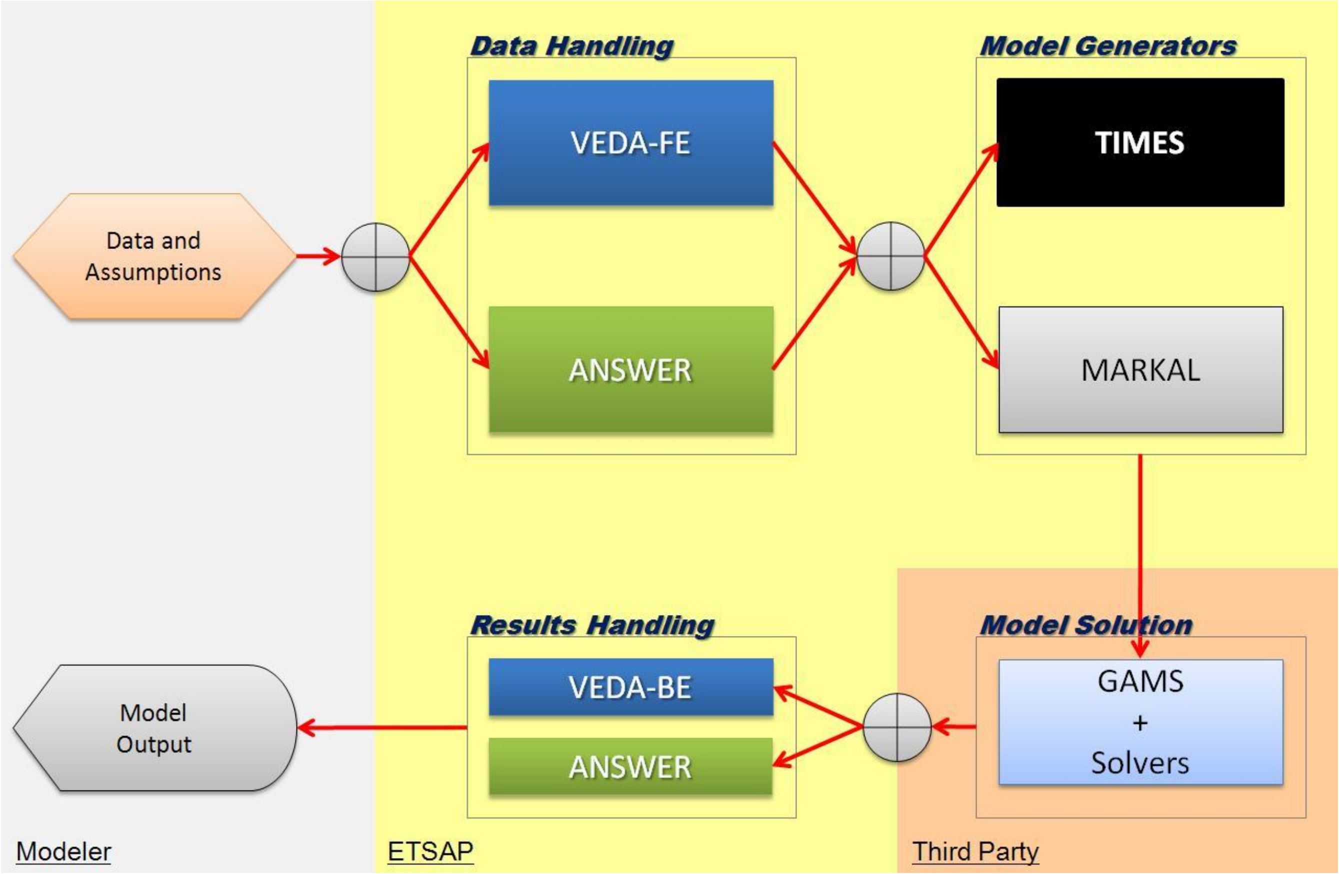
<u>where:</u>

NPV	is the net present value of the total cost (the OBJ);
ANNCOST(y)	is the total annual cost in year y;
$d_{r,y}$	is the general discount rate;
REFYR	is the reference year for discounting (2005);
YEARS	is the set of years for which there are costs in the horizon

Total System Cost

- Capital Costs incurred for investing and dismantling plant;
- Fixed and variable Operation and Maintenance (O&M) Costs;
- Costs for exogenous imports and for domestic resource production;
- Revenues from exogenous exports;
- Delivery costs for required fuels consumed by plant;
- Taxes and subsidies associated with fuel flows and plant activities;
- Salvage value of plant at the end of the planning horizon;
- Welfare loss resulting from reduced end-use demands.

ETSAP Tools



Data Handling
Model Generators
VEDA-FE
TIMES
Data and Assumptions
ANSWER
MARKAL
Results Handling
Model Solution
VEDA-BE
GAMS + Solvers
Model Output
ANSWER
Modeler
ETSAP
Third Party

In Summary …

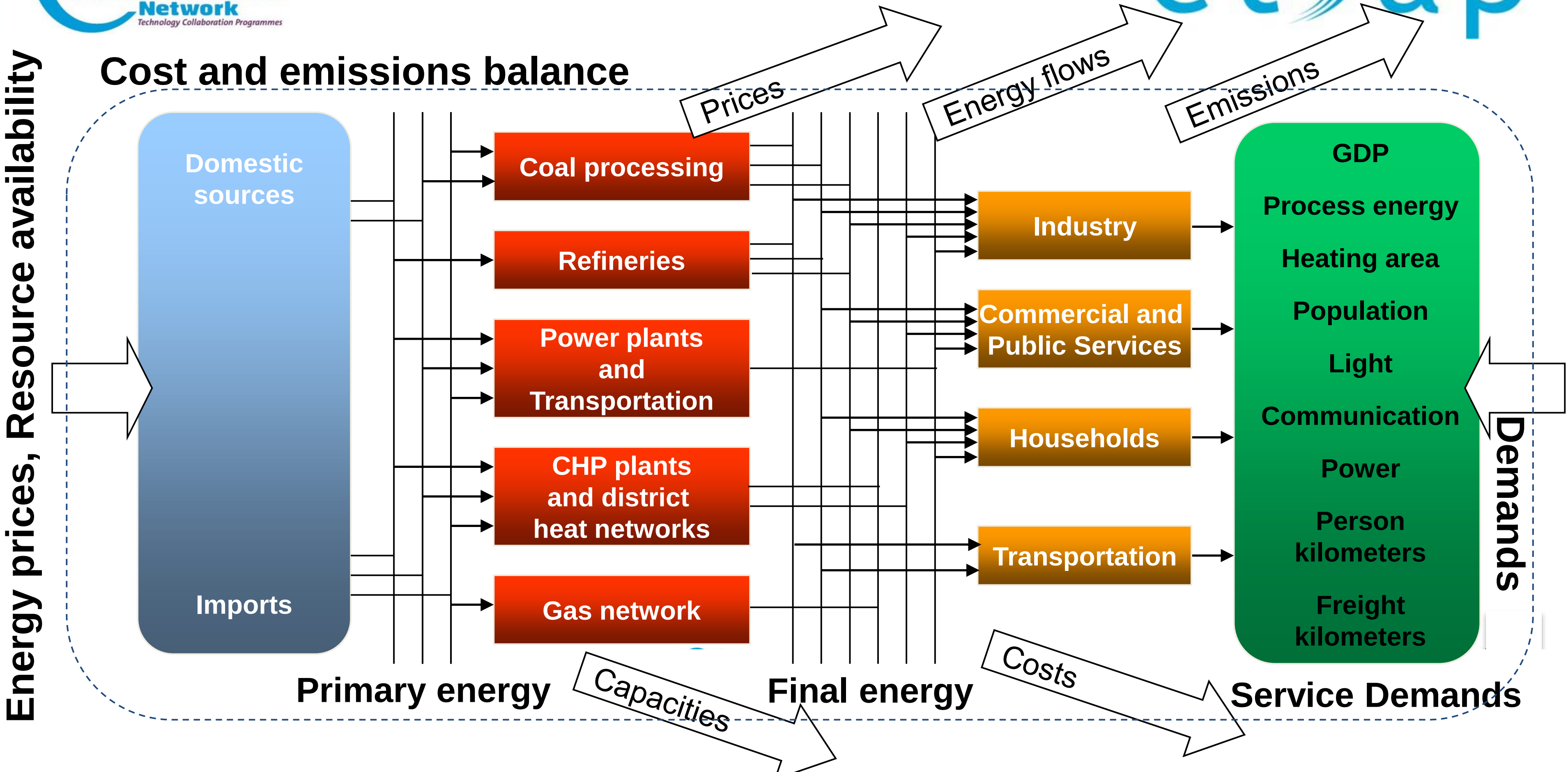
Given…

- technology data (e.g. 1300)
- service demands (e.g. 73)
- import fuel prices
- Supply curves
- emission constraints
- other parameters
  - discount rate
  - time horizon definition
  - time slice definition

Models provide…

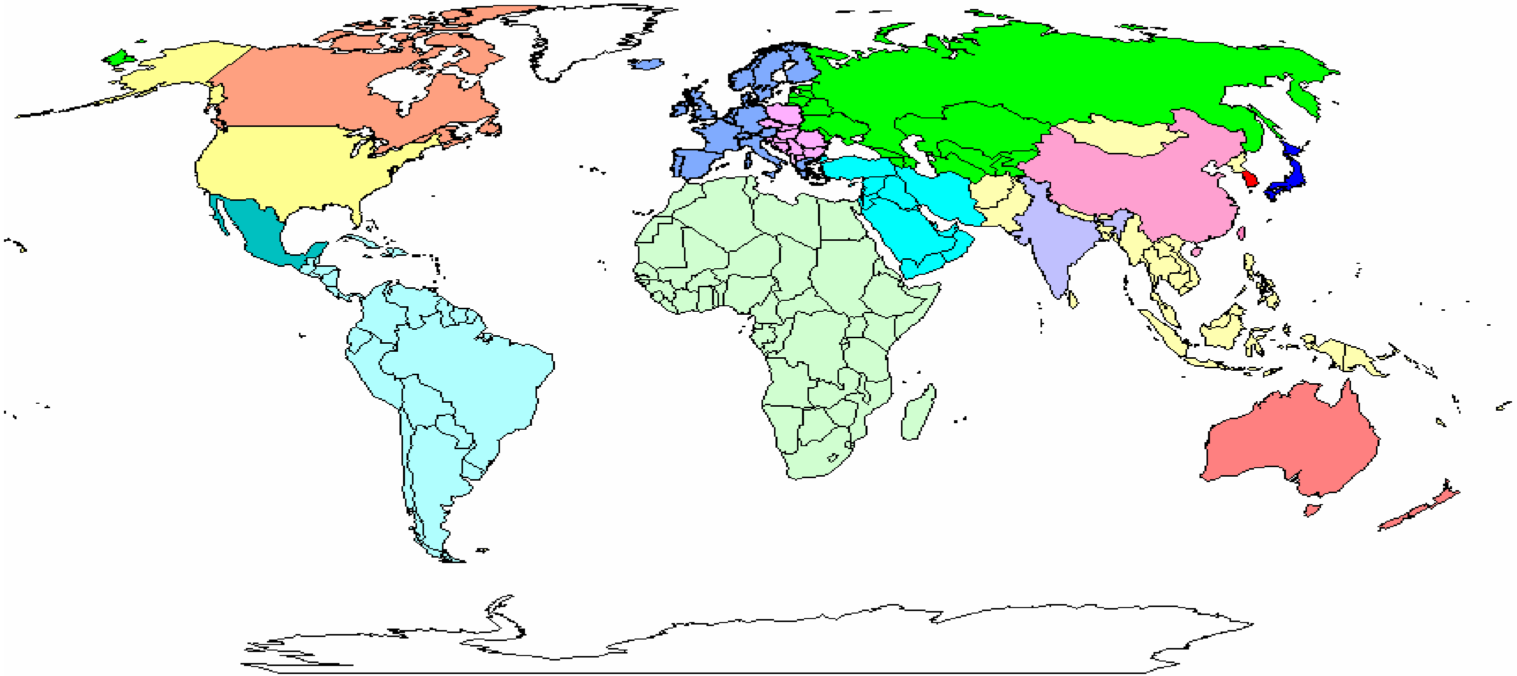
- technology investments
- technology activities
- emission trajectories
- adjusted demands
- marginal energy prices
- imports/exports
- total system cost

TIMES Model



Cost and emissions balance
Prices
Energy flows
Emissions
Energy prices, Resource availability
Domestic sources
Imports
Coal processing
Refineries
Power plants and Transportation
CHP plants and district heat networks
Gas network
Industry
Commercial and Public Services
Households
Transportation
GDP
Process energy
Heating area
Population
Light
Communication
Power
Person kilometers
Freight kilometers
Demands
Primary energy
Capacities
Final energy
Costs
Service Demands

ETSAP TIAM



- Global model (ETSAP-TIAM) now available in addition to modelling tools (TIMES)
- 15 Region global TIMES model available to ETSAP Contracting Parties
- Developed by GERAD and currently updated by ETSAP Collaborative Project
- Includes several thousand technologies and models climate forcing

ETSAP-TIAM

- distributed to 10 ETSAP Contracting Parties
- available on request by participants
- several projects have used TIAM:
  - EMF-22, EMF-24 (Stanford, US)
  - Low Carbon Society (**NIES, Japan**, UK-ERC, …)
  - IPCC-IAMC, special report on Renewable Scenarios
  - IEA-RETD, Achieving Climate and Energy Security (ACES)
  - EC-FP7, REACCESS on Energy Corridors for EU
  - Asian Modelling Exercise
- currently being updated and re-calibrated in ETSAP project led by DTU

Workshops & Training

- ≥ two workshops per annum on energy systems modelling
  - http://iea-etsap.org/index.php/workshops
  - Cork, Ireland May 30-31 2016
  - Madrid, Spain Nov 17-18 2016
  - Tokyo, Japan Dec 14 2016
  - Sao Paulo, Brazil Jan 30 2017
  - Maryland, USA July 10-11 2017
- joint organiser of IEW (International Energy Workshop), Maryland, USA, July 12-14 2017
- Deliver ≥ 2 training courses for the ETSAP tools biannually
  - Tokyo, Japan Dec 15-16 2016

ETSAP Outputs

Annex XII Report > 300 publications 2011-2013 (including 110 peer-review papers) from:

i) **Global Models:** incl. IEA ETP model, original TIMES Integrated Assessment Model (TIAM), derived TIAM models, ETSAP-TIAM model

ii) **Regional Models**: Pan-European TIMES model, MARKAL-TIMES Models for Europe, Asia and North America.

Multi-regional models

iii) **National Models** of 32 countries (including China).

iv) **Sub-National Models:** Western China, Reunion Island (France), Lombardy (Italy), Pavia (Italy), and Kathmandu Valley (Nepal).

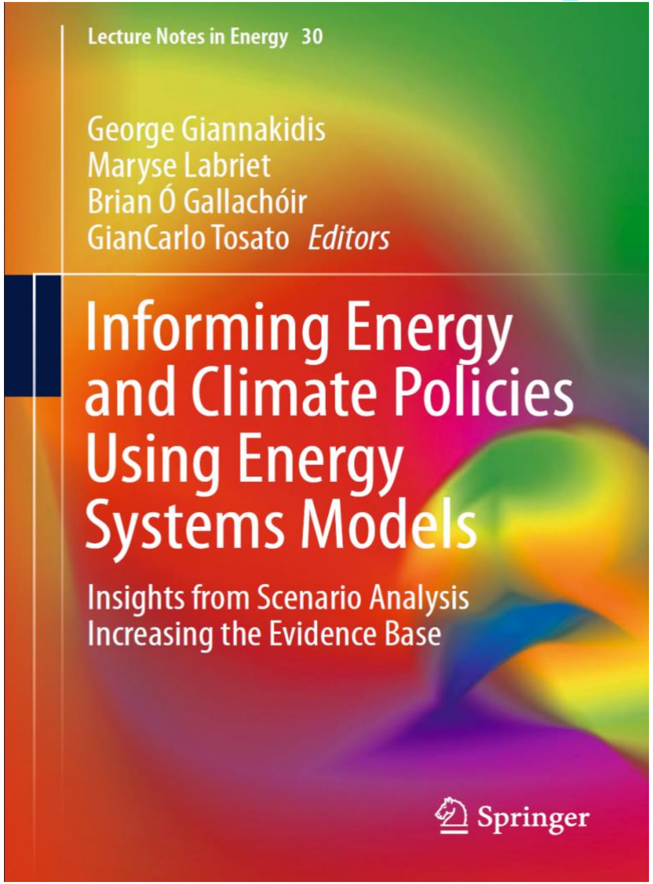
v) **Local Models** for rural areas and cities in Austria, Germany and Italy, other bigger cities such as Madrid (Spain), Beijing, Guangdong and Shanghai (China), Johannesburg (South Africa) and New York City (United States).

http://iea-etsap.org/finreport/ETSAP_Annex_XII_Final%20Report.pdf

ETSAP Recent Outputs

- Methodologies and case studies
- Demonstrating use of energy systems models
- Support energy and climate policy
- Critical analysis of rich and varied applications
- Includes diverse global case studies
- Role of technology in energy systems

www.springer.com/gp/book/9783319165394



UCC Green Campus

- world's first green flag campus
- world's 1st university to achieve the ISO 50001 standard
- 4th in world in the UI World Green Metric University Rankings 2015
- Environmental Research Institute 2000
- SFI MaREI Centre 2015




ENERGY

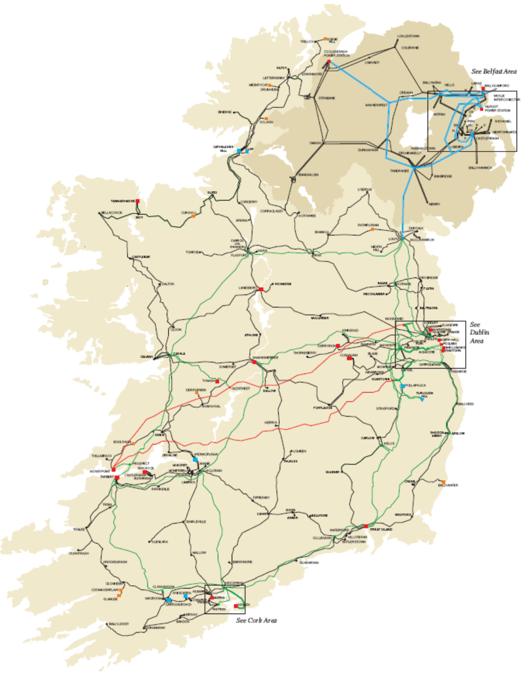
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

MaREI
Centre for Marine and Renewable Energy

ERI
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE CORK

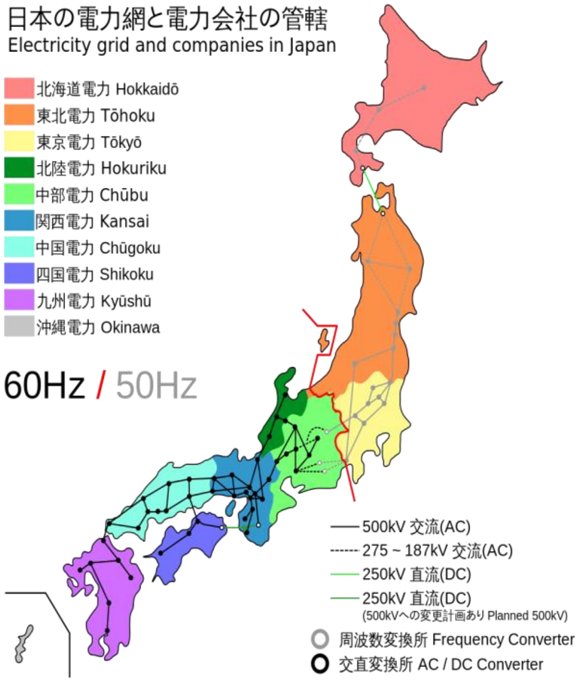
Ireland and Japan

Ireland	
Population	4.5m
GDP PPP	€165bn *€36k*
Electricity Consumption	26 TWh *5.6 MWh*
Peak Demand	5.1 GW
CO_2 Emissions	35 Mt *7.6t*
Installed Capacity*	9 GW
Total Fossil Fuels	7 GW
Hydro	0.2 GW
Wind	2 GW



Value in italics are per person

Japan	
Population	127m
GDP PPP	€3993bn *€31k*
Electricity Consumption	988 TWh *7.8 MWh*
Peak Demand (GW)	200 GW
CO_2 Emissions	1265 Mt *10t*
Installed Capacity*	293 GW
Total Fossil Fuels	185 GW
Hydro	27 GW
Wind Solar	3 GW 34 GW



Informing Climate Action

Technical support on developing low carbon sector roadmaps for Ireland

Low Carbon Energy Roadmap for Ireland

Paul Deane, John Curtis, Alessandro Chiodi, Maurizio Gargiulo, Fionn Rogan, Denis Dineen, James Glynn, John FitzGerald and Brian Ó Gallachóir

20 December 2013

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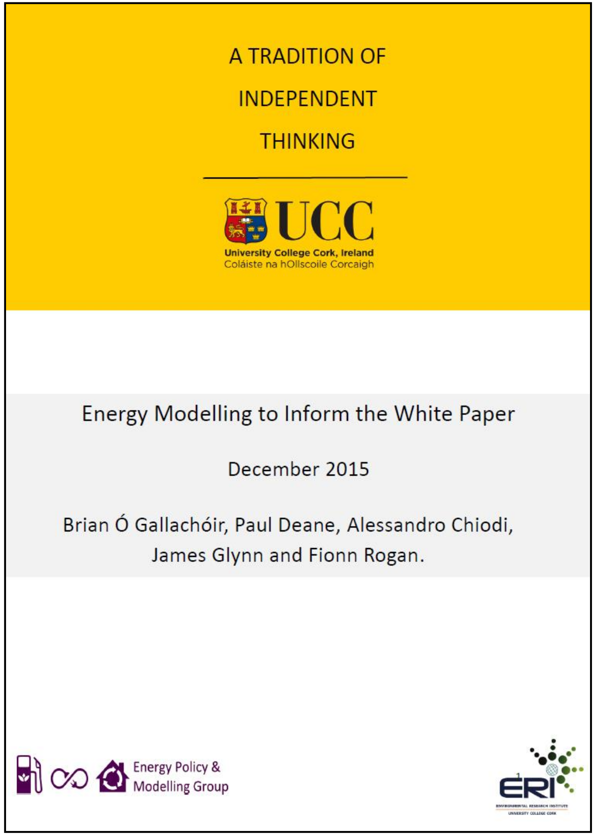
Number 46 of 2015

Climate Action and Low Carbon Development Act 2015

Informing Energy Policy



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University College Cork, Ireland

Coláiste na hOllscoile Corcaigh

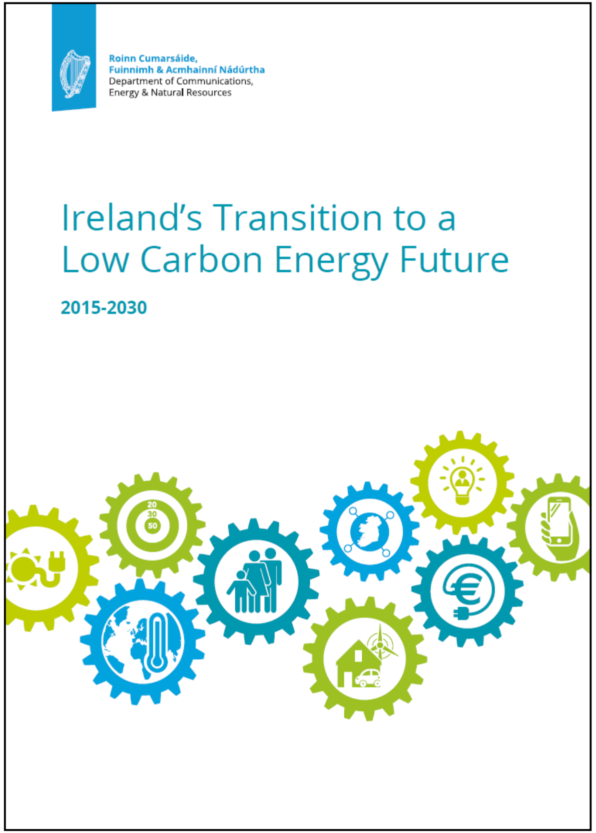
Energy Modelling to Inform the White Paper

December 2015

Brian Ó Gallachóir, Paul Deane, Alessandro Chiodi,
James Glynn and Fionn Rogan.

Energy Policy &
Modelling Group

ERI

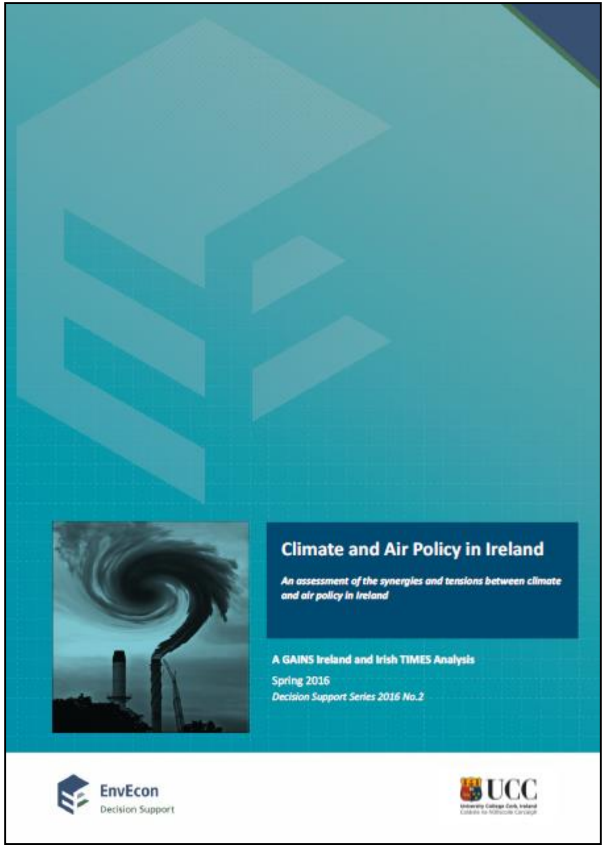


Roinn Cumarsáide,
Fuinnimh & Acmhainní Nádúrtha
Department of Communications,
Energy & Natural Resources

Ireland's Transition to a
Low Carbon Energy Future

2015-2030

Climate – Air Policy Interface



Climate and Air Ireland - Synergies and Tensions

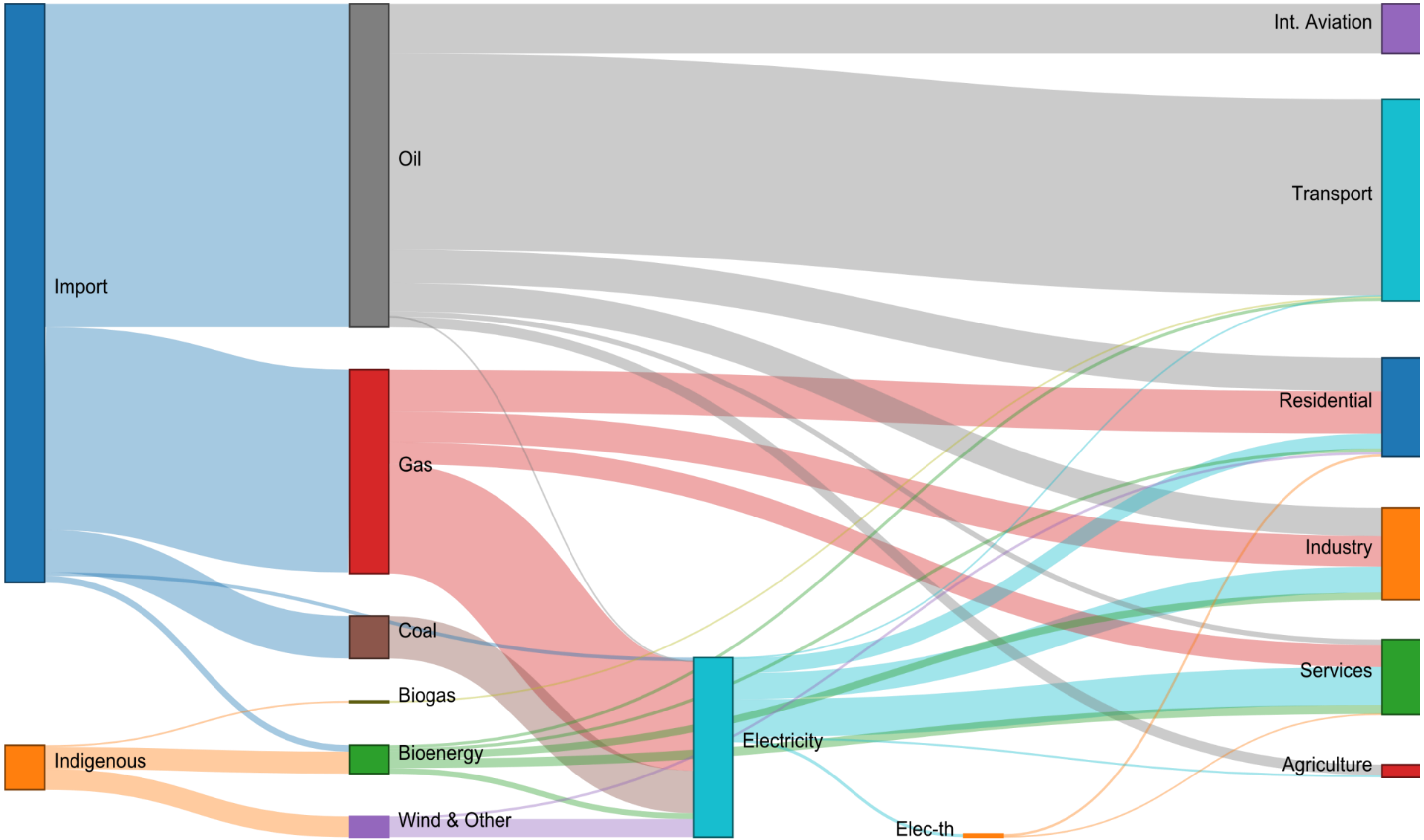
A GAINS Ireland and Irish TIMES analysis

Andrew Kelly[a], Alessandro Chiodi[b], Miao Fu[a], J.P. Deane[b], Brian P. Ó Gallachóir[b]

[a] EnvEcon, Dublin, Ireland

[b] Energy Policy and Modelling Group, Environmental Research Institute, University College Cork, Ireland

Ireland 2050 - BaU

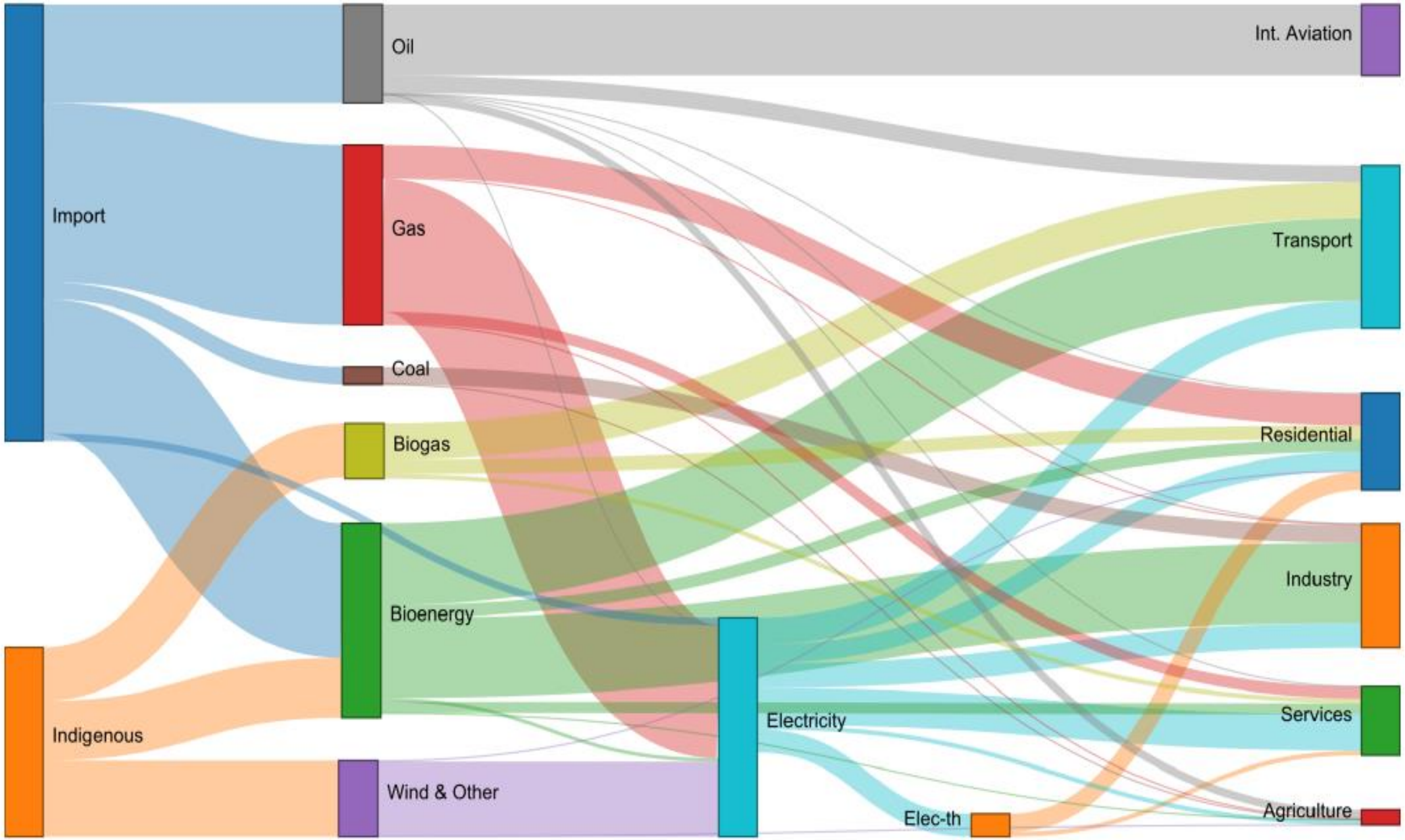


TFC
200 TWh

Elec = 17%
=34 TWh

=33% growth
on 2015

Ireland 2050 CO2-80

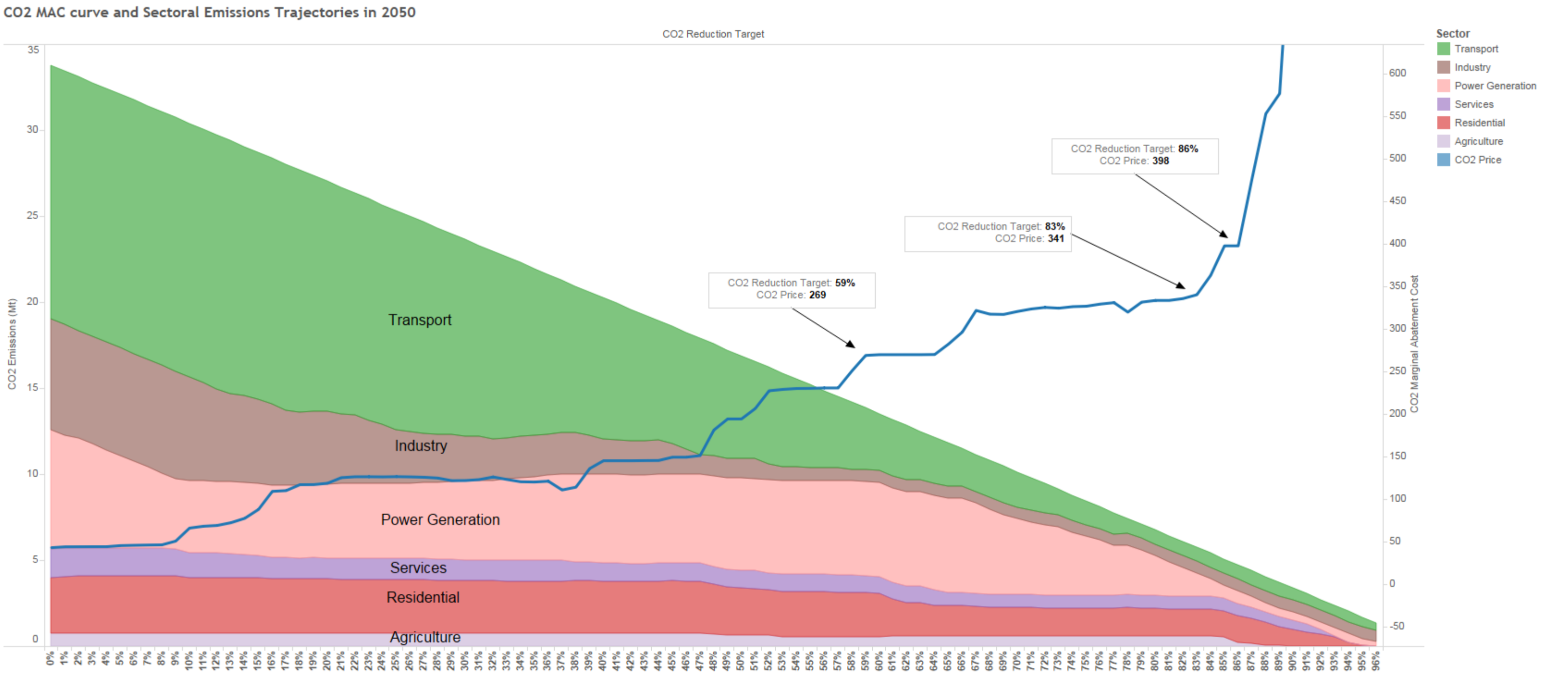


TFC
136 TWh

Elec 25%
=34 TWh

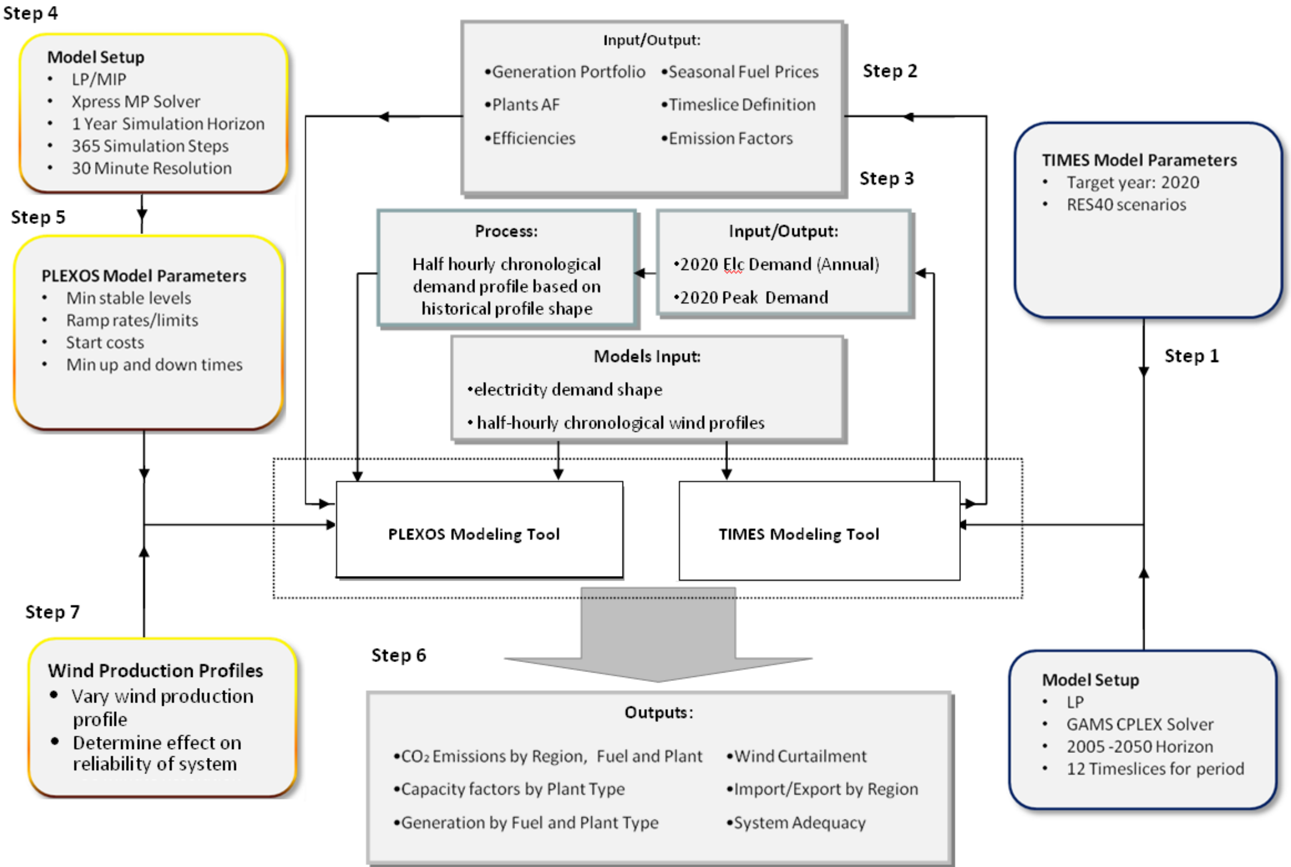
Post Paris – Beyond -80%

CO2 MAC and Sectoral Emissions Trajectories in 2050 under 0-96% Carbon Constraints



The trends of CO2 marginal abatement costs and emissions in each sector under 1-100% mitigation targets in 2050 compared to 1990. The interim targets in 2030 and 2040 are linearly interpolated. The model found no feasible solutions above 96% reduction target. The MAC curve is not linear and a tippipng point can be identified at 86% reduction constraint.

Multi-Model Approach 1 – Power Systems



Similar approach in Japan

Japan

OPGM Model:

- Cost Minimization Model
- 10-min consideration of Wind & PV

Detailed evaluation for wind & PV integration

RES Integration Curve

Additional constraints in DNE21

Global Energy Model (DNE21):

- Cost Minimization Model
- Temporal Resolution: 4 hours

More plausible evaluation of wind & PV integration in rough time-resolution model

Ireland

Irish TIMES:

- Energy Systems Model
- Low Carbon Roadmap
- 12 time slices

Extract 2020 or 2030 power system results

PLEXOS_Ireland:

- Dispatch Model
- 15 min – 1 hr temporal
- power plant detail

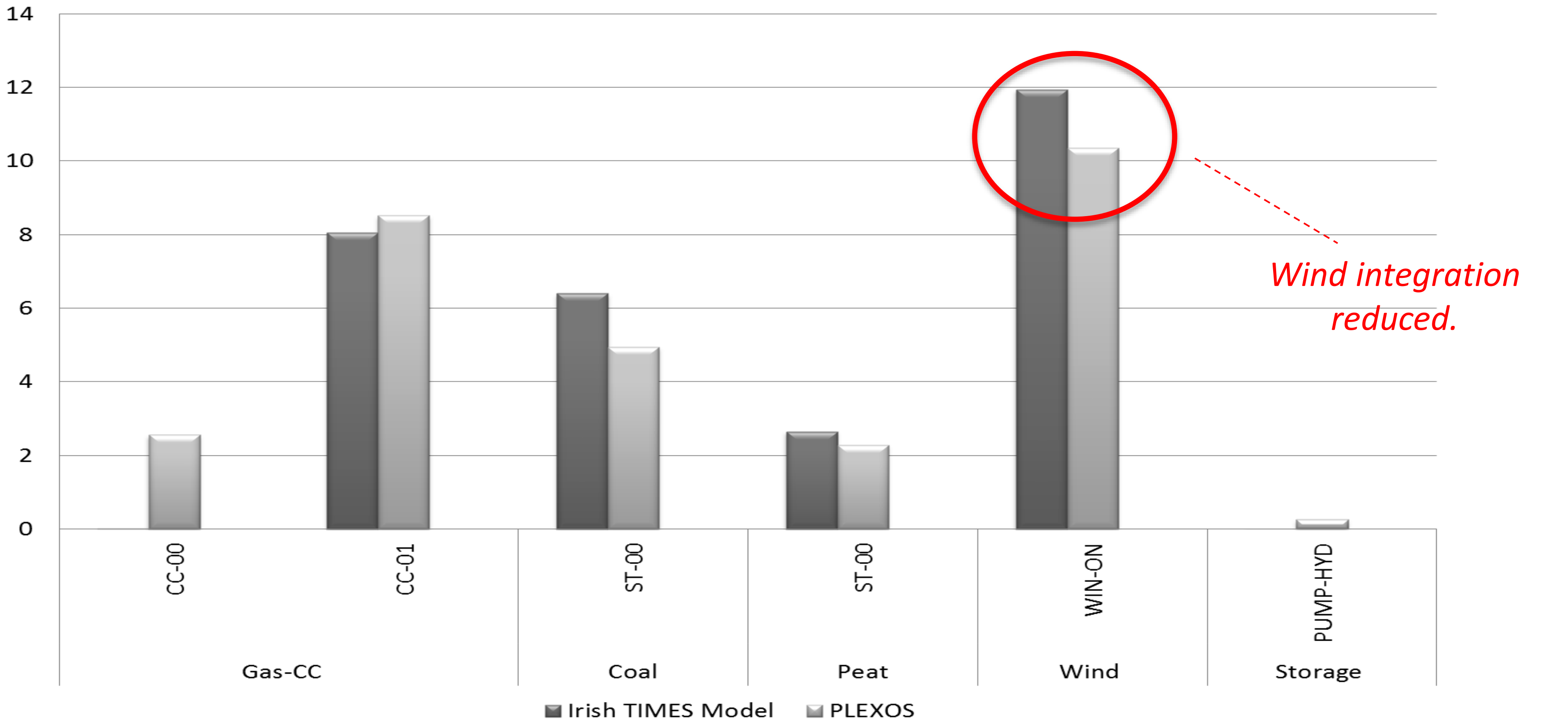
Additional constraints in Irish TIMES

Irish TIMES:

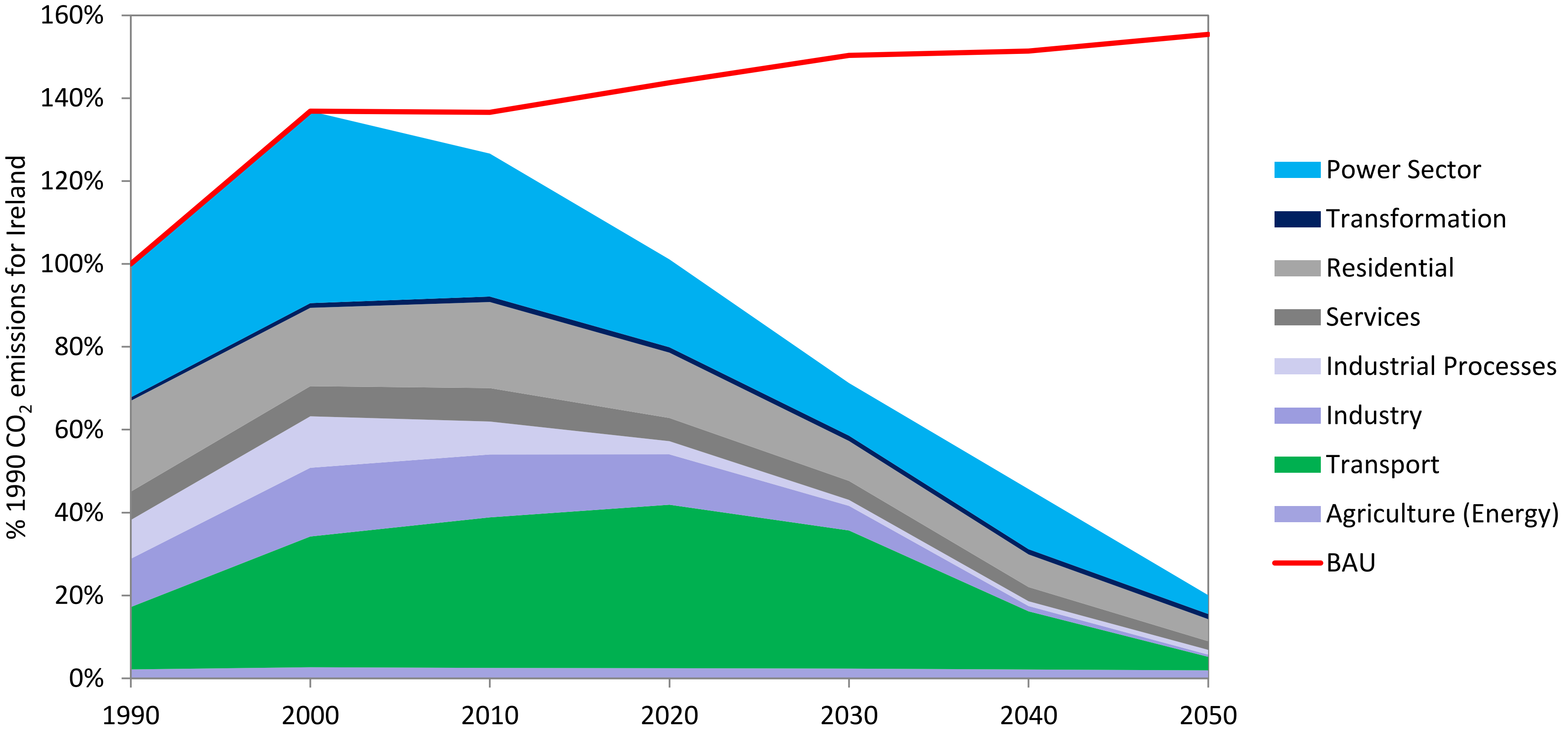
- SNSP = 75%
- Equiv 50% VRE

More plausible power system results in Irish TIMES

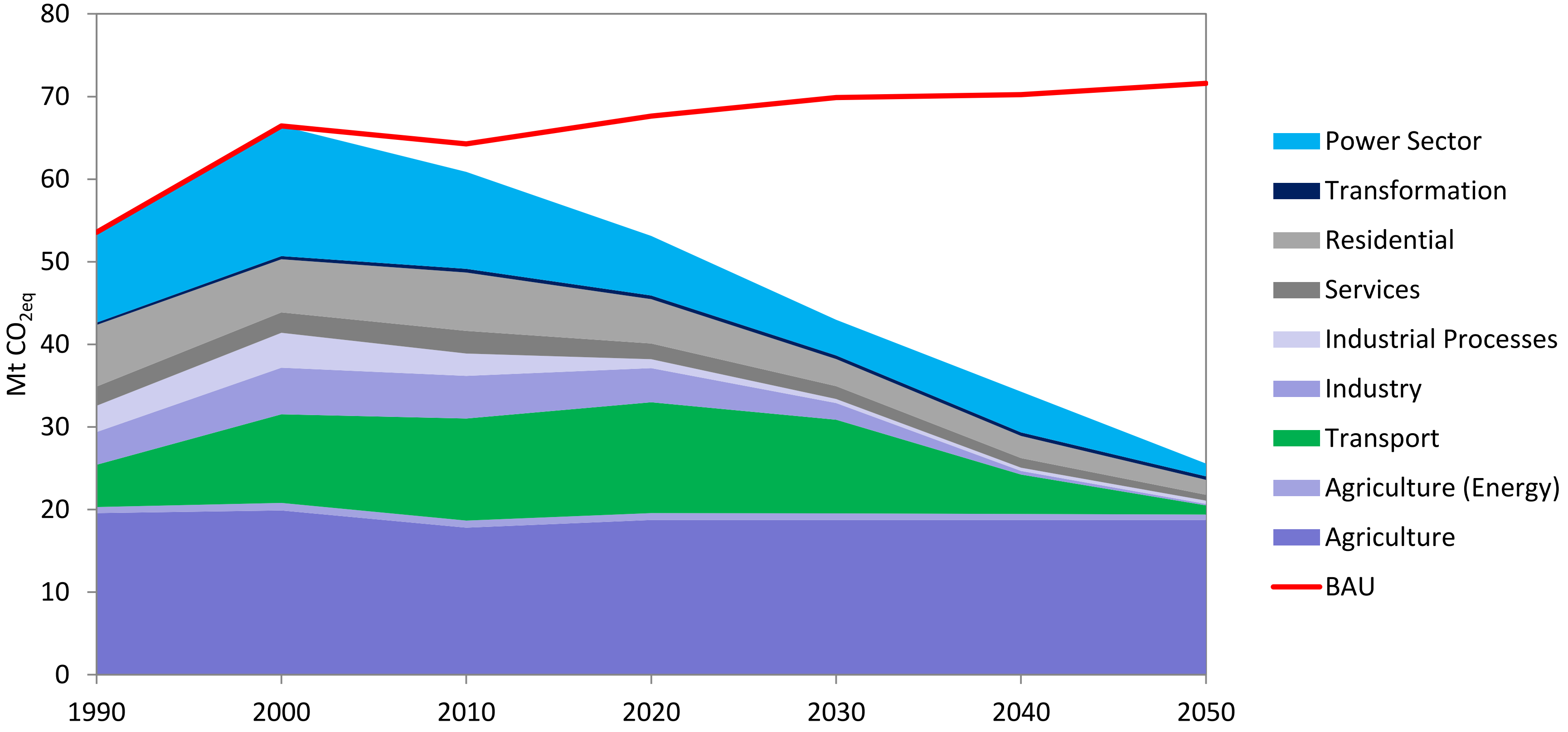
Quantifies Wind Curtailment



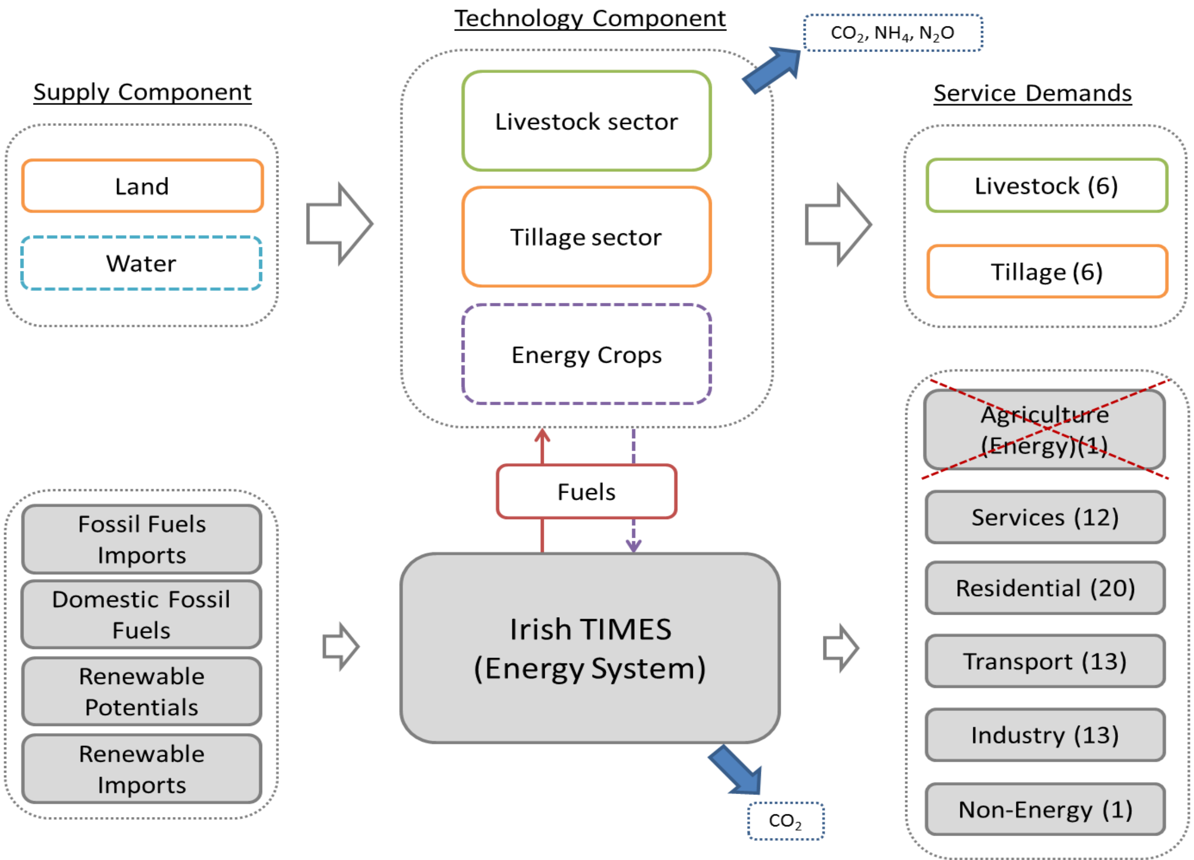
Low Carbon Energy Roadmap



What about Agri-GHG?



Multi-model 2: AGRI-TIMES

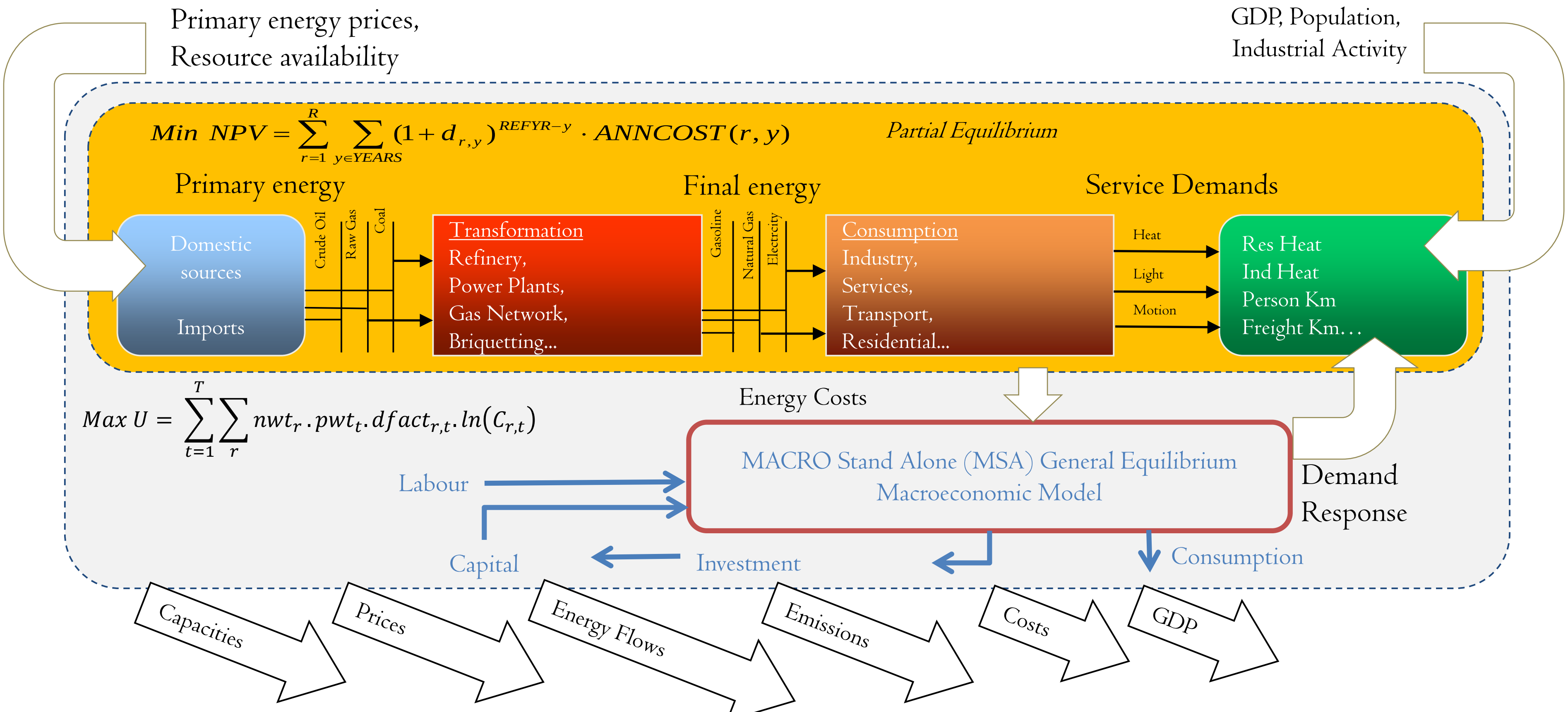


Multi-model 2: AGRI-TIMES

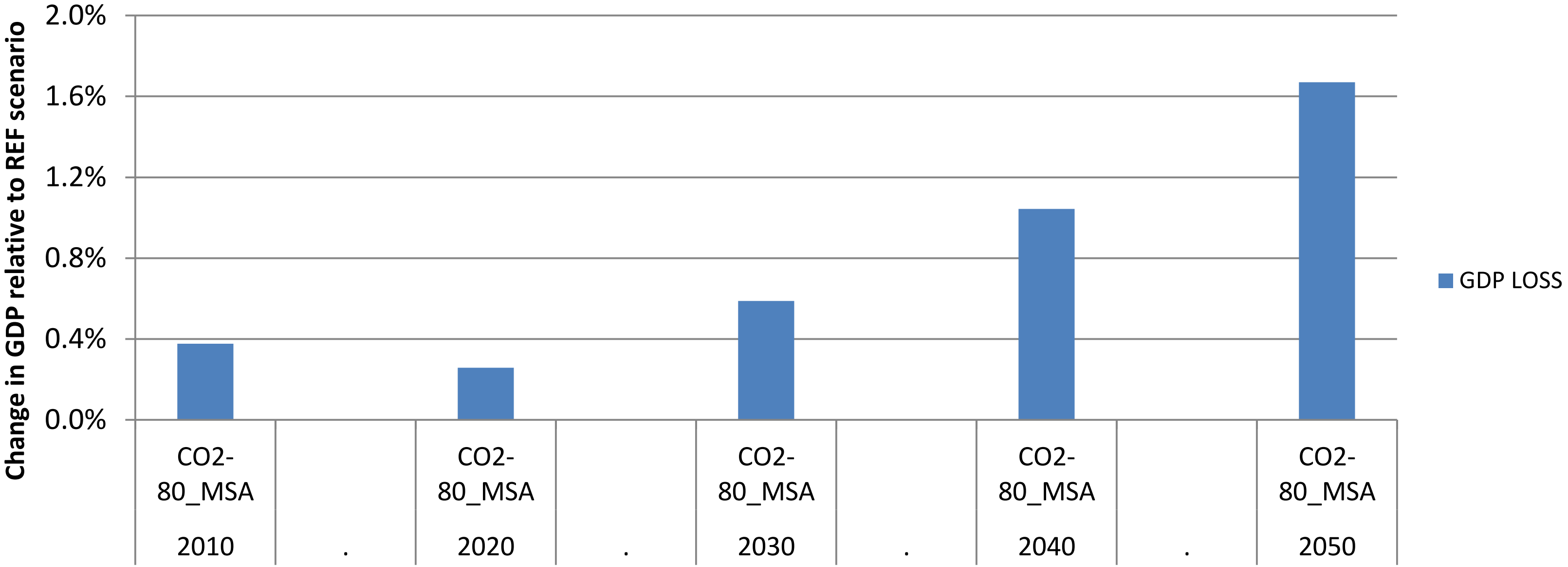
GHG sectoral reductions (rel. 1990)

	2005	2030		2050	
Sectors\Scenarios		**GHG-50**	**GHG-60**	**GHG-50**	**GHG-60**
Power Generation	37%	-56%	-55%	-73%	-94%
Industry (incl. process)	26%	-35%	-39%	-90%	-90%
Transport (incl. int. aviation)	149%	95%	68%	-76%	-84%
Residential and services	1%	-58%	-60%	-67%	-82%
Agriculture (CO_2, non-CO_2)	-3%	4%	4%	-7%	-13%
Transformation	62%	-100%	-100%	-100%	-100%
Energy	44%	-30%	-36%	-73%	-88%
Non-Energy	-3%	1%	1%	-18%	-22%
Total	**24%**	**-17%**	**-20%**	**-50%**	**-60%**

Multi-model 3: TIMES-MSA

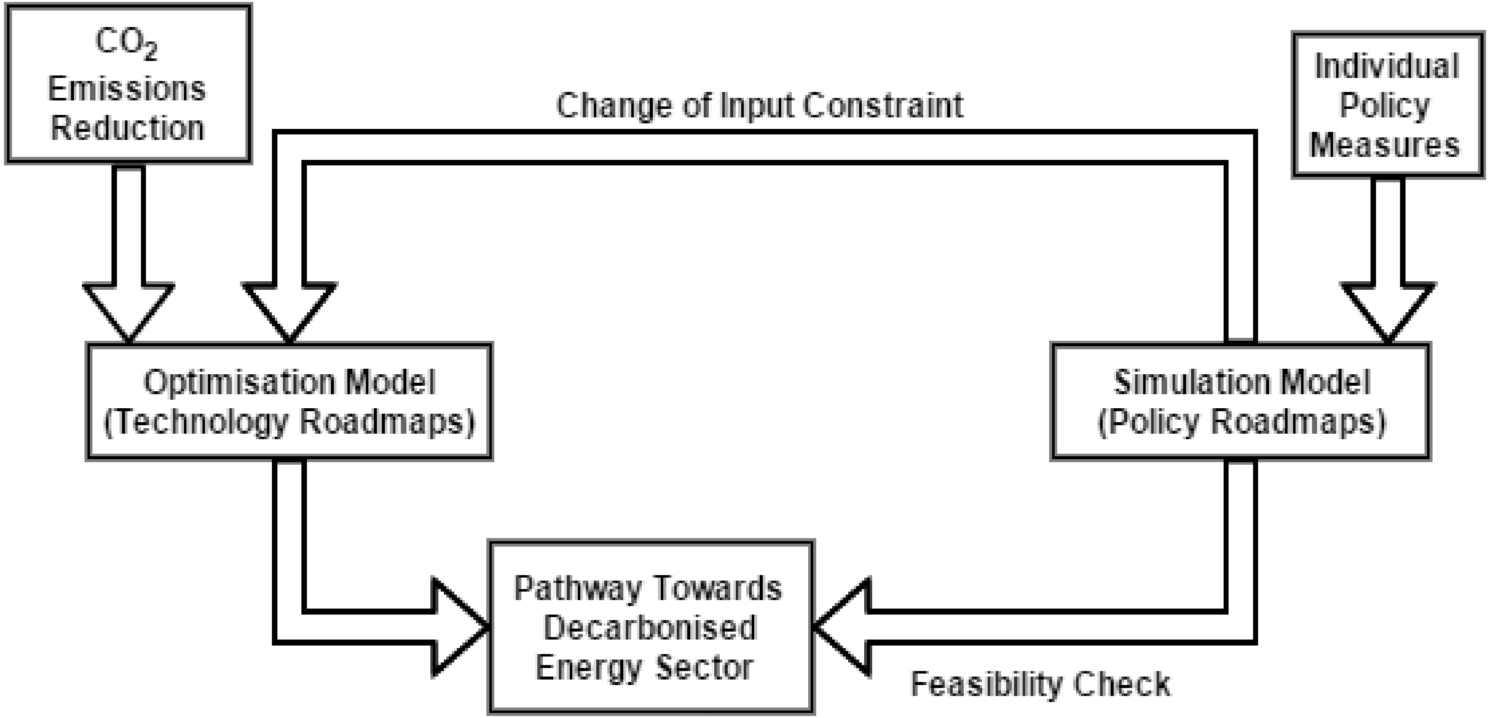


Quantify GDP 'loss' of mitigation

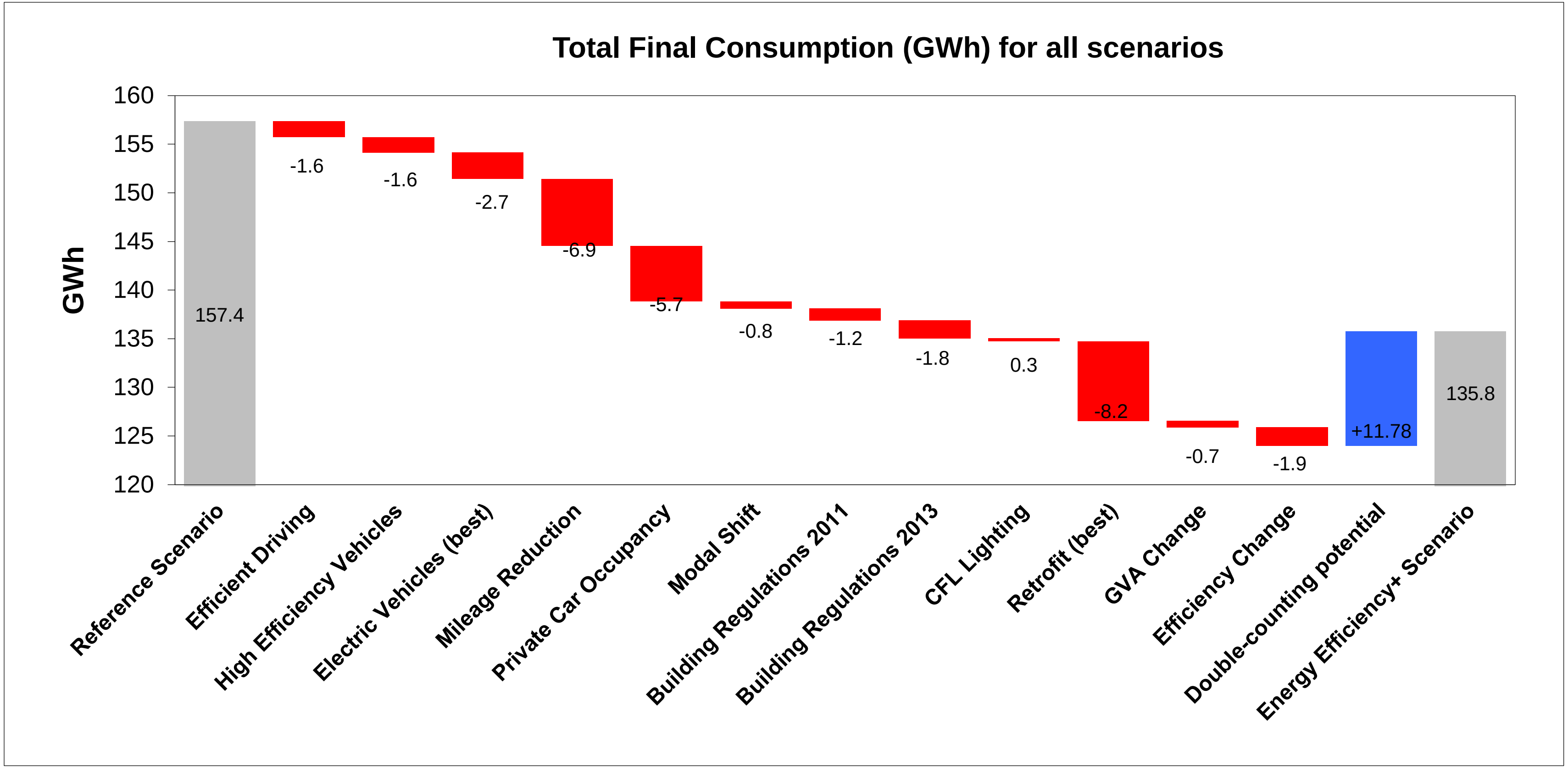


- Estimates potential reduction in macro consumption
- Energy Service Demand reductions drive additional TFC reductions
- Scenario-relative reductions in emissions and emission costs

Multi-model 4: TIMES and Policy Simulation



Multi-model 4: Energy Efficiency Policy Roadmap



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ISCA Japan
International Strategic Cooperation Award

MaREI
Centre for Marine and Renewable Energy

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