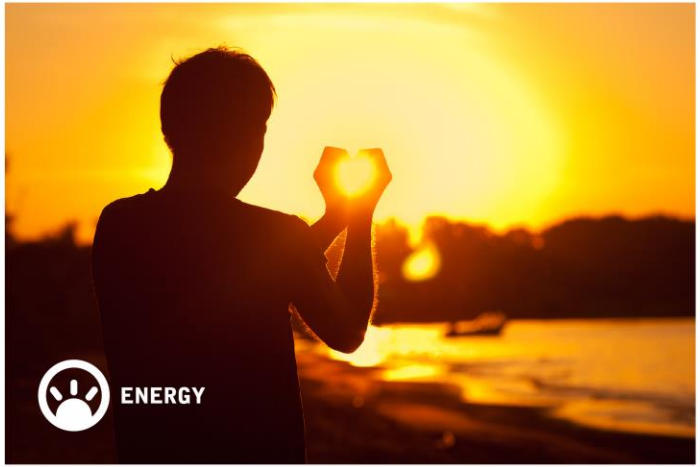
ERI
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE CORK



A TRADITION OF INDEPENDENT THINKING

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Developing and using a multi-model approach: One size fits all does not work!

Brian Ó Gallachóir

WholeSEM Conference July 6-7 2015, Cambridge

Overview

ENERGY

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

We need GHG mitigation, not just CO_2 mitigation

How many jobs?

Technology roadmaps are not policies

Publications

Modelling Tools

TIMES *integrated energy systems model*

- Irish TIMES (scenarios to 2020, 2030 and 2030) and *AGRI-TIMES*
- TIAM – TIMES Integrated Assessment Model (Global TIMES)
- **Technology Roadmaps** and **Targets**

PLEXOS *integrated electricity and gas dispatch model*

- PLEXOS-IE model of Ireland
- PLEXOS-EU-28 model of European Union
- Increased **detail** on **electricity and gas** (water being added)

Sectoral *energy demand simulation models*

- CARStock, ArDEM, LEAP_IE
- **Policies and measures**

Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

We need GHG mitigation, not just CO_2 mitigation

How many jobs?

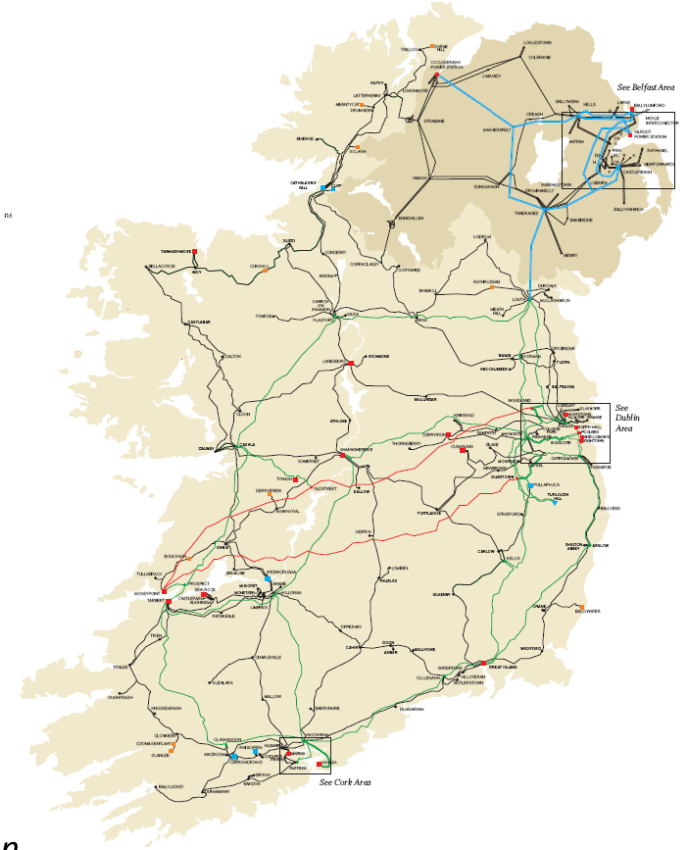
Technology roadmaps are not policies

Publications

Context

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



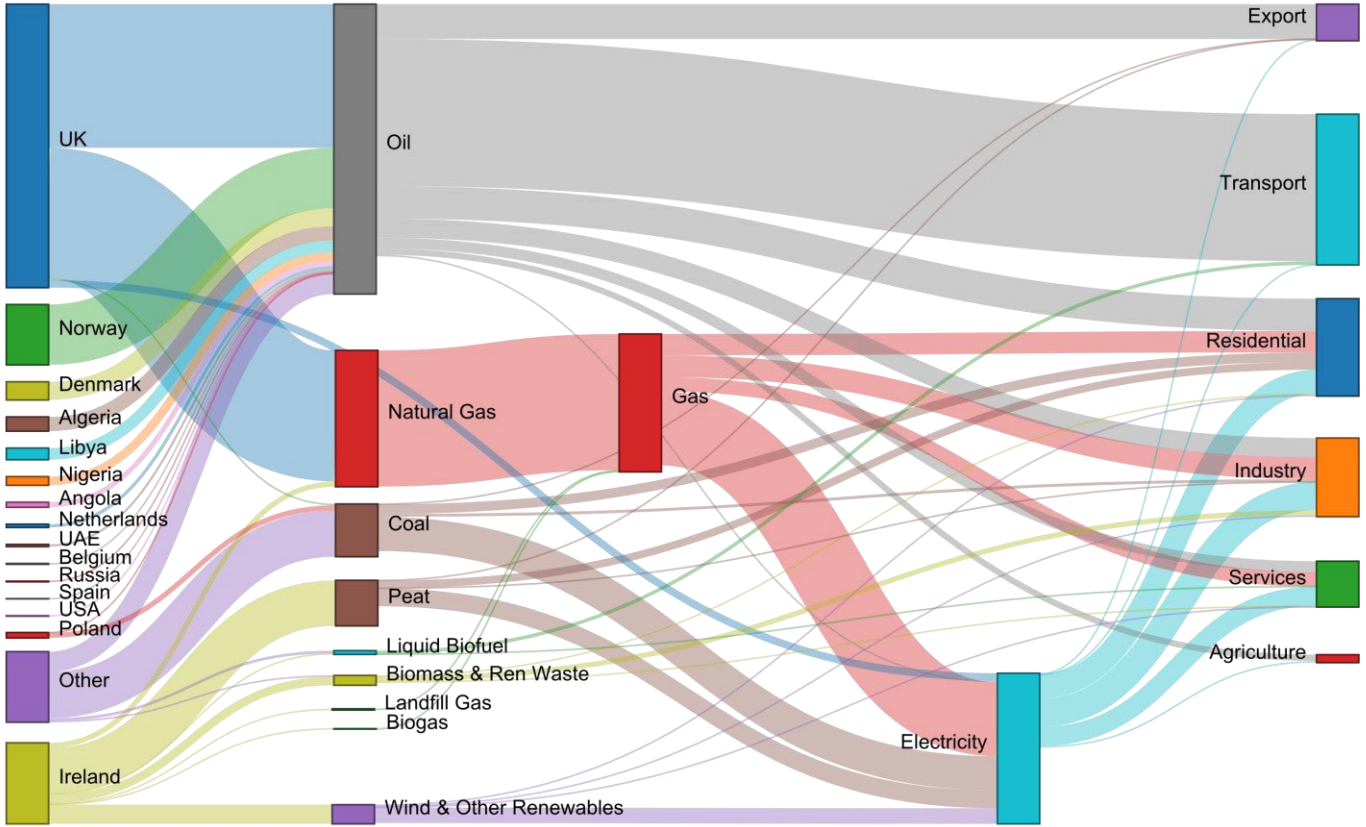
Future (2020)

- 16% RES comprising
  - 40% RES-E
  - 10% RES-T
  - 12% RES-H
- 20% EE including
  - 50k EVs by 2020
  - 800k home retrofits
- -20% non-ETS GHG by 2020
  - Uh oh!

Future (2050)

- 80% CO_2 reduction by 2050 (relative to 1990 levels)

Ireland's Energy System 2013



TFC
126 TWh

Elec 19%

Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

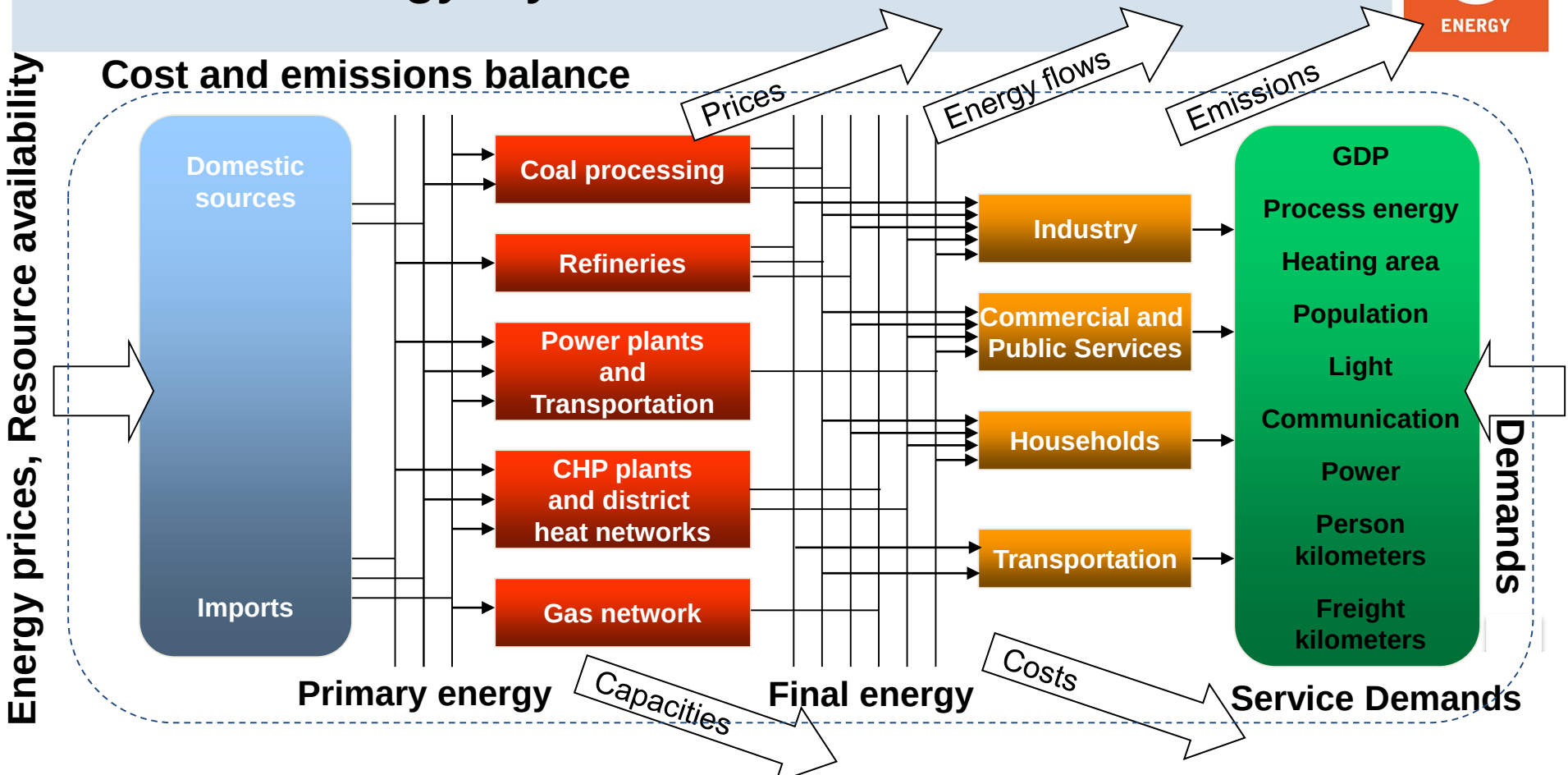
We need GHG mitigation, not just CO_2 mitigation

How many jobs?

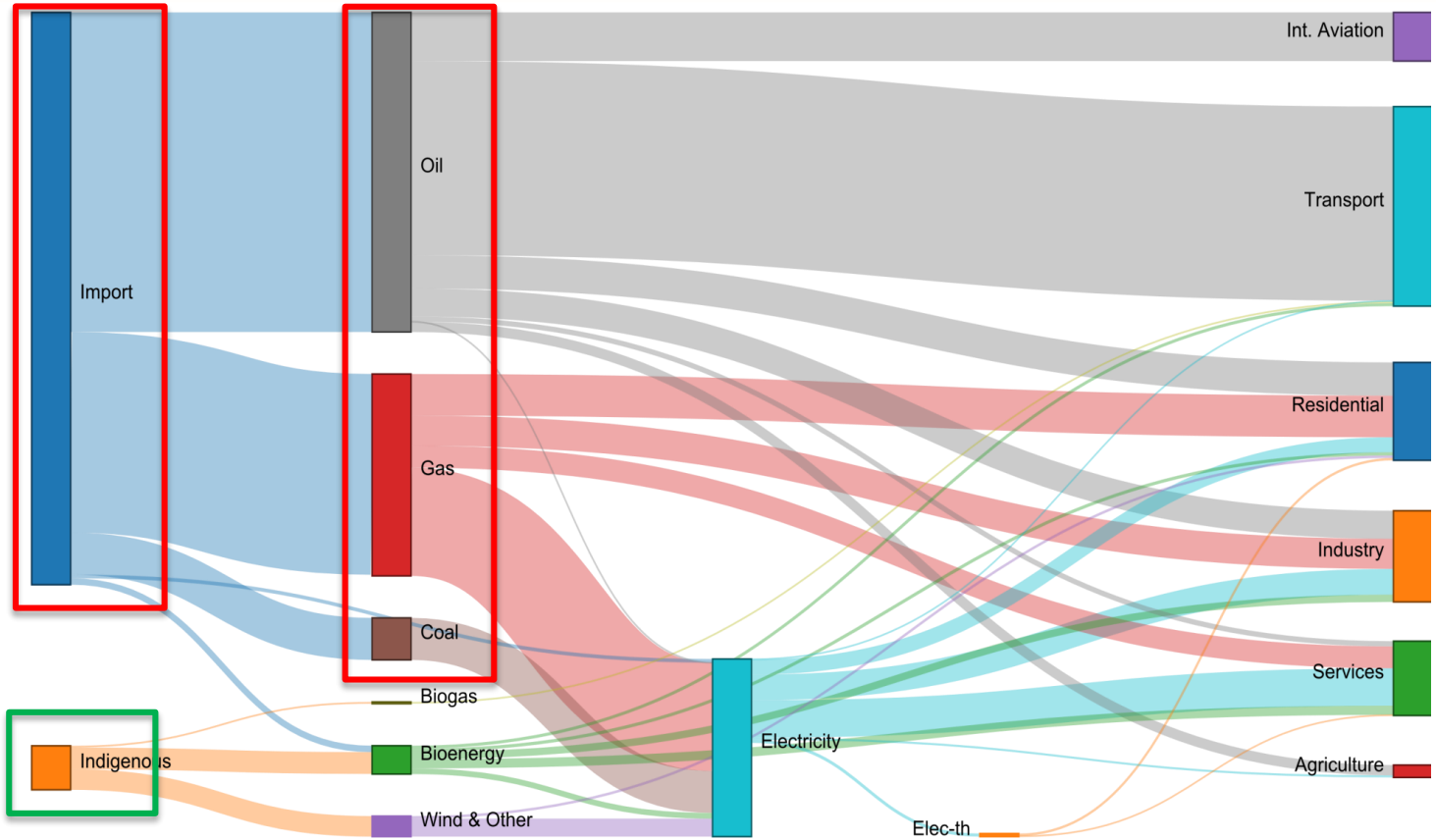
Technology roadmaps are not policies

Publications

TIMES Energy Systems Model



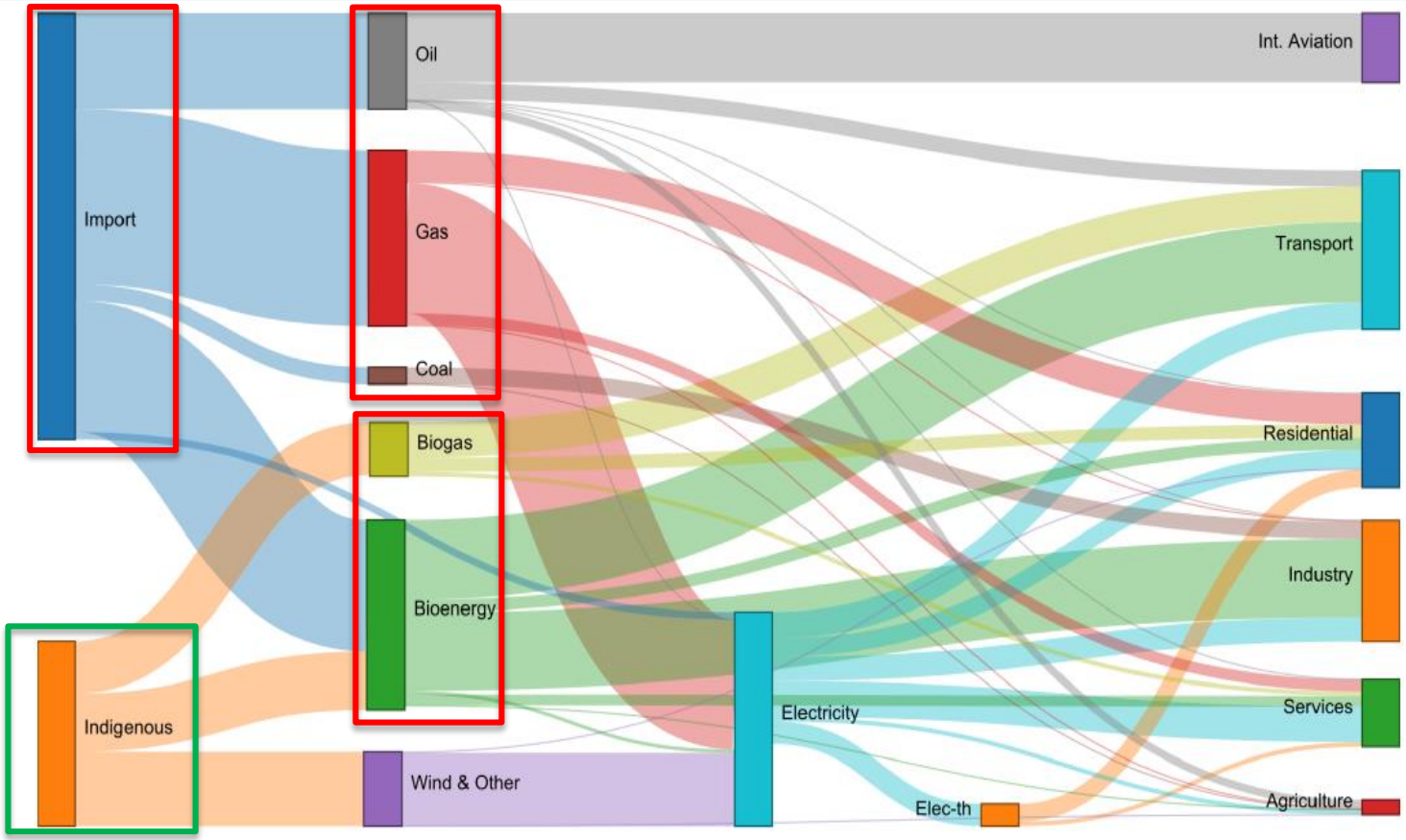
Energy System 2050 - BaU



TFC
180 TWh

Elec 18%

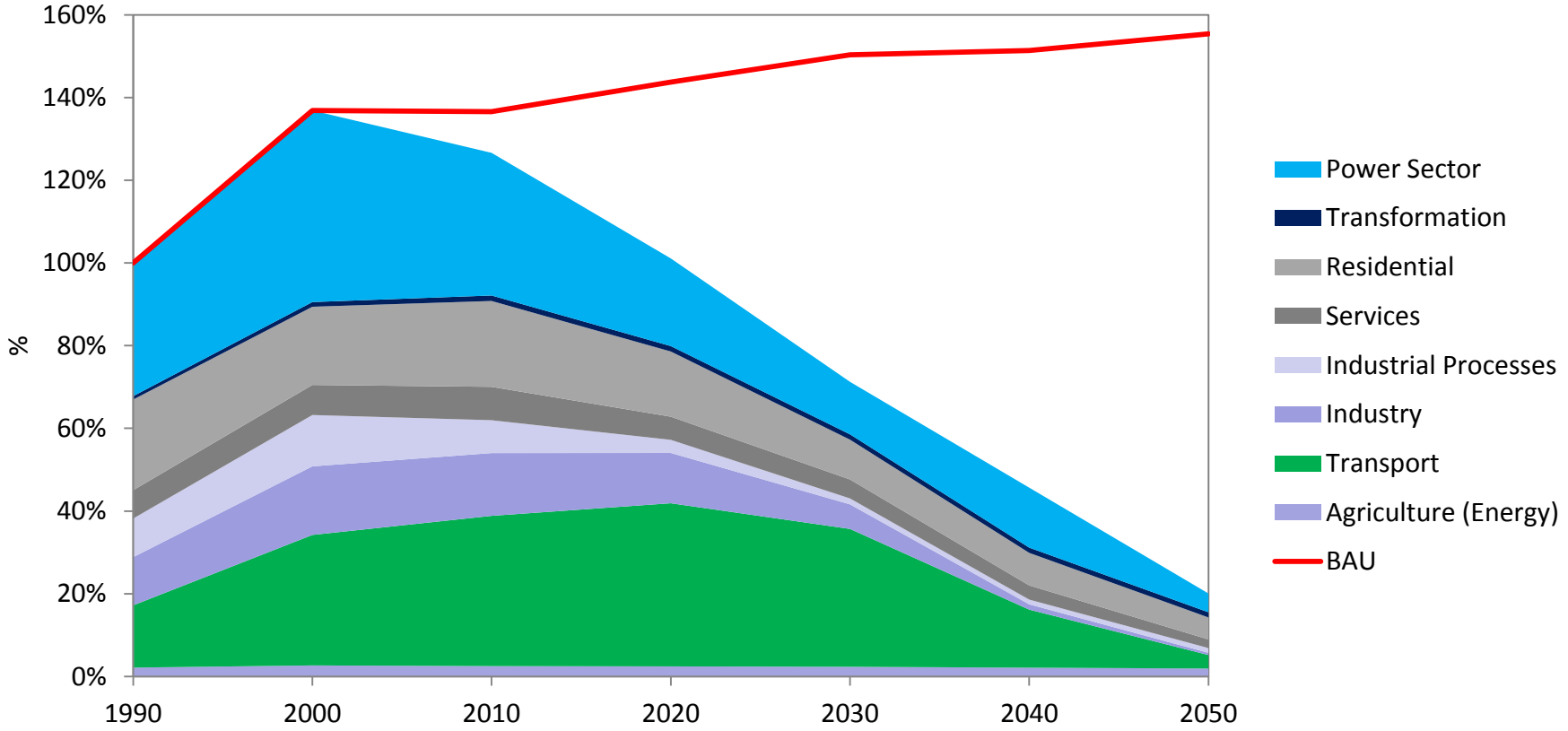
Energy System 2050 – 80% CO_2 Reduction



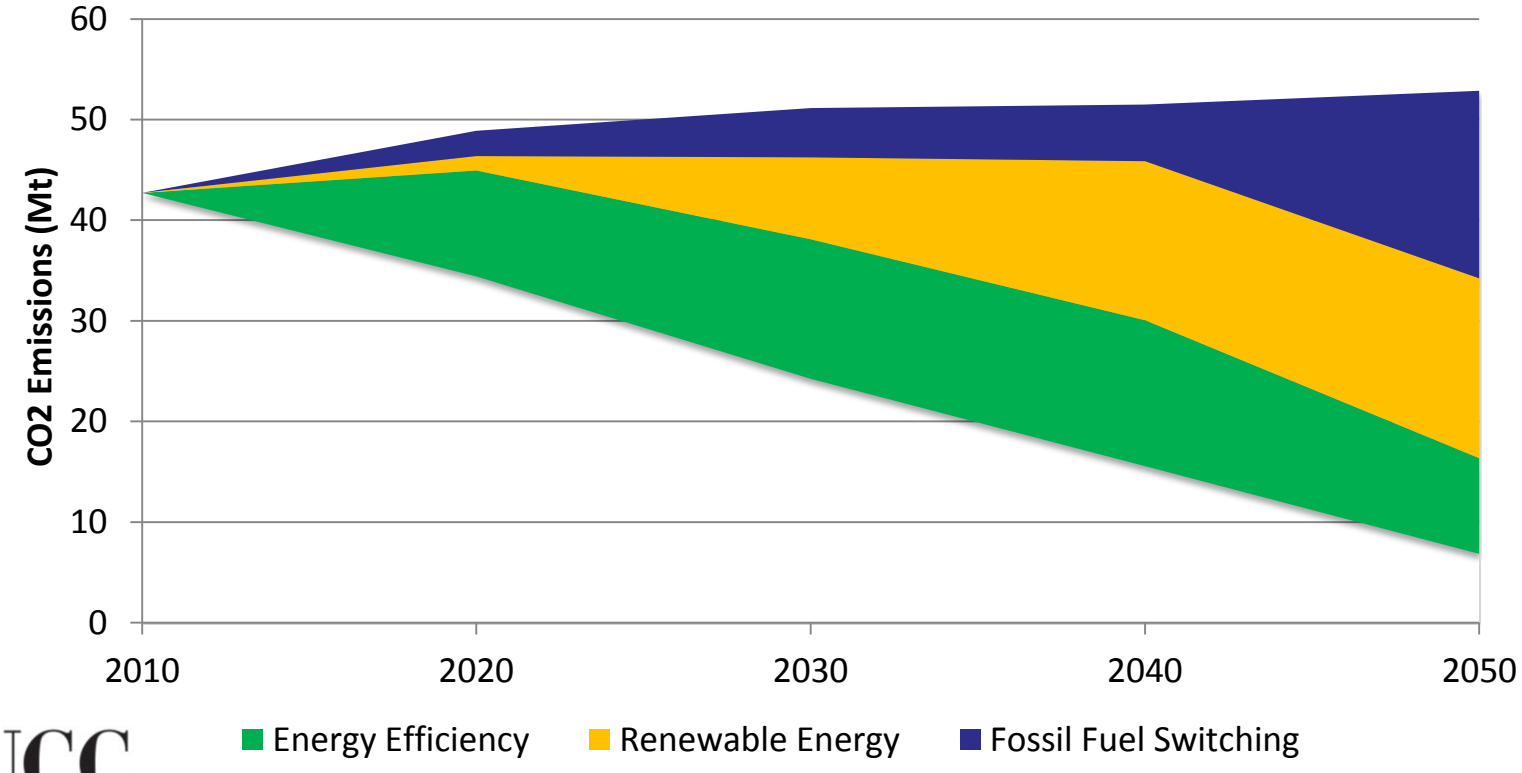
TFC
120 TWh

Elec 31%

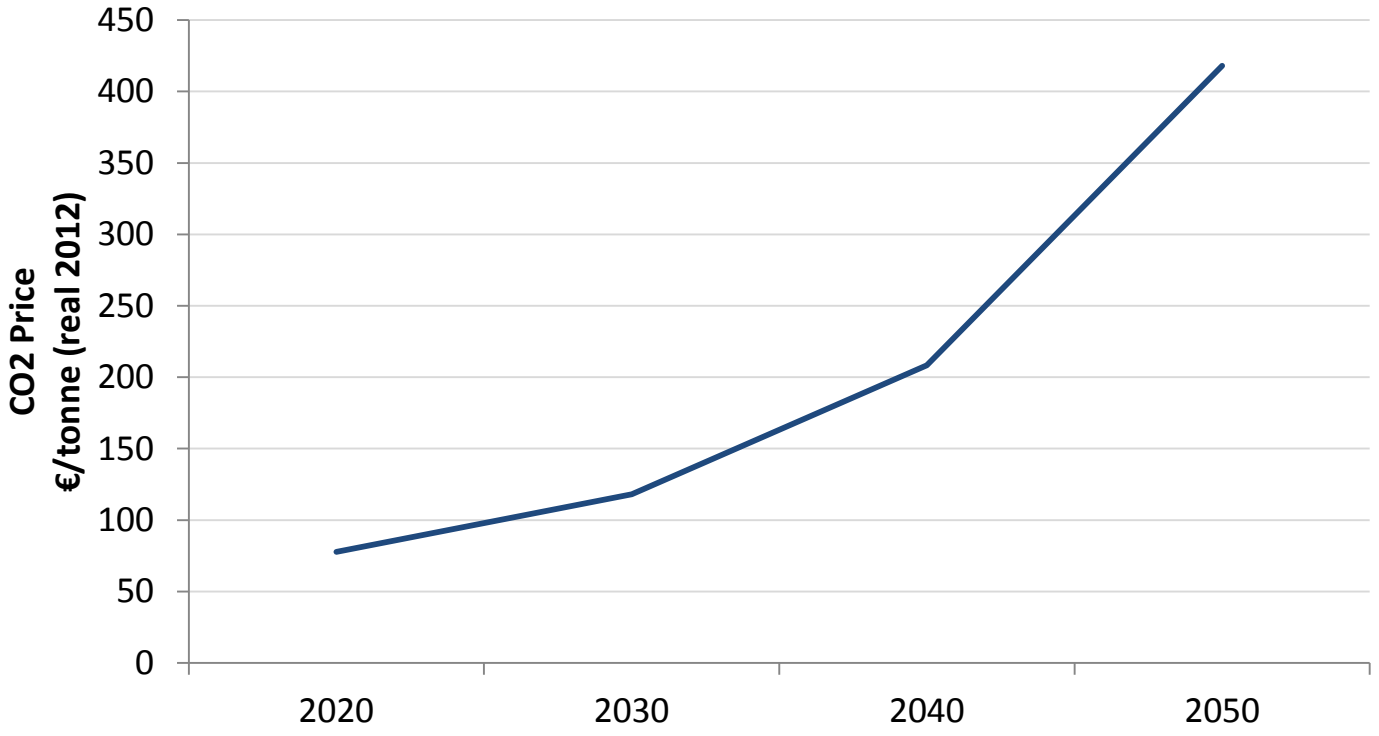
Low Carbon Pathway to 2050



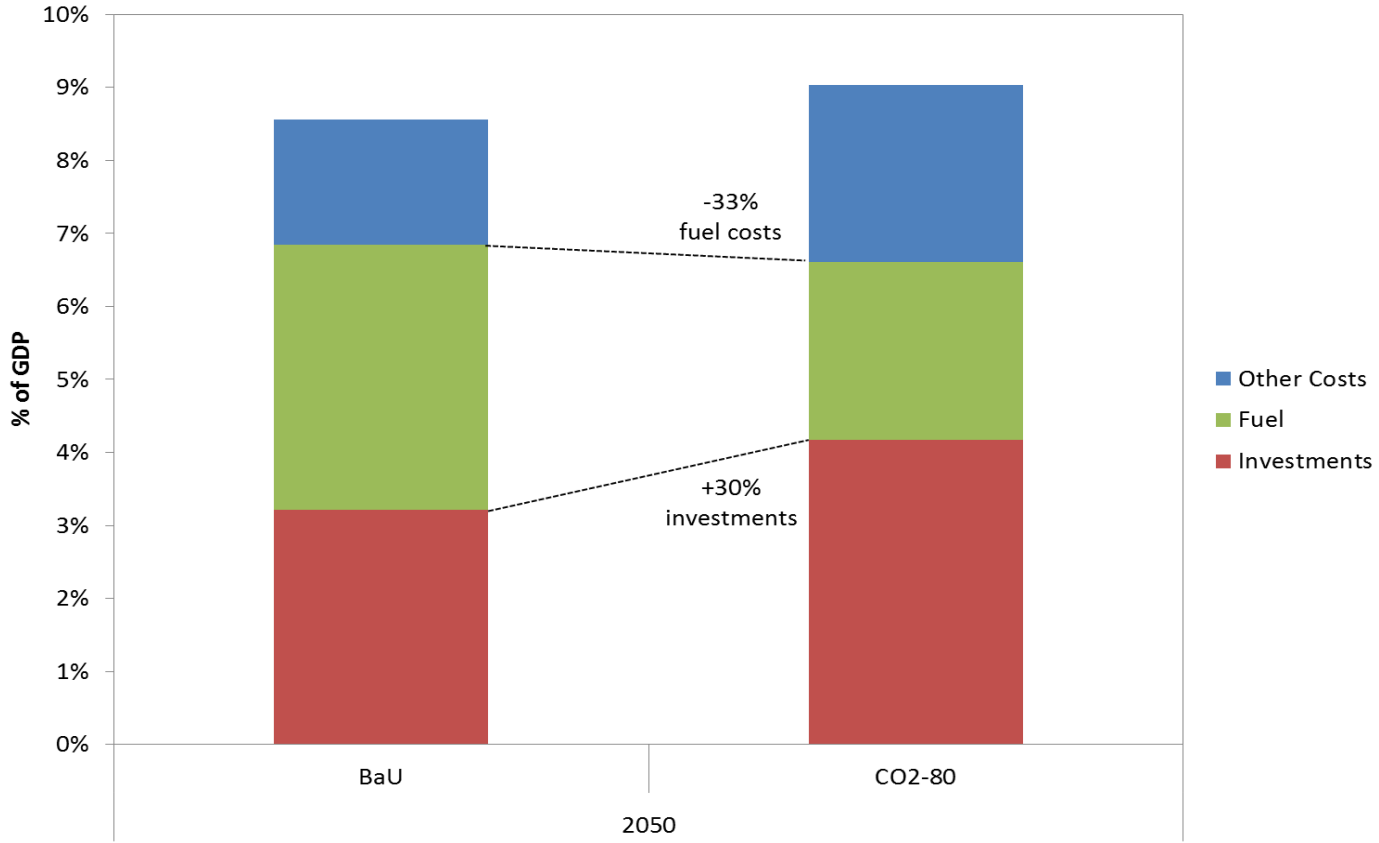
Low Carbon Pathway to 2050



Marginal Abatement Cost in 2050



Change in Energy Systems Cost in 2050



Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

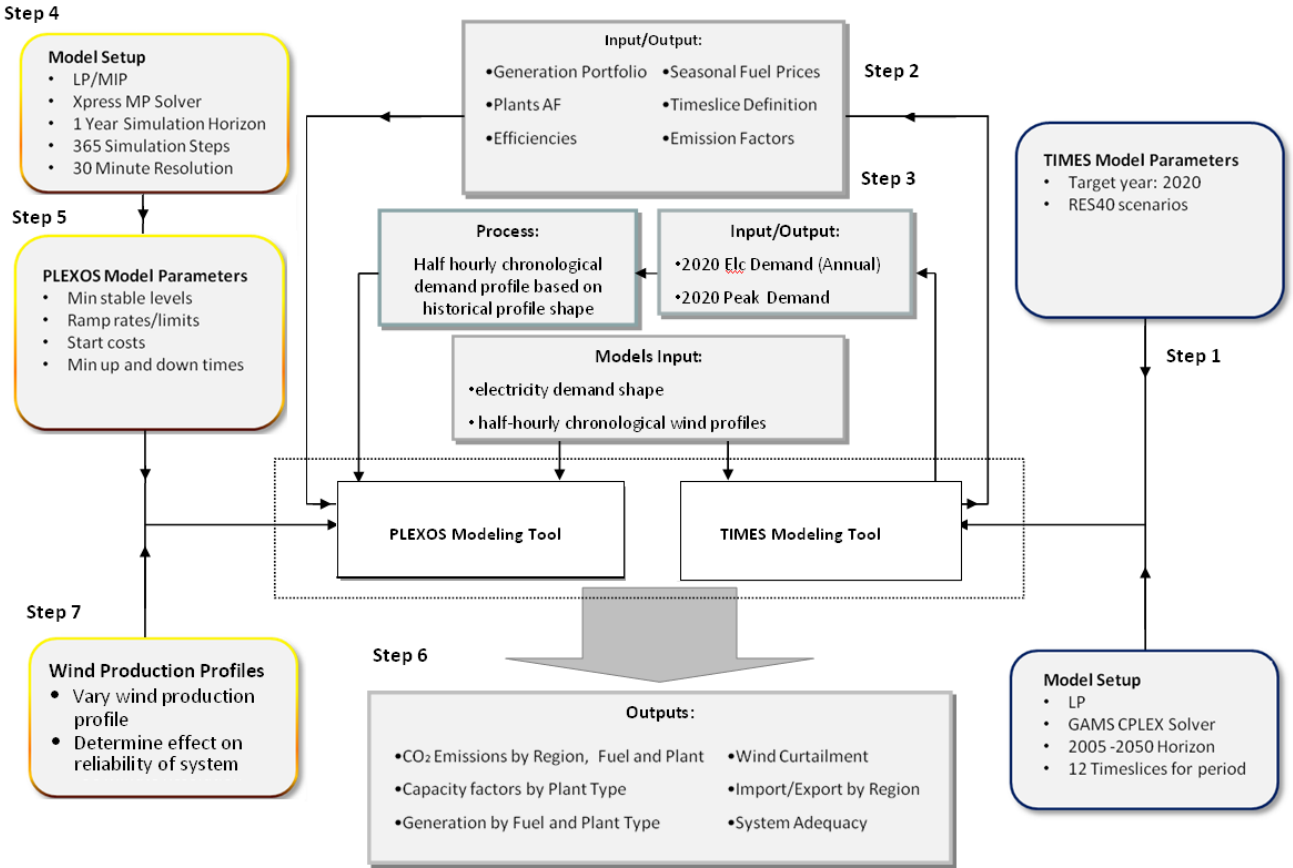
We need GHG mitigation, not just CO_2 mitigation

How many jobs?

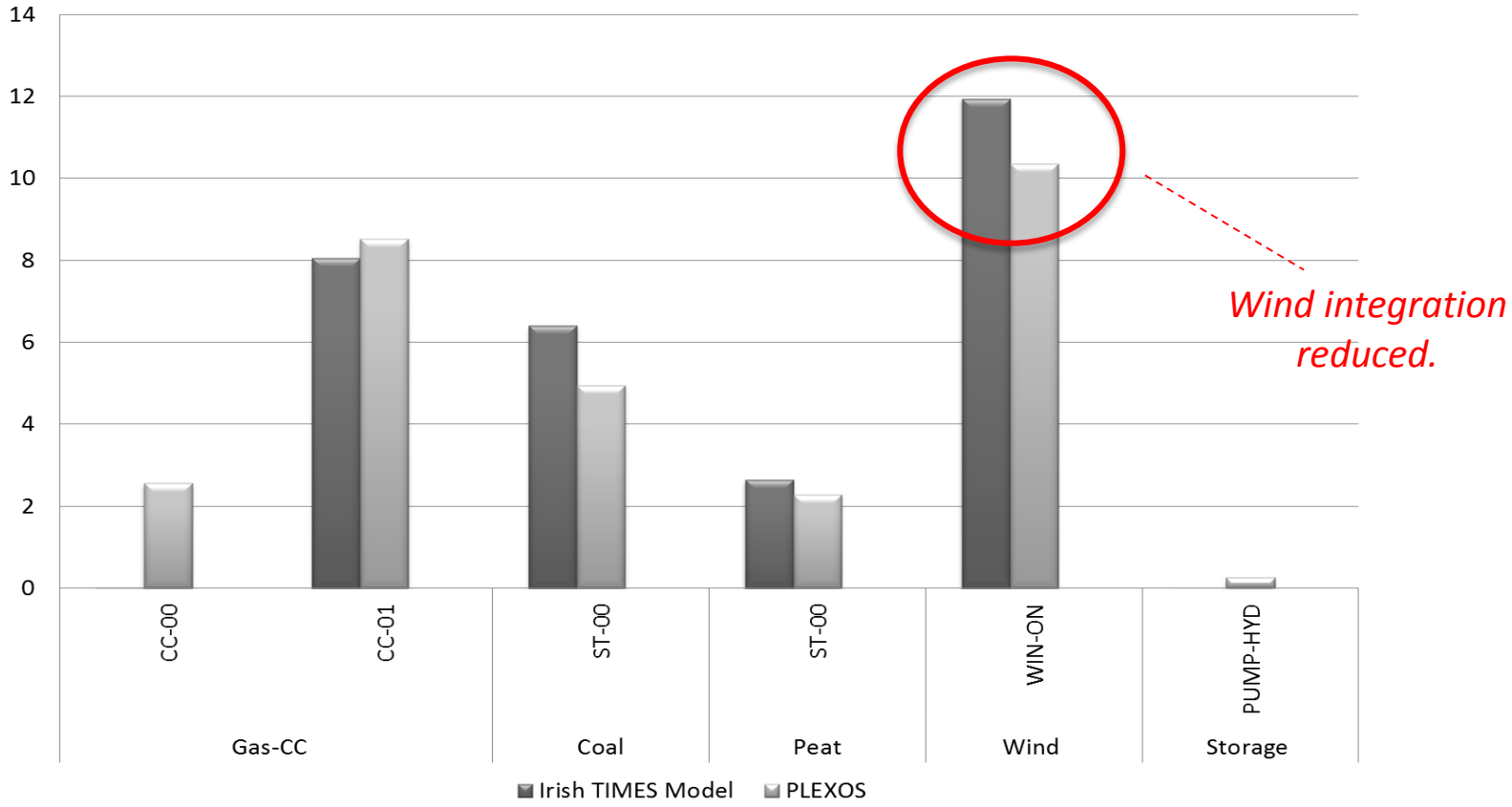
Technology roadmaps are not policies

Publications

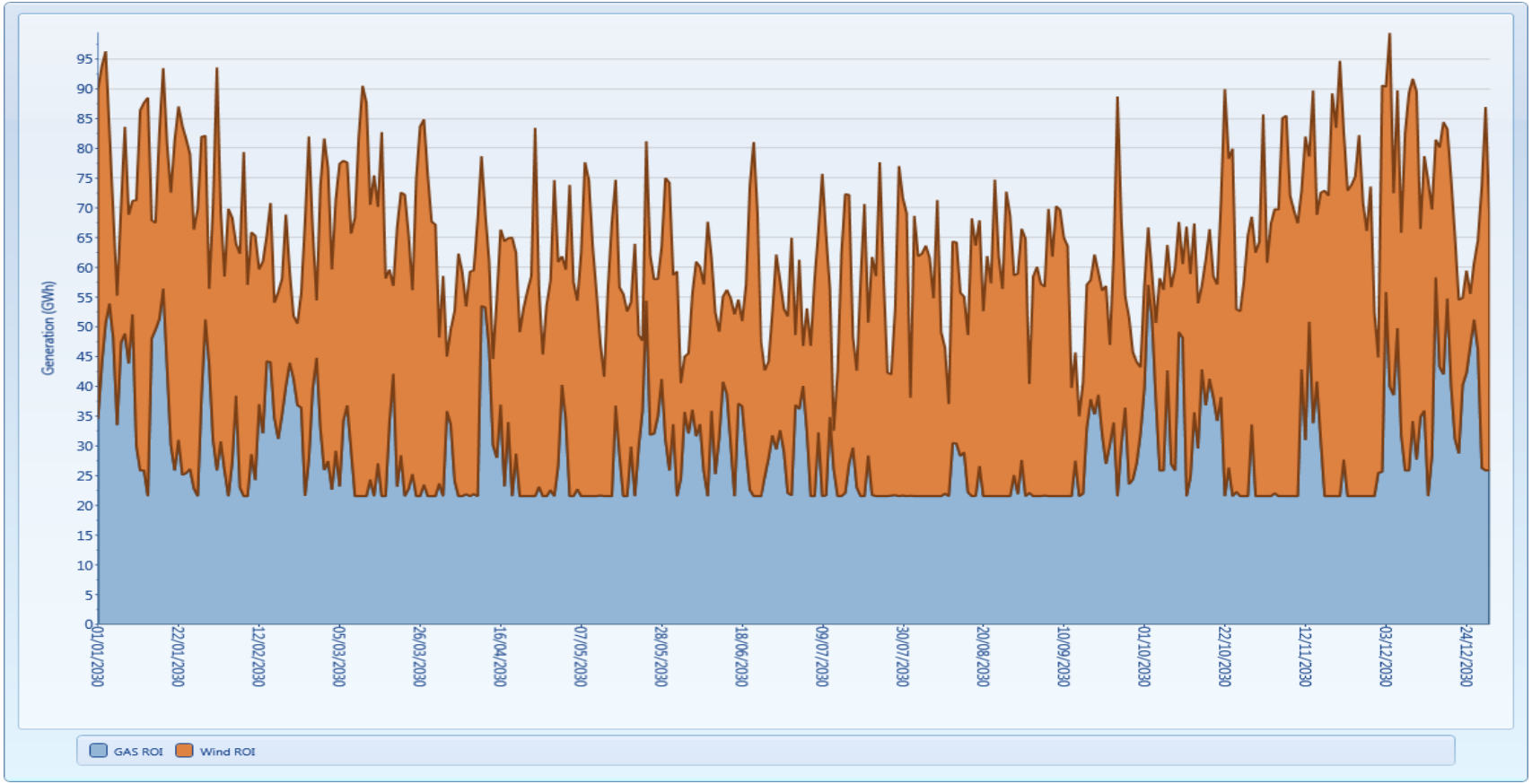
Multi-Model Approach - Electricity

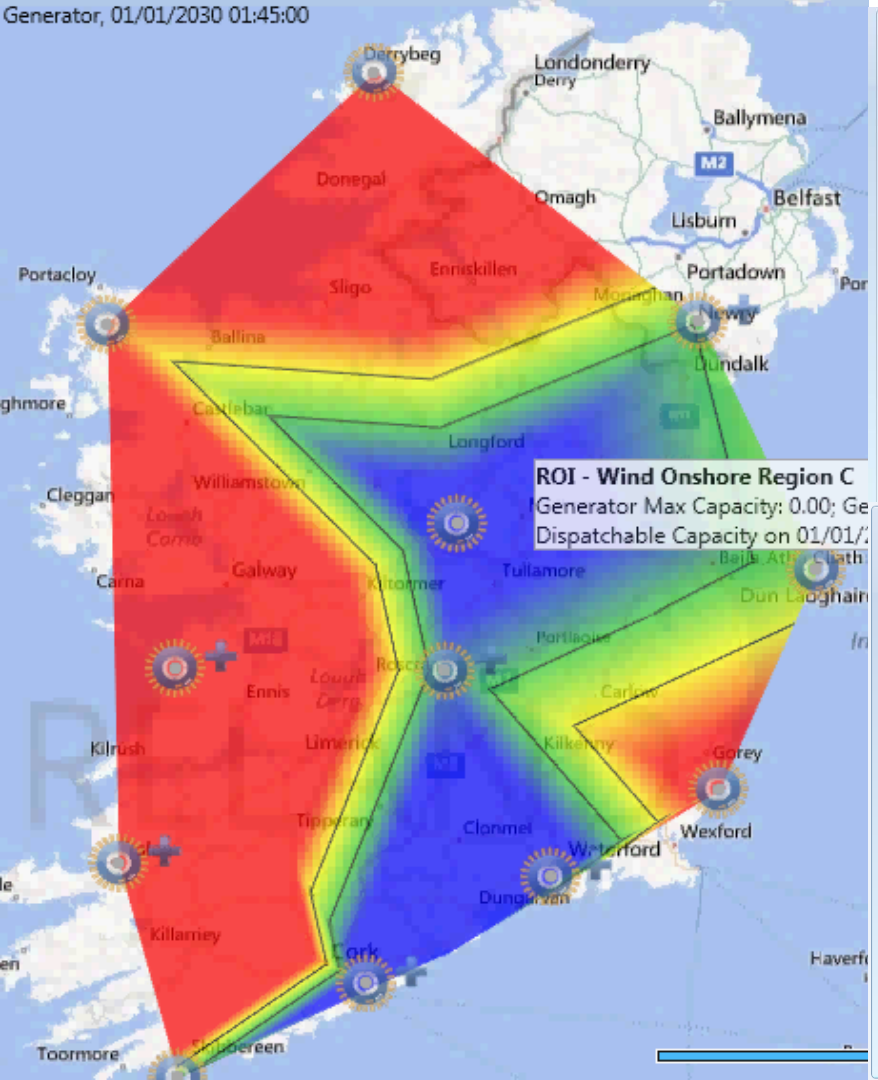


Results: 2020 Annual Generation (GWh)



Wind and Gas Interactions 2030




Generator, 01/01/2030 01:45:00
Derrybeg
Londonderry
Derry
Ballymena
M2
Donegal
Omagh
Belfast
Lisburn
Portacloy
Sligo
Enniskillen
Portadown
Monaghan
Newry
Ballina
Dundalk
Castlebar
Longford
Williamstown
Cleggan
Galway
Carna
Tullamore
Ennis
Limerick
Kilrush
Gorey
Wexford
Tipperary
Clonmel
Waterford
Killarney
Cork
Toormore
ROI - Wind Onshore Region C
Generator Max Capacity: 0.00; Ge
Dispatchable Capacity on 01/01/


Flow (TJ)


Generation (MW)
Landfill Gas ROI
CHP ROI
GAS ROI
COAL ROI
DISTILLATE ROI
WASTE ROI
HYDRO ROI
Marine ROI
SOLAR ROI
PUMPED STORAGE ROI

Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

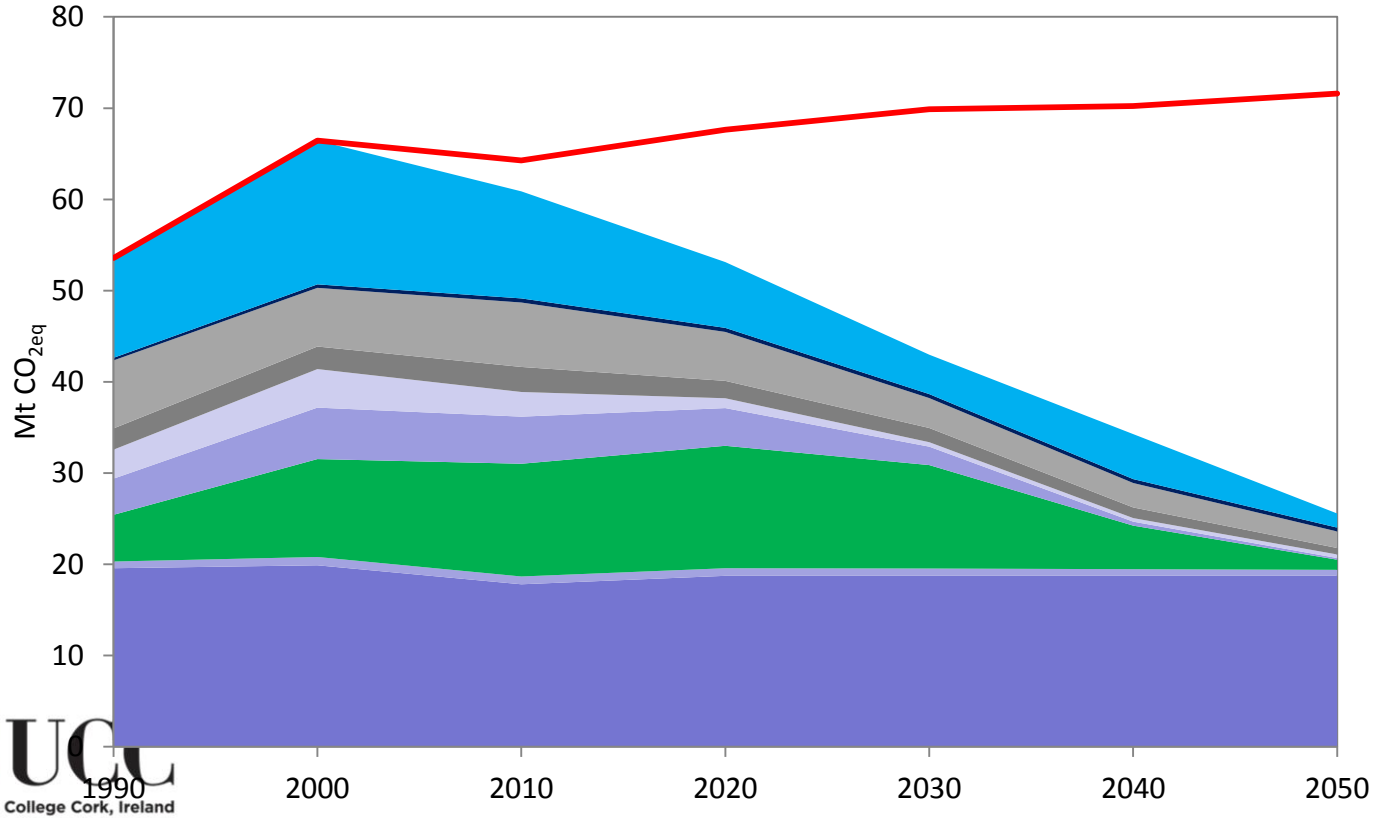
We need GHG mitigation, not just CO_2 mitigation

How many jobs?

Technology roadmaps are not policies

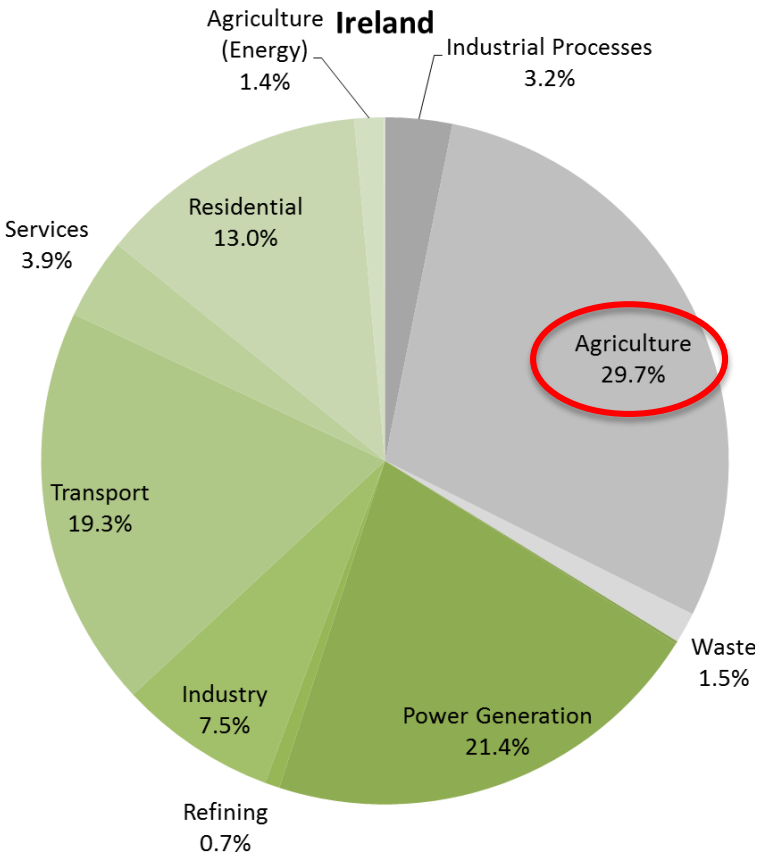
Publications

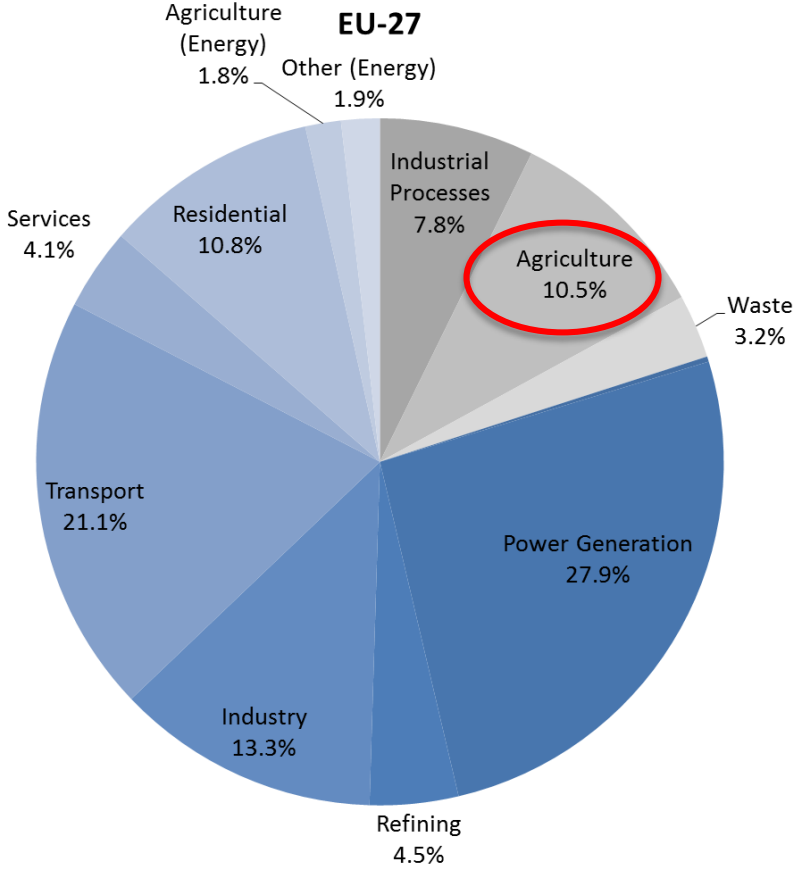
80% CO2 reduction = 50% GHG reduction



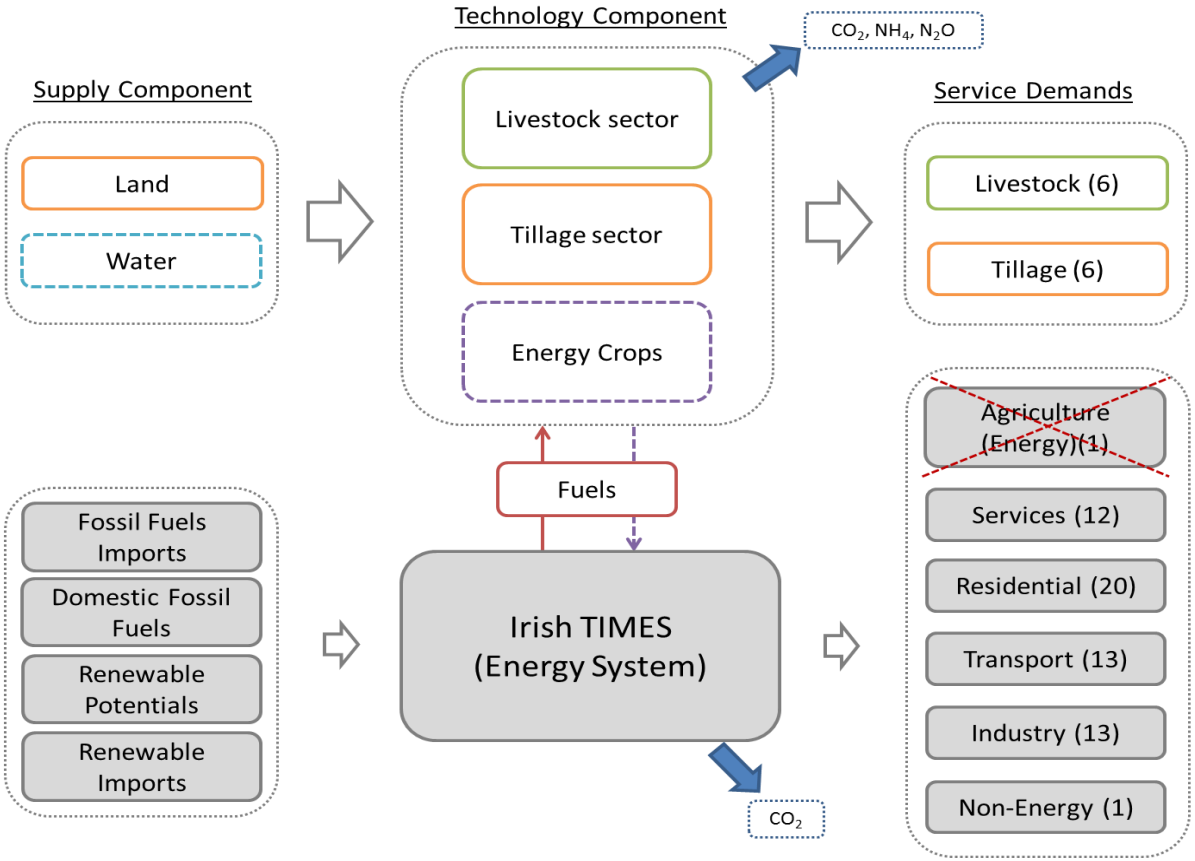
Why model agriculture?

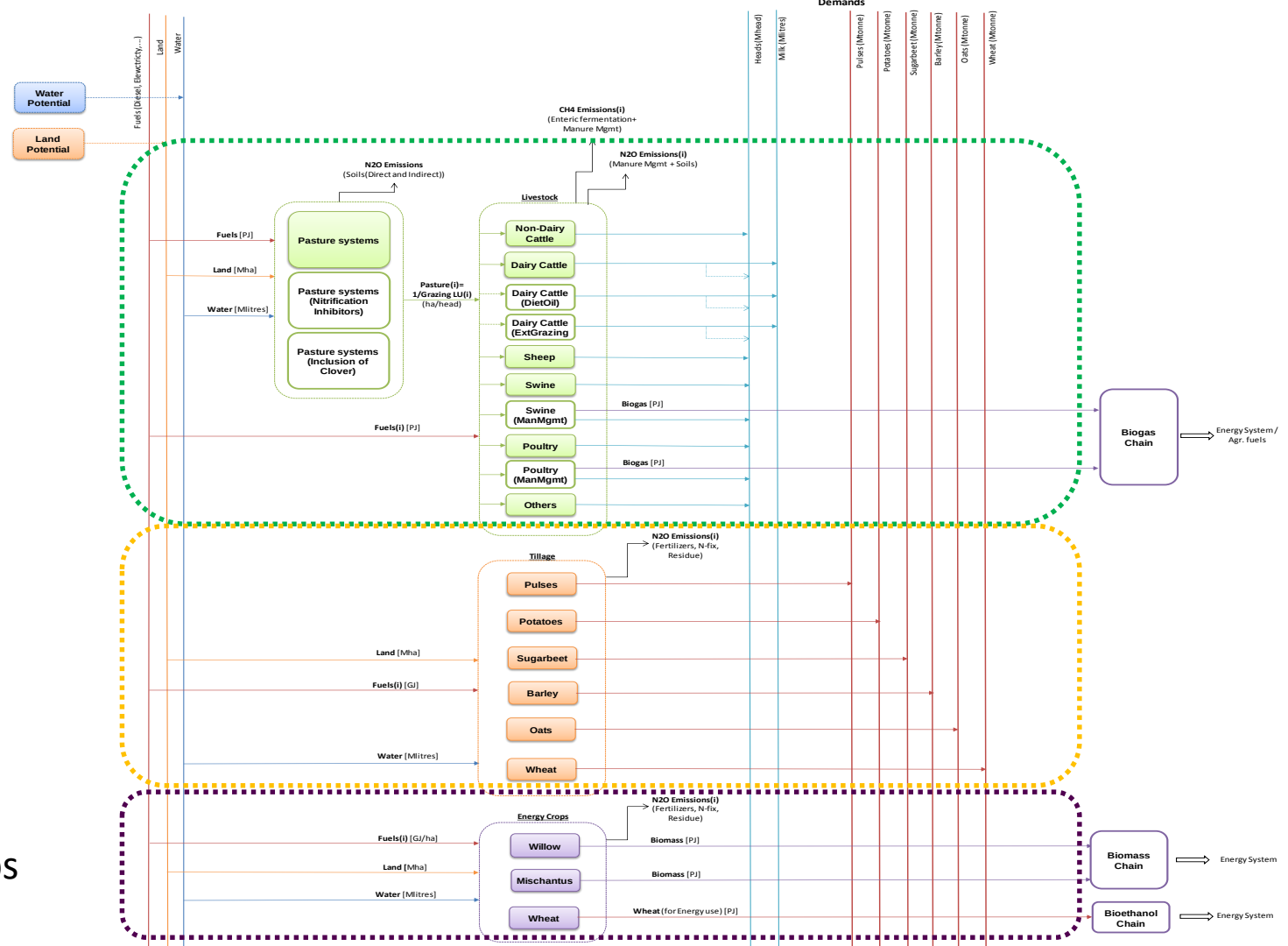
ENERGY





Multi-Model Methodology – AGRI-TIMES





Livestock

Tillage

Energy Crops

Results – GHG Reduction

GHG sectoral reductions (rel. 1990)

Sectors\Scenarios	2005	2030		2050	
		GHG-50	GHG-60	GHG-50	GHG-60
Power Generation	37%	-56%	-55%	-75%	-93%
Industry (incl. process)	26%	-37%	-39%	-90%	-90%
Transport (incl. int. aviation)	149%	96%	68%	-75%	-84%
Residential and services	1%	-57%	-60%	-63%	-81%
Agriculture (CO_2, non-CO_2)	-3%	4%	4%	-8%	-14%
Transformation	62%	-100%	-100%	-100%	-100%
Energy	44%	-30%	-36%	-73%	-87%
Non-Energy	-3%	1%	1%	-19%	-23%
Total	**24%**	**-17%**	**-20%**	**-50%**	**-60%**

Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

We need GHG mitigation, not just CO_2 mitigation

How many jobs?

Technology roadmaps are not policies

Publications

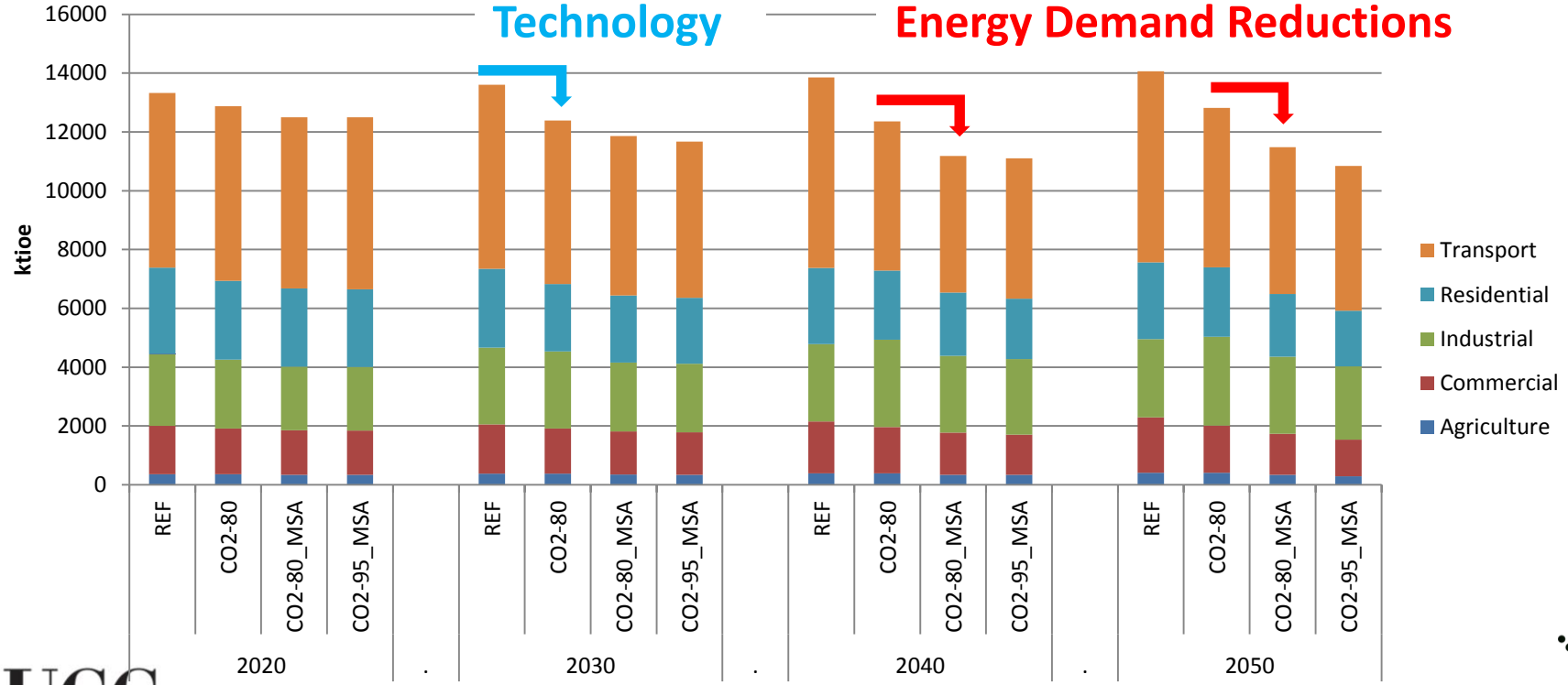
Multi-Model Methodology: Economy Feedback

1. **Irish-TIMES Elastic demand** (simple demand response to energy price).

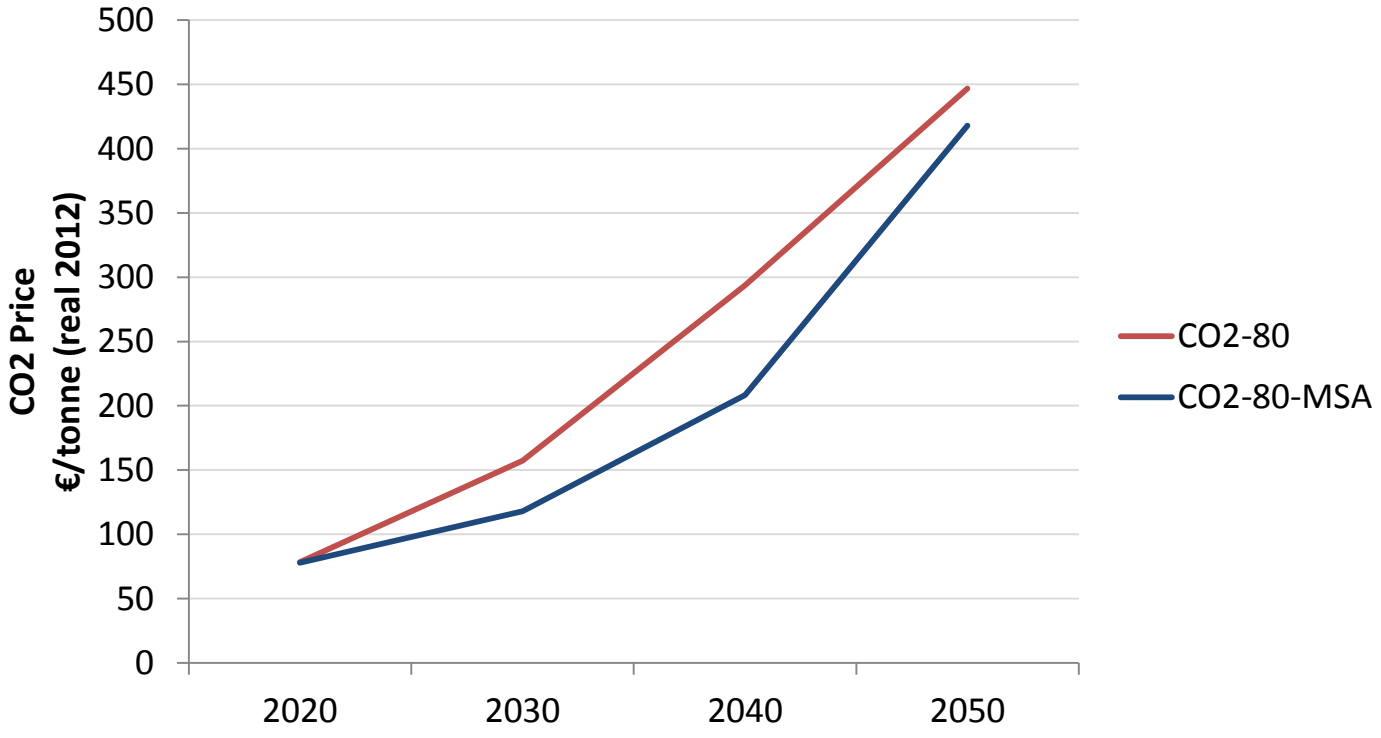
2. **Irish-TIMES-MSA** (simple macroeconomic response to energy system cost). MSA is a production function model which estimates the macroeconomic response to changes to the energy system.

3. **Irish TIMES-HERMES** (macroeconomic model of the Irish economy) to allow feedback between the Irish TIMES and HERMES models to allow better insight on the interaction of the energy system and the economy.

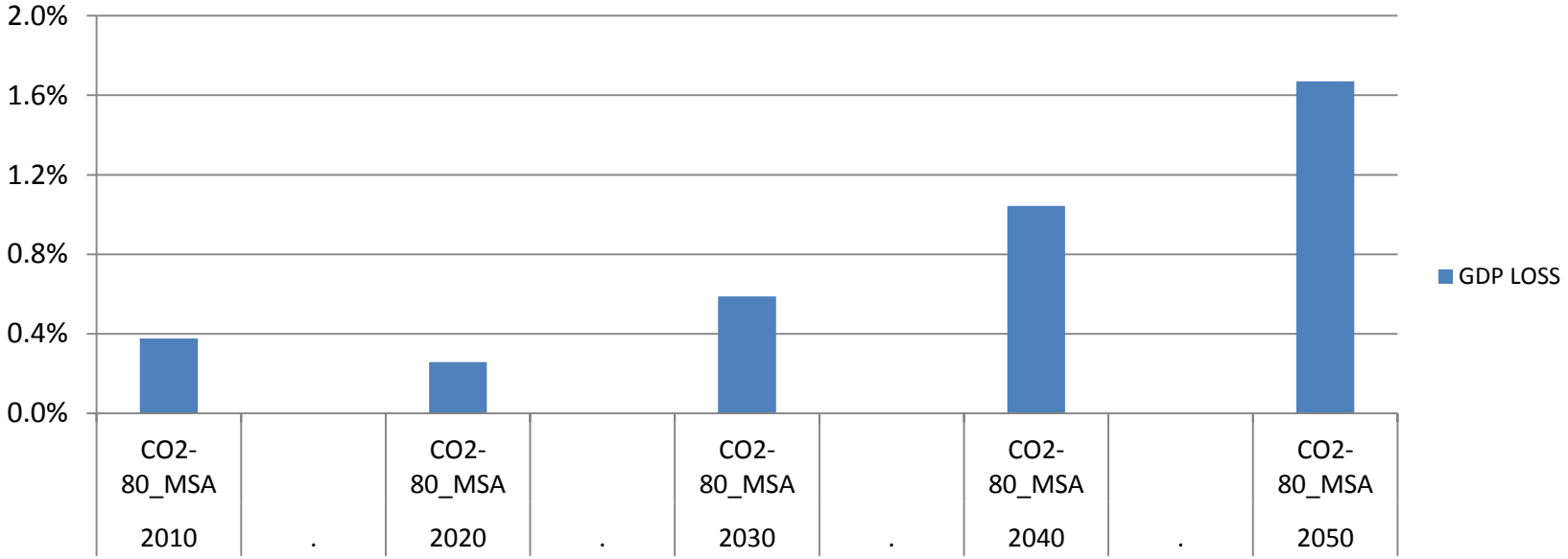
Final Consumption – Irish TIMES MSA



Marginal Abatement Cost – Irish TIMES MSA



GDP Loss (rel to REF) – Irish TIMES MSA



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

Beyond GDP Loss – Irish TIMES-HERMES

- Revenue from carbon tax and ETS allowances used to …..
  i. pay off Govt debt, or
  ii. reduce labour taxes
- Quantify impacts of investments, additional energy costs and (i) or (ii)
- employment
- sectoral GVA
- personal consumption of goods and services
- income levels

Overview

UCC-EPMG and modelling tools we use

Context – policy challenges

Low carbon roadmap a good starting point

Power systems require higher resolution (not just temporal)

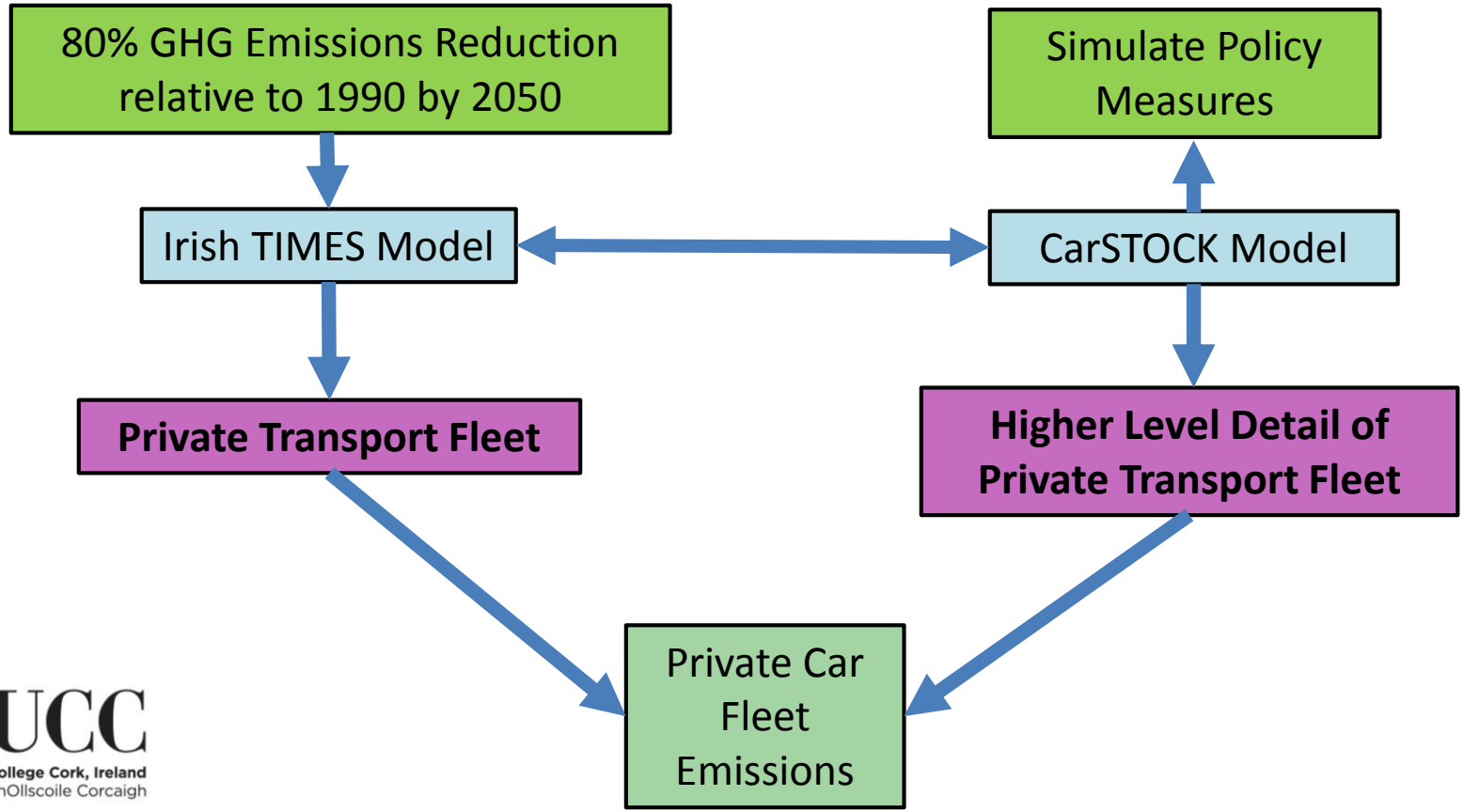
We need GHG mitigation, not just CO_2 mitigation

How many jobs?

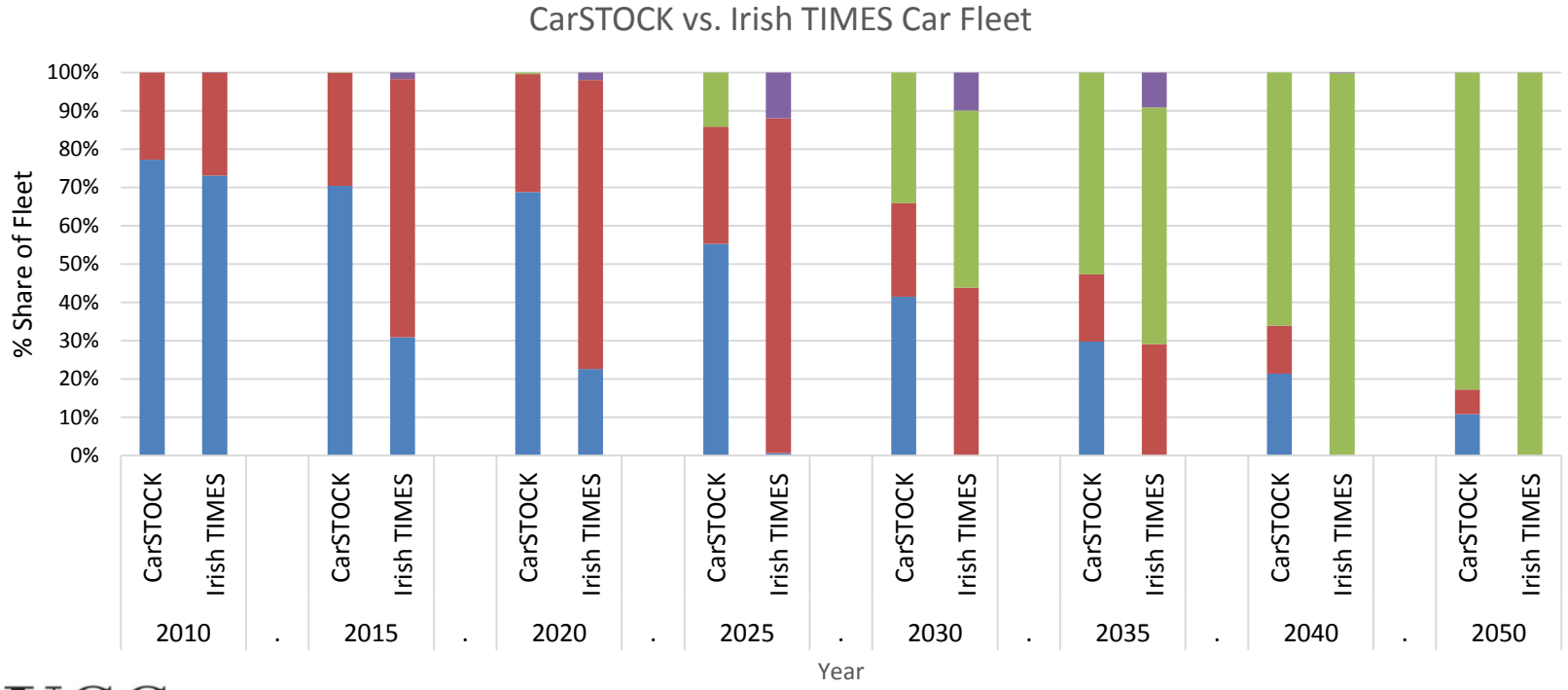
Technology roadmaps are not policies

Publications

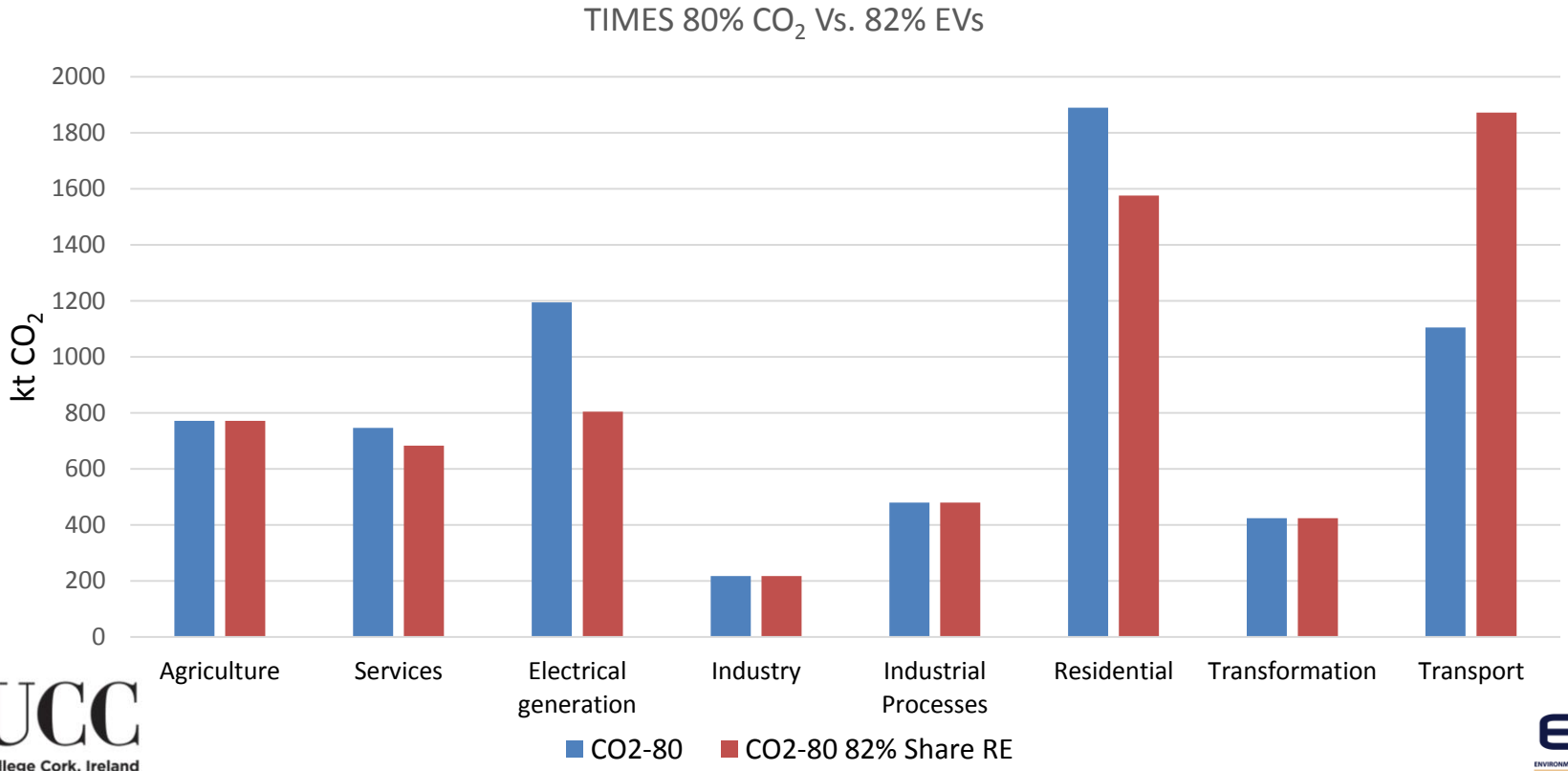
Multi-Model Methodology – Car Transport



Multi-Model Methodology – Car Transport



Multi-Model Methodology – Car Transport



Outputs - Multi-model power system…

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

Welsch M., Deane J.P., Howells M., Ó Gallachóir B.P., Rogan F., Bazilian M. And Rogner H.H. 2014 *Incorporating Flexibility into long-term energy system models – A case study on high levels of renewable electricity penetration in Ireland.* **Applied Energy,** Vol 135 Pages 600-615.

Welsch M., Howells M., Hesamzadeh M., Ó Gallachóir B.P., Deane J.P., Strachan N., Bazilian M., Keronen J., Ollus S.E., Kammen D., Jones L., Strbac G. 2014 *Supporting Security and Adequacy in Future Energy Systems – The need to enhance long-term energy system models to better treat issues related to variability.* **International Journal of Energy Research** Vol 39 Pages: 377–396.

Deane J.P., Drayton G., Ó Gallachóir B.P. 2014 *The impact of sub-hourly modelling in power systems with significant levels of renewable generation.* **Applied Energy** Vol 113, Pages 152-158

Deane J.P., McKeogh E.J. and Ó Gallachóir B.P. 2013 *Derivation of Intertemporal Targets for Large Pumped Hydro Energy Storage with Stochastic Optimisation.* **IEEE Transactions on Power Systems** Vol. 28, No. 3 Pages 2147 – 2155

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

Outputs - Multi-model GHG …

Chiodi A.; Donnellan T., Breen J., Hanrahan K., Gargiulo M., and Ó Gallachóir B.P. *Integrating agriculture and energy within an energy systems models to assess GHG emissions reduction - a Methodological approach.* **Climate Policy** (http://dx.doi.org/10.1080/14693062.2014.993579)

Chiodi A., Breen J., Donnellan T., Gargiulo M., Deane P, and Ó Gallachóir B. 2014 *Land use competition between energy and food – the case of climate mitigation in Ireland* Proc 14th International Association of Energy Economists European Conference October 28 – 31, 2014 Rome, Italy.

Chiodi A., Gargiulo M. and Ó Gallachóir B. P. 2012 *Climate Change Mitigation - Don't forget about agriculture.* Proc International Energy Workshop 2012 University of Capetown June 19 - 21, Capetown, South Africa.

Outputs - Multi-model economy …

Glynn J., Fortes P., Krook-Riekkola A., Labriet M., Vielle M., Kypreos S., Lehtilä A., Mischke P., Dai H., Gargiulo M., Helgesen P.I., Kober T., Summerton P., Merven B., Selosse S., Karlsson K., Strachan N., Ó Gallachóir B. 2015 '*Economic Impacts of Future Changes in the Energy System—National Perspectives.* Chapter in **Springer Book** Informing energy and climate policies using energy systems models' pp 359-387 (ISBN 978-3-319-16539-4)

Gargiulo M, Glynn J. and Ó Gallachóir B. 2014 *Modelling macroeconomic impacts of a carbon constrained energy system using Irish-TIMES MSA* Proc International Association of Energy Economists 2014 Conference October 28 – 31, 2014 Rome, Italy.

Glynn J., Gargiulo M. and Ó Gallachóir B. 2014 *Modelling global macroeconomic impacts of a carbon constrained energy system using ETSAP-TIAM MSA* Proc International Association of Energy Economists 2014 Conference October 28 – 31, 2014 Rome, Italy.

Gargiulo M, Glynn J., Curtis J, FitzGerald J. and Ó Gallachóir B 2014 *How do future changes in the energy systems impact on the economy?* Proc. ESRI – UCC Energy Research Workshop 2014 ESRI, Dublin 16th June 2014

Gargiulo M., Chiodi A., Deane P., Ó Gallachóir B. *Impact of economic recession on the costs of climate mitigation.* Proc 12th IAEE European Energy Conference, Energy Challenge and Environmental Sustainability, 9-12 September, Venice, Italy.

Outputs - Multi-model policy measures …

Mulholland E., Rogan F. and Ó Gallachóir B. 2014 *Soft-Linking a TIMES Model and Sectoral Simulation Model for Individual Policy Measures* Proc**.** 66th Semi-annual IEA ETSAP Workshop, Copenhagen, Denmark, November 17 – 18 2014.

Daly H.E., Ramea K., Chiodi A., Yeh S., Gargiulo M., Ó Gallachóir B.P. 2014 *Modelling modal choice behaviour within a linear energy system model* **Applied Energy** 135 429-439

Rogan F., Cahill C., Daly H.E., Dineen D., Deane J.P., Heaps C., Welsch M., Howells M., Bazilian M., Ó Gallachóir B.P. 2014 *LEAPs and Bounds - A Hybrid Energy Demand and Constraint Optimized Model of the Irish Energy System.* **Energy Efficiency** Vol 7, 441-466

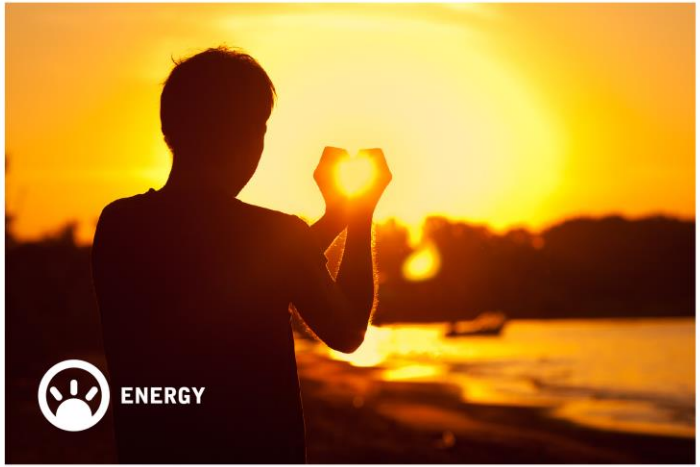
Leinert S., Daly H.E., Hyde B., Ó Gallachóir B.P. 2013 *Co-benefits? Not always. Quantifying the negative effect of a CO2-reducing car taxation policy on NOX emissions* **Energy Policy** Vol 63, Pages 1151-1159

Daly H.E. and Ó Gallachóir B. P. 2012 *Future Energy and Emissions Policy Scenarios in Ireland for Private Car Transport* **Energy Policy** Vol 51, Pages 172 - 183.

Cahill C., and Ó Gallachóir B. P. 2012 *Quantifying the savings of an industry energy efficiency programme.* **Energy Efficiency**, 5 (2):211-224

Rogan F, Dennehy E, Daly H. E., Howley M. and Ó Gallachóir B. P. 2011 *Impacts of an Emission Based Private Car Taxation Policy – One Year Ex-Post Analysis.* **Transportation Research Part A Policy and Practice** Volume 45, Issue 7, Pages 583-597

ERI
ENVIRONMENTAL RESEARCH INSTITUTE
UNIVERSITY COLLEGE CORK



A TRADITION OF INDEPENDENT THINKING

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Developing and using a multi-model approach: One size fits all does not work!

Brian Ó Gallachóir

WholeSEM Conference July 6-7 2015, Cambridge