Climate Change Advisory Council Secretariat

CB WG Meeting 4

29th June 2023

Agenda

Time	Agenda Item
13:30	1. Opening of Meeting
13:35	2. Scoping of Modelling Work
14:15	3. Macroeconomic Impacts of carbon budgets
15:00	4. Climate Justice and ‘Paris Test’
16:15	5. Carbon Budgets Work Plan
16:25	6. Next Steps and Agenda for next meeting
16:30	7. AOB
16:30	Meeting Close

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
3	20/04/23	Expand discussion of macroeconomic inputs/ drivers	CCAC Secretariat and relevant CB WG Members	Q3 2023	Ongoing – Update to be provided at CB WG Meeting 4
5	20/04/23	Further develop the approach and preparation for topical discussions	CCAC Secretariat	Q3 2023	Ongoing – Secretariat to provide an update on the approach and preparation for upcoming topical discussions at each meeting.

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2. Scoping of Modelling Work

Additional modelling and testing of results to be carried out by three groups;

1. **ESRI's Ireland Environment, Energy and Economy Model (I3E) model** focusing on the the Irish economy in sectoral detail,
2. **Central Bank's COre Structural MOdel of the Irish economy (COSMO) a** structural econometric model of the Irish economy, and
3. **SEAI's National Energy Modelling Framework (NEMF)** used to model policy uptake.

- Model Overview
- Key questions to ask the model
- Model Inputs (assumptions / variables / constraints)
- Model Outputs
- Sensitivities

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3. Macroeconomic Impacts of carbon budgets

Carbon Budgets Programme 2 Methodology V1.3

Update to Section 3.3 following feedback from ESRI on D/Taoiseach's Research & Modelling Macroeconomic Subgroup:

'The Dept. of Taoiseach's macroeconomic modelling subgroup is encouraging efforts to link models across Ireland, specifically the link between the and ESRI's Ireland Environment, Energy and Economy Model (I3E) model and the UCC TIM model and a recalibration of the link between I3E and the NEMF (these are already linked) to look at National Climate Action Plan measures. The Central Bank's COre Structural MOdel of the Irish economy (COSMO) was also noted as having potential to feed into the carbon budgeting process'.

3. Macroeconomic Impacts of carbon budgets

- Updating I3E for Carbon Budgets
- Update on D/Taoiseach’s Research & Modelling Macroeconomic Subgroup

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4. Overview of the ‘Paris Test’ for the 1st programme of carbon budgets

Summary Table: Additional Impact of Ireland’s emissions from 2020 on Global Temperature in 2050						
	Unit	E51%-A51%	E57%-A40%	E61%-A33%	E65%-A25%	E69%-A19%
Net Change in Global Temperature in 2050 relative to 2020	$x10^{-3}$ °C	-0.04	0.03	0.07	0.11	0.15
Upscaled to Global level Temperature change to 2050	°C	-0.05	0.04	0.11	0.16	0.24
Remaining gap to global 1.5 degree goal (with confidence range)	°C	0.23 (0.14- 0.32)	0.23 (0.14- 0.32)	0.23 (0.14- 0.32)	0.23 (0.14- 0.32)	0.23 (0.14- 0.32)

- 1.5°C target and IPCC analysis implying a remaining distance of 0.23°C
- Simple linear equations used to calculate the temperature impact, scaled up on a pro rata per capita basis

CCAC Carbon Budgets Technical Report Section 4.2.1

4. Climate Justice and ‘Paris Test’

- Presentation and discussion on the ethics of the Paris Test and what it means for Ireland

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5. Carbon Budgets Work Plan: MoU Requests for Modelling Capacity

Item	Description	2023									2024											
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	**Modelling / Analysis Iteration 1**																					
1.1	Agree inputs, paramaters and assumptions																					
1.2	Core pathways development and modelling																					
1.3	Paris Test Assessment																					
1.4	Additional modelling and testing of results																					
1.5	Post-hoc analysis																					
2	**Modelling / Analysis Iteration 2**																					
2.1	Agree inputs, paramaters and assumptions																					
2.2	Core pathways development and modelling																					
2.3	Paris Test Assessment																					
2.4	Additional modelling and testing of results																					
2.5	Post-hoc analysis																					
3	**Modelling / Analysis Iteration 3**																					
3.1	Agree inputs, paramaters and assumptions																					
3.2	Core pathways development and modelling																					
3.3	Paris Test Assessment																					
3.4	Additional modelling and testing of results																					
3.5	Post-hoc analysis																					

June 2023 Follow up letters issued with a more detailed request for Modelling Services based on the Carbon Budgets Work Plan; DECC (cc-ing UCC), DECC (cc-ing NUIG), Teagasc, ESRI and SEAI.

July 2023: Liaison officer contact point meeting scheduled for July (Date TBC).

5. Carbon Budgets Work Plan: Topics for Meetings

CB WG Meeting No.	Proposed Date and Time	Topic(s) for Consideration
1	Thursday 9th March 2023 10:00 – 13:00	Carbon Budgets Methodology
2	Thursday 20th April 2023 13:30 – 16:30	Carbon Budgets Methodology / Scoping of modelling work
3	Wednesday 31st May 2023 10:30 – 13:30	Vision for 2050 and Beyond/ Scoping of modelling work/
4	Thursday 29th June 2023 13:30 – 16:30	Climate Justice and 'Paris Test'/ Scoping of modelling work/ Macroeconomic Impacts of carbon budgets/
5	Thursday 27th July 2023 13:30 – 16:30	Focused discussion on methane/ Scoping of modelling work/
6	Friday 8th September 2023 13:30 – 16:30	Populations Projections/ *Socioeconomic considerations*
CB WG Workshop 1	Week 2 September 2023 (TBC)	Input model parameters for 2030 starting points, scenario development and assumptions
7	Thursday 19th October 2023 13:30 – 16:30	Landuse Review/ *Biodiversity Considerations/* 2024 Projections Process (EPA, SEAI & ESRI)
8	Thursday 23rd November 2023 10:30 – 13:30	Role of Negative Emissions/ *International approaches to carbon budgets*
9	Friday 15th December 2023 13:30 – 16:30	TBC

5. Carbon Budgets Work Plan: Meeting No. 5: 27th July 13:30 – 16:30

1.a. Focused discussion on methane

- Secretariat briefing note on methane
- Invited Speaker Joe Wheatley, Energy Institute UCD '*Temperature neutrality and Irish methane policy*'

1.b. Ethics of methane emissions and climate change

- Presentation and discussion on the ethics of Methane and Climate Change and what it means for Ireland

➢ *Discussion of the Act requirement to take account of "relevant scientific advice, including with regard to the distinct characteristics of biogenic methane" and approach for the second programme*

2. Scoping of Modelling Work

- Overview of the NTA and FERS models and discussion of core modelling inputs, parameters and assumptions
- Draft Workshop Agenda (13th September) to be circulated for review and comment

5. Carbon Budgets Work Plan: Meeting No. 6: 8th Sept. 13:30 – 16:30

1. Populations Projections

- Detailed Census results will be used over the summer to revise the intercensal population estimates i.e., from 2017-2022 and are due for publication in September along with the latest estimate for 2023.
- Update from CSO on timeline for the next round of national population projections.

2. Socioeconomic Considerations (NESC)

- Overview of the NESC report on exploring a Just Transition on Agriculture and Land use

➢ *Discussion of the Act requirement to take account of "a just transition to a climate neutral economy which endeavours, in so far as is practicable, to maximise employment opportunities, and support persons and communities that may be negatively affected by the transition" and approach for the second programme*

5. Carbon Budgets Work Plan: Workshop 13th September 13:30 – 16:30

Objective: Develop a shared understanding of model inputs and expected outputs

Proposed Agenda

1. 2030 starting points and 2050 targets
2. Model inputs and assumptions
3. Model constraints
    - Competing Land Use Requirements e.g. biomethane and afforestation
    - Biodiversity constraints
    - Population growth
4. Scenario development for 2nd Carbon Budget Programme
5. Model Outputs and scope for testing of results and post-hoc analysis

Post Workshop

- ➢ Secretariat to prepare an outcome report for CCAC meeting on 28th September
- ➢ Modelling/Analysis Iteration 1 Commences following CB WG meeting No. 7 19th October

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6. AOB

AOB?

SEAI National Energy Modelling Framework Overview

Emma Lynch – Head of Energy Modelling, SEAI

29th June 2023

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Overview

- SEAI Energy Modelling Function
- National Energy Modelling Framework Overview
- NEMF Key Questions and Sensitivities
- Applications of NEMF Outputs
- Example Insights from Latest Projections
- NEMF Development Process

SEAI Energy Modelling Function

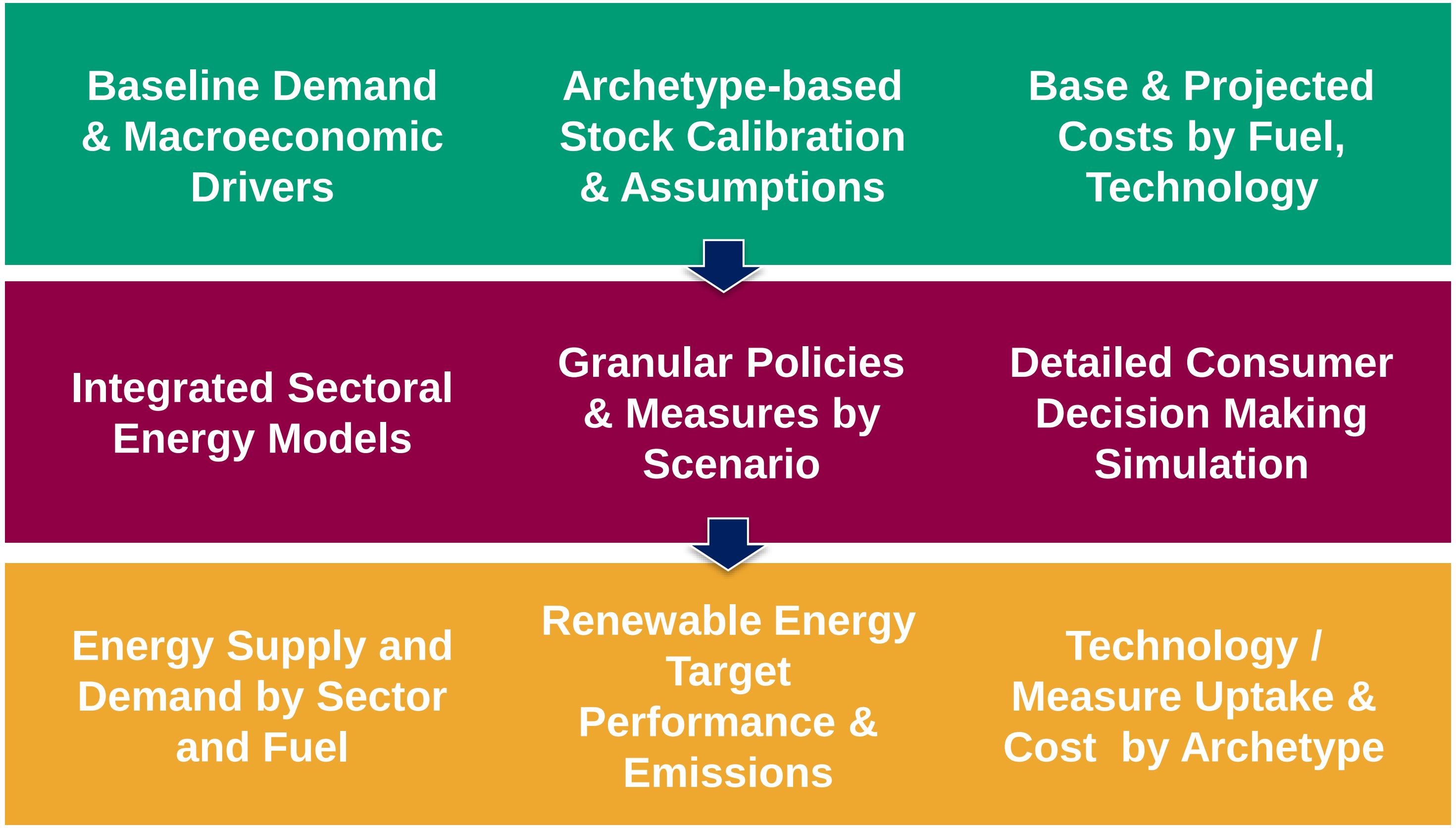
- SEAI functions established by the Sustainable Energy Act, 2002
  - share information and projections on energy production and use
  - assist State with coordinating sustainable energy activity

- SEAI Energy Modelling purpose
  - Simulate future energy supply and demand
  - Quantify effects of policy on trends
  - Identify gaps to targets and priority areas
  - Fulfil reporting requirements

SEAI National Energy Modelling Framework Overview

The National Energy Modelling Framework (NEMF):

- Combines sectoral energy models with baseline demand incorporating macroeconomic inputs
- Simulated consumer decision-making and measures uptake under alternative scenarios
- Assesses combined impact of granular policies and measures on energy supply, demand and energy-related emissions



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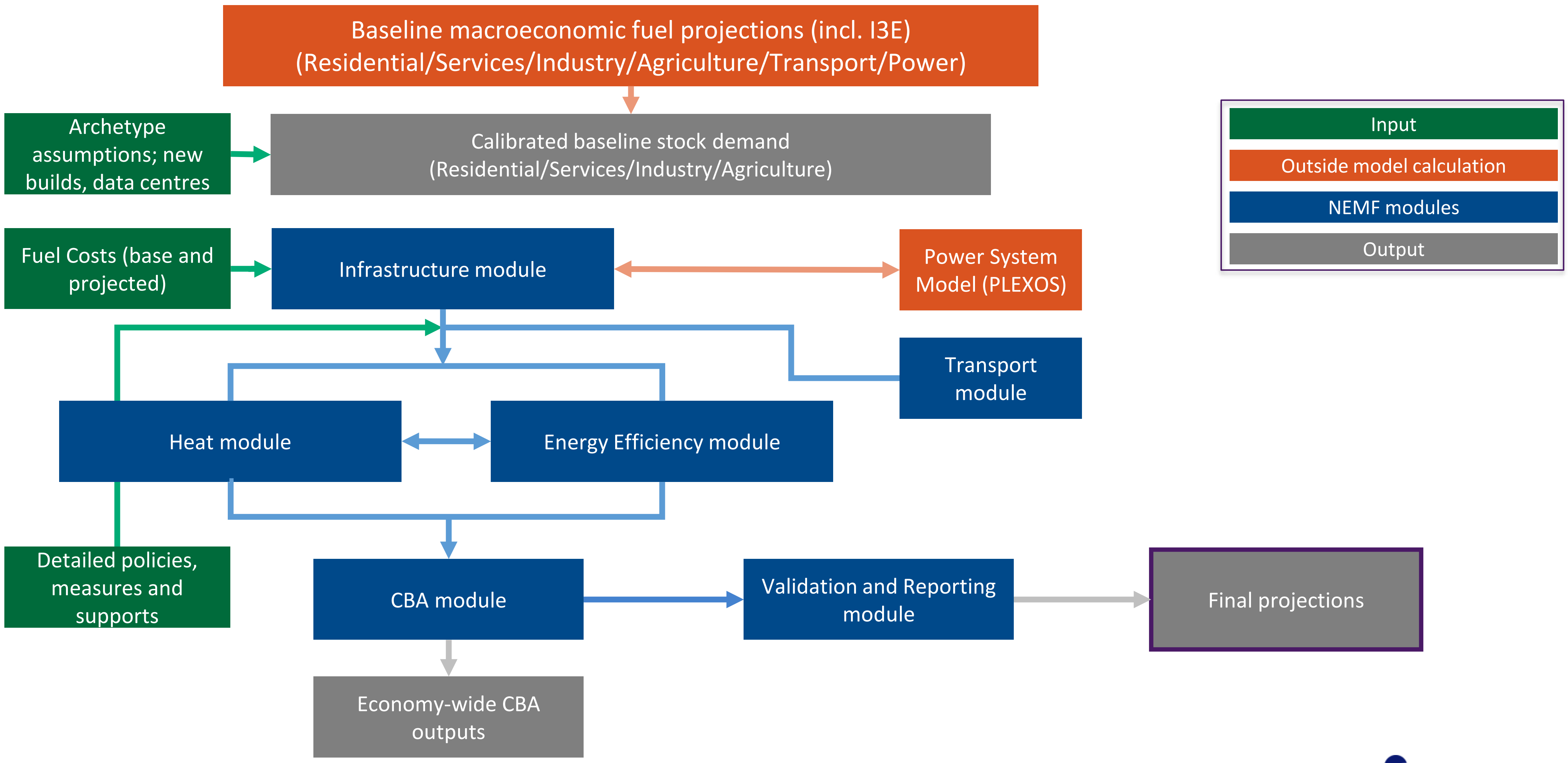
SEAI NEMF Modular Structure and Inputs



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NEMF Key Questions and Sensitivities

- For given **set of policies and measures**, what is the **range of potential impact** on future energy supply and demand?
- For set of scenarios each with **specified focus in longer-term strategy**, to what extent and how quickly does the energy economy **approach targets**?
- How can **changes to consumer considerations** like cost impact on uptake of schemes and what additional supports can **bridge the gap**?
- What are some of the **critical milestones** for consumer uptake and technology deployment that have the **biggest impact** on reaching targets?

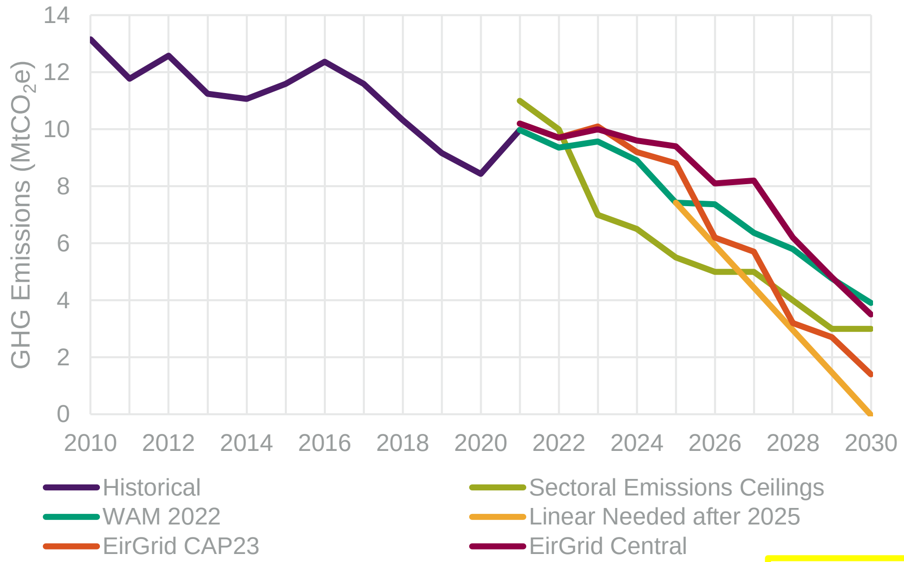
↔

- More **detailed policy assumptions** yield better outputs (implementation plans and credible risks)
- Plans **extending beyond 2030 targets** allow for more robust modelling
- **Account for potential changes** in demand, perception and costs for informative range of scenario outputs
- Additional measures and emergency levers to provide **plan for risk mitigation**

NEMF Key Outputs and Applications

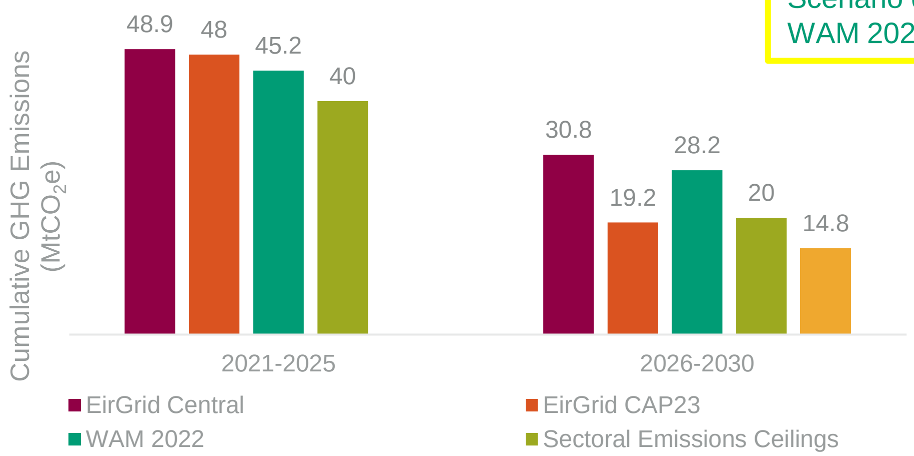
- National and International reporting and monitoring against targets
  - Annual National Energy Projections produced since 2006 (latest data online Energy Data | SEAI Statistics | SEAI)
  - collaboration with EPA, DECC, ESRI and others
  - Key input to EPA's GHG Emissions Projections
  - Analysis informs National Energy & Climate Plan
- Extensive focused scenario-based pathway evaluation for decarbonisation
  - National Heat Study and targeted reports on paths to net zero by 2050
- Focused scheme impact analysing savings within and across sectors
  - Retrofit Grants and Financing, SSRH, SSG, etc.

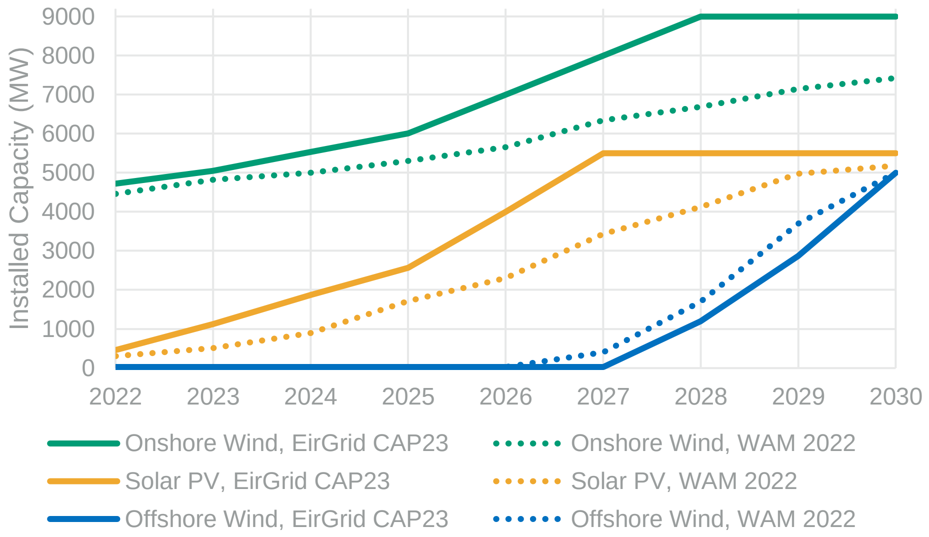
Latest Projections - Scale of Challenge - Electricity Generation



- First two emissions ceilings for Electricity are extremely challenging.
- Accelerated variable onshore renewables deployment essential to meeting sectoral emissions ceilings

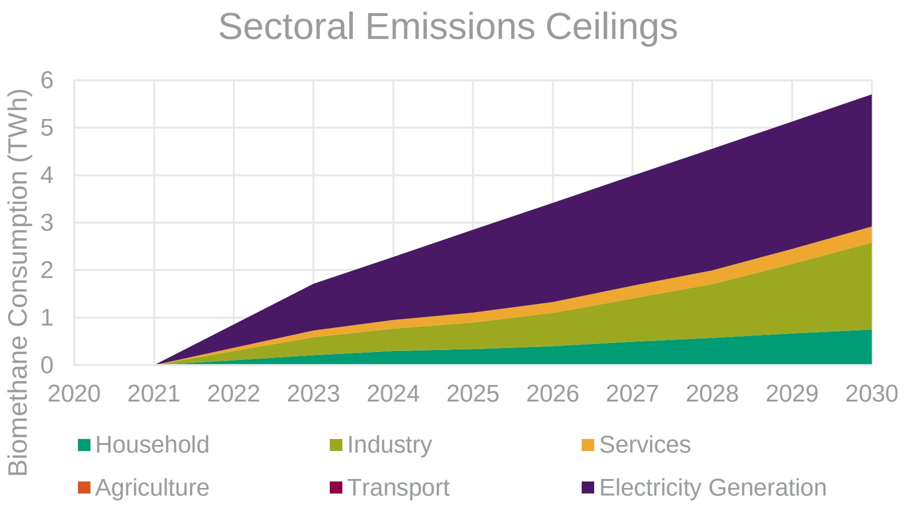
SEAI's Projections Scenario denoted as WAM 2022

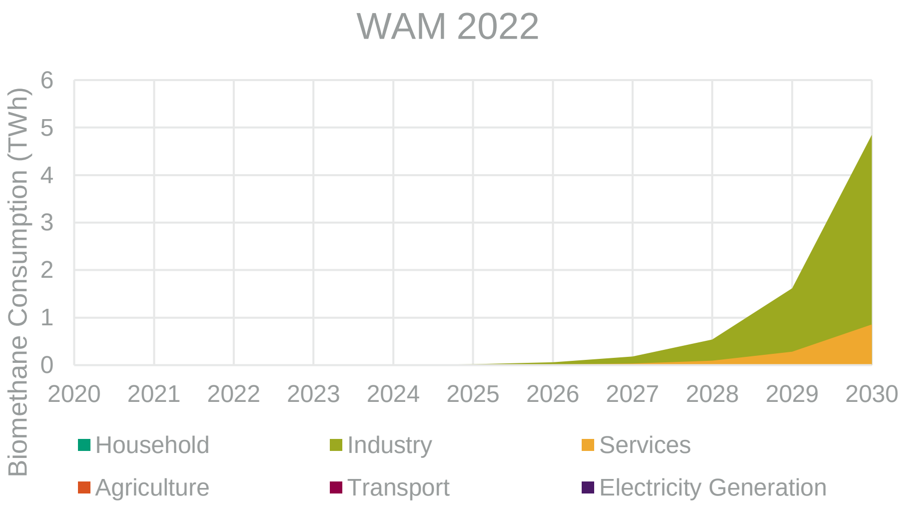




Sources: SEAI National Energy Projections; EPA GHG Emission Projections 2022-2040; DECC CAP23

Latest Projections – Scale of Challenge - Renewable Gas

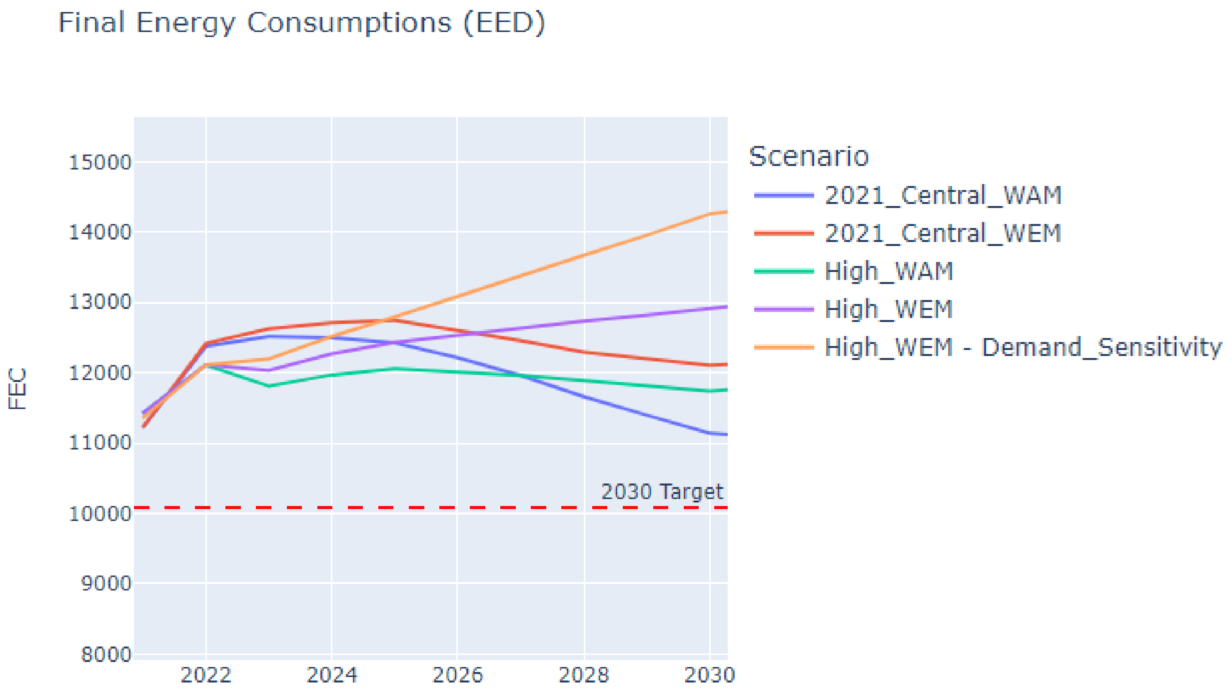


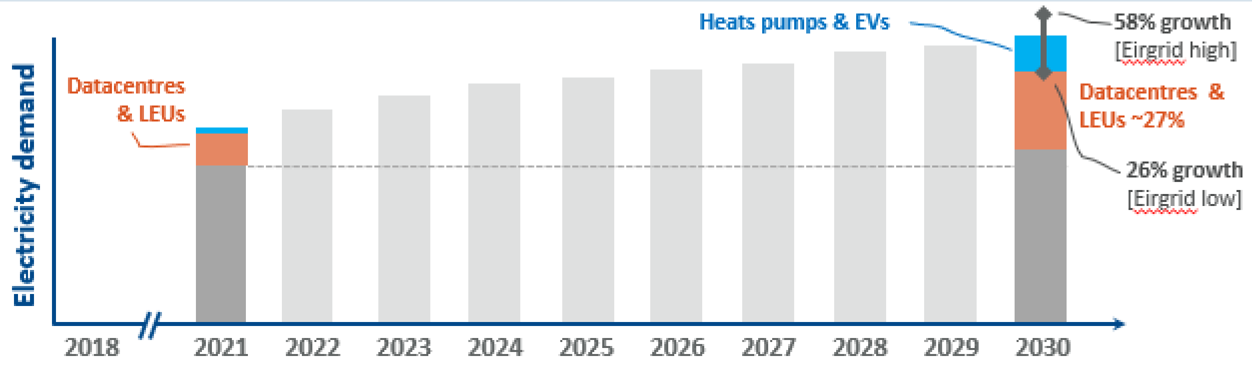


- Ramping up biomethane production will take time.
- To maximise RES share, biomethane is better allocated to RES-H than RES-E.
- Hydrogen blending at low-medium %s has a reduced CO_2 abatement potential.

Source: SEAI, Energy Projections 2022

Latest Projections – Scale of Challenge – Demand Growth





- Recast EED requires significant reduction in final energy use across all sectors. More policy levers are needed to mitigate risk.
- Variable renewable deployment must outpace demand growth to meet carbon budgets.

Source: SEAI, Energy Projections 2022, WAM

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NEMF Development and Application Approach

- Software
  - Primarily written in Python
  - additionally use PLEXOS for unit commitment and economic dispatch in power module
- Time Horizon
  - Capability to run to 2050, though value of projections limited by granularity and quality of policy and technology inputs
- Model Development Approach
  - Implement Python best practice for improved flexibility and usability
  - Git for version control - Maintain stable and development versions
- Model Application Approach
  - Continuously share key findings, enrich datasets, and produce more timely insights
  - Make it real, working with Research & Technology and Delivery capabilities to supplement analysis and support pilots
  - Consider the complex / unknown and stay agile, producing collaborative research to reassess mix of measures and identify gaps

Cycle of Innovation in NEMF Development

- Leverage behavioural economics research to inform consumer choice modelling

- Continuously upgrade tools and methodology for agility and robustness

- Assess economic impacts on energy market and decision making in model

- Monitor on-the-ground performance of schemes to calibrate model and refine scenarios

Questions

Further questions or interest in collaboration:

[redacted]

in @ seai_ie

Ireland's European Structural and Investment Funds Programmes 2014-2020

Co-funded by the Irish Government and the European Union

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Banc Ceannais na hÉireann
Central Bank of Ireland
Eurosystem

Modelling the Macroeconomic Impact of Carbon Budgets using COSMO

COSMO: COre Structural MOdel

- Medium-scale **semi-structural** (structural econometric) model of the Irish economy
  - Semi-structural nature allows considerable flexibility in adapting model to incorporate additional features
  - Easy integration of international shocks from global SSMs such as NiGEM
- Core model comprises **three sectors**:
  - **Traded** sector depends on **world** demand and Ireland's export prices relative to competitiors
  - **Non-traded** sector primarily driven by **domestic** economic conditions
  - **Government** sector grows in line with rest of economy in absence of **exogenous policy changes**.
- **Investment** in each sector decomposed into **CRE** and **non-CRE**
- Wide range of **linkages** between banking sector and real economy
  - Banks set interest rates as markup over funding costs reflecting **endogenous risk premium** and policy factors
  - Households and firms demand credit based on income/profits, interest rates and collateral values

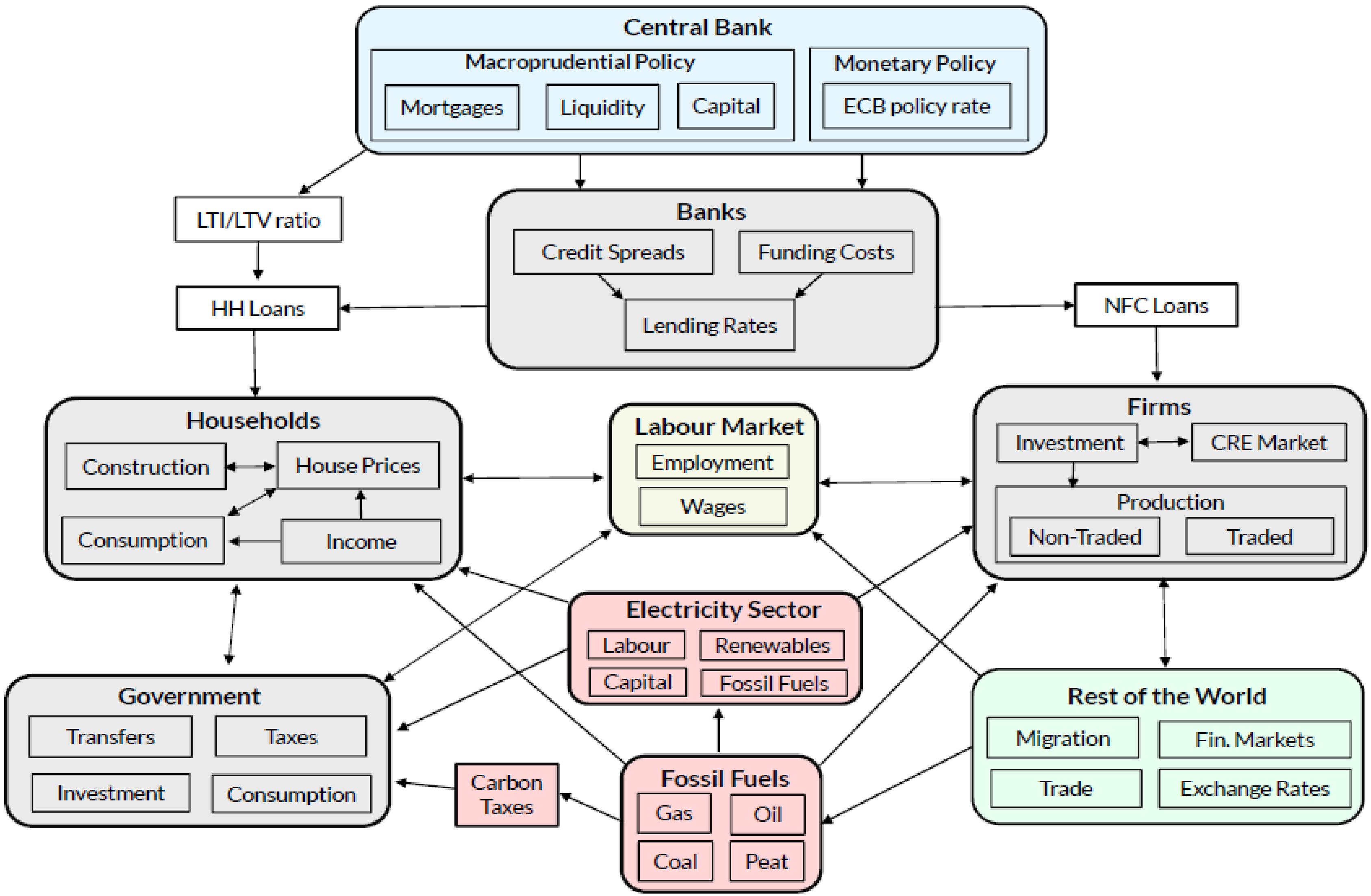
COSMO: COre Structural MOdel

- Error-correction framework highlights importance of short- to medium-rigidities.
  - Plots quarterly path of how economy gets to long-run equilibrium following a shock.
  - Partly reflects that expectations are **mainly adaptive**
- However, current version of COSMO lacks detailed **energy features**
- **Production** in each sector has following form:
  - Capital, labour and (labour-augmenting) technology combine to produce goods
  - Energy demand modelled only as demand for oil and only as component of **production**
  - Limited role for oil price shocks as did not feed into producer or consumer prices (marginal costs=wages)
- Household **consumption** modelled in aggregate
- No fiscal revenue from **carbon taxes**

Incorporating transition-related features in COSMO

- New version of CBI's COSMO tries to augment the model with more detailed energy-related features
- Production in each sector now uses **variety of energy inputs**
  - Nested CES structure with substitution between different **carbon-intensive** inputs, **renewables** and **electricity**
- Fossil fuels subject to **carbon tax**
  - Energy prices affect both producer and consumer prices
  - **Error-correction** allows different effective elasticities of substitution in the short and long run
  - ETS prices not included as yet
- Electricity sector generates output using 'dirty' (gas, coal etc) and 'clean' (renewables) fuel types
- Household consumption **decomposed** into energy (heating, cars) and non-energy components
- Government **recycles** carbon tax revenue back to economy according to a policy rule

Energy-augmented COSMO



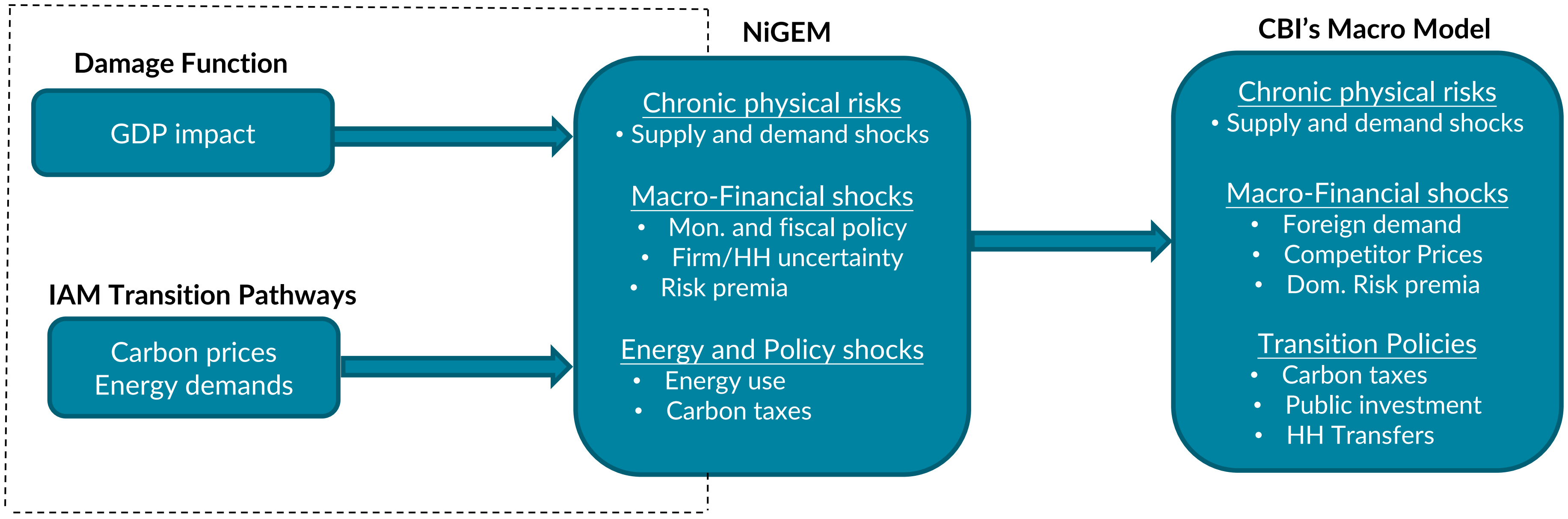
Incorporating international climate-related spillovers

- UK CCC Sixth Carbon Budget recognised need to consider *inter alia* “global impacts and factors”
  - Previous Irish carbon budget generally abstracted from international **spillovers** to Ireland
  - Potential rise in **interest rates** could have important consequences for output/employment in Ireland (FitzGerald, 2021)
  - **Small open economies** are particularly exposed to spillovers
- Incorporating international dimension requires **global model** which can be used as a satellite
  - Cross-country heterogeneity in transition paths and physical impacts of climate change
- **Key channels**:
  - Foreign demand for Irish goods due to lower growth abroad
  - International **energy** prices and non-commodity import prices
  - Transmission of shocks through interest rates, risk premia, and equity prices, and exchange rates
- Issues of **Carbon leakage**
  - Carbon prices consistent with Net Zero by 2050 might lead to offshoring carbon-intensive production (assume **CBAM**?)

Suite-of-Models Approach

- **Suite-of-Models** can be to comprehensively model impact of **global** transition scenarios on Ireland.
- **IAM**
  - Generate scenarios for carbon prices, land use, energy demand and technological progress *consistent with a given emission pathway*
  - **Physical risks** from empirical damage functions and natural catastrophe models.
- **NiGEM Macroeconomic Model**
  - **Physical** risks from IAM mapped as shocks to supply and demand in macro model
  - **Transition** risks from IAM imposed as constraints on the trajectories of energy use, carbon prices and technological progress
  - Model equations augmented with transmission mechanisms for climate related risks
  - Can use existing mechanisms to simulate relevant fiscal policy and macro-financial shocks related to the transition
- **COSMO**
  - International spillovers are incorporated by **imposing paths** generated by global model for **external variables**
  - Supply, price-setting and fiscal components modified to incorporate climate-related risks
  - Domestic physical risks included as shocks to demand and supply
  - Domestic transition risks modelled as shocks to carbon taxes, risk premia, credit conditions and fiscal policy instruments.

Modelling Impact of Climate Shocks on the Irish Economy

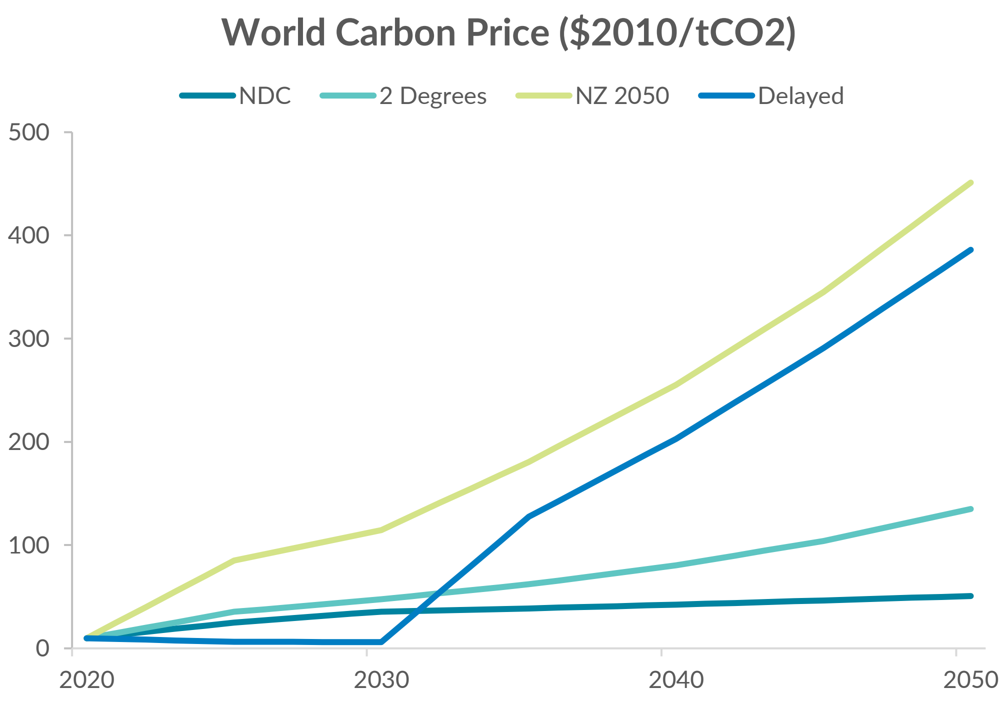


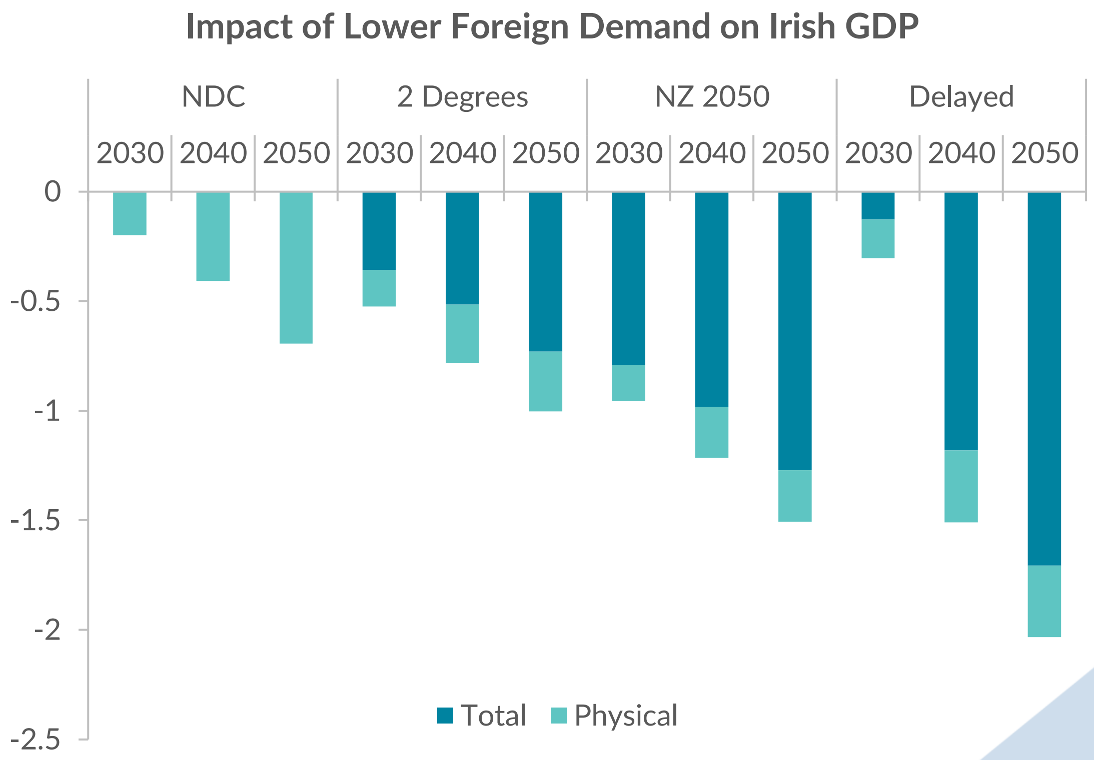
Potential spillovers of international climate risks to Irish Economy

- **NGFS** has designed set of transition scenarios for analyzing climate risks to the economy and financial system
  - Orderly and disorderly transition scenarios
  - Different models used to mitigate uncertainty around modelling climate related macro-financial risks
  - Physical risks include both chronic and acute risks
- Illustrate how **spillovers** from international climate risks can shift baseline path for **Irish GDP**
  - **NDCs**: Includes all pledged targets even if not yet backed up by implemented effective policies (2.6°C)
  - **Net Zero 2050**: Limit global warming to under 1.5°C (1.4°C) via stringent climate policies and innovation
  - **Below 2 Degrees**: Gradual increased stringency of climate policies giving 67% chance of limiting warming to below 2°C (1.6°C)
  - **Delayed Transition**: Emissions rise until 2030 necessitating stringent policies to limit warming to below 2°C (1.6°C)

International climate-related Spillovers and Irish GDP

- Impact of international transition and physical shocks on the Irish economy in each NGFS scenario





Potential role of CBI models in analysis of carbon budgets

- **COSMO** (and NiGEM) can be useful for informing long-term transition pathways
  - Scenarios for economic and population growth using CSO and global growth scenarios
  - Global scenarios for oil, gas, coal, renewable energy prices
- **International fiscal policy**
  - 'Green' investment requirements of 2-3% of GNI (Pisani-Ferry, 2021)
  - With full employment in world economy this will require shifting resources away from other activities (FitzGerald, 2021).
  - Higher investment with fixed global savings would also raise interest rates
- **Domestic fiscal policy**
  - Economic impact of 'green' investment can vary according to how it is financed (debt, tax, expenditure cuts)
  - Options for carbon tax revenue recycling
  - Interaction of CAP with Housing for All and National Investment Plans (demand for labour, materials, cement etc)
- **Interest rates** including policy rates, domestic and international risk premia, and domestic credit conditions

Potential linkages with other models used by CCAC

- **TIM** can provide several important scenario inputs to **COSMO**
  - **Total energy demands** from end use sectors and the optimal **energy mix**.
  - **Technoeconomic** parameters including **efficiency** trends (AEEI) and optimal **investment**
  - Investment requirement from TIM enables consideration of **different fiscal policy** options (debt vs tax)
  - Pathway-consistent **carbon prices** can inform potential carbon tax scenarios
- Outputs from **COSMO** could be useful to **TIM**
  - Scenario pathways for population growth (net migration), GVA and household income
    - Different growth rates for domestically- and foreign-oriented sectors.
    - Allow for calculation of GVA (GNI*) per person as drivers of energy service demands in TIM
  - **Interest rates** for private and public investment (deviation from social planner perspective)
  - Scenario paths for investment in dwellings, CRE and public capital stock could be used to derive demand for **cement**
- Potentially useful scenario outputs for **I3E** might include economic and population growth, world energy prices, interest rates and exchange rates.

The Ireland Environment, Energy and Economy (I3E) Model

Kelly C. de Bruin
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Aykut Mert Yakut
[redacted]

INSTITIÚID TAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

Carbon Budget Working Group
Meeting 4

29 June 2023

The I3E model was developed to understand the impacts of climate change policies in Ireland and fill a gap in the modelling of the interaction between energy use and the economy.

No macroeconomic model developed so far includes energy inputs or sector-level disaggregation.

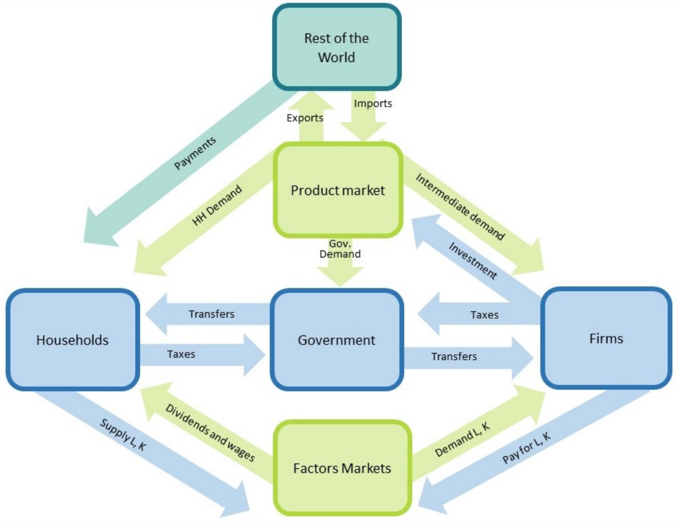
To investigate the connection between climate policies and the economy:

- explicit modelling of carbon inputs,
- ability to introduce policies in detail, and
- inclusion of secondary impacts

are required, and Computable General Equilibrium (CGE) modelling is the most suitable tool.

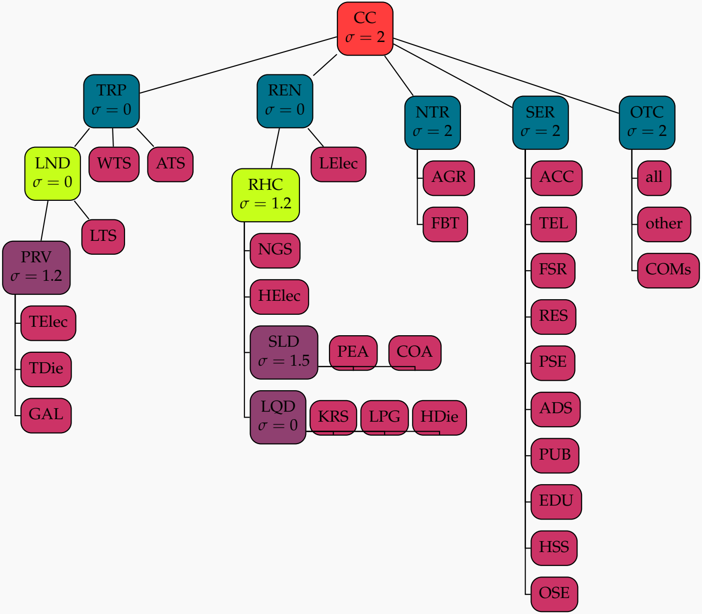
The Ireland Environment, Energy and Economy (I3E) model is the first fully dynamic general equilibrium model for the Irish economy and includes

- 39 firms producing 49 commodities,
- 10 representative household groups,
- government,
- enterprises, and
- the rest of the world accounts.


Rest of the World
Imports
Exports
Payments
Product market
HH Demand
Intermediate demand
Investment
Gov. Demand
Households
Transfers
Taxes
Government
Taxes
Transfers
Firms
Supply L, K
Dividends and wages
Factors Markets
Demand L, K
Pay for L, K

Households

- 10 Ramsey-type RHGs maximising their intertemporal utility (CRRA type utility function) by choosing composite consumption.
- Five urban resident & five rural resident RHGs based on disposable income consists of net-of-tax wage and dividend income, welfare transfers, pensions, income from foreign asset holdings, and non-means tested transfers (e.g. COVID-related payments).
- Composite consumption is disaggregated based on a detailed nested structure.
- Data: Household Budget Survey & Survey on Income and Living Conditions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TEL
FSR
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PSE
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EDU
HSS
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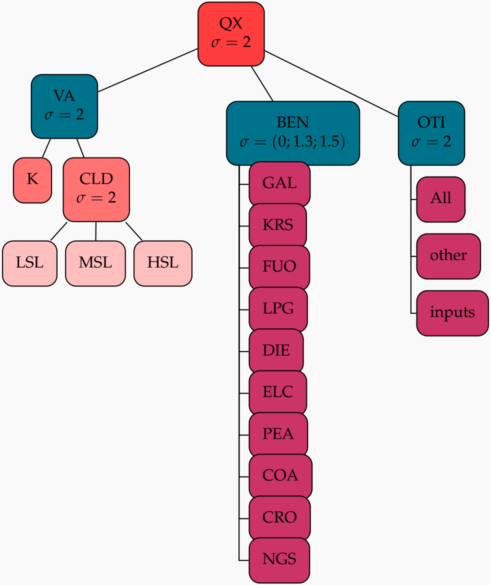
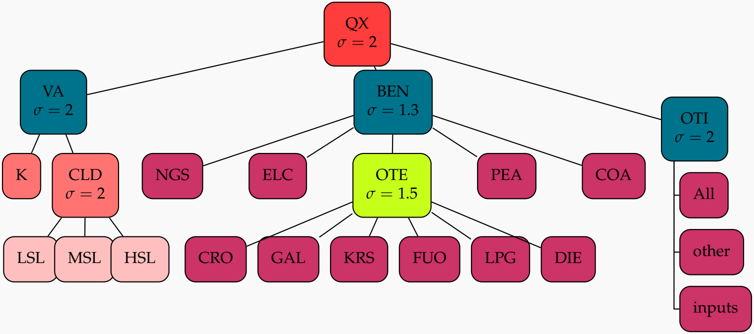
all
other
COMs

Production

- There are 39 sectors, 35 of which have dynamic investment decisions: maximising the present discounted value of the dividend stream by choosing capital, labour, and investment.
- Four sectors' investment is a function of their net-of-corporate tax profits.
- Three groups of firms based on the composition of energy demand and electricity production.
- There are 49 commodities, 10 of which are energy commodities: coal, peat, crude oil, gasoline, LPG, fuel oil, diesel, kerosene, natural gas, and electricity.
- Data: Supply and Use Tables, Exiobase, Energy Balance & Business Energy Use Survey

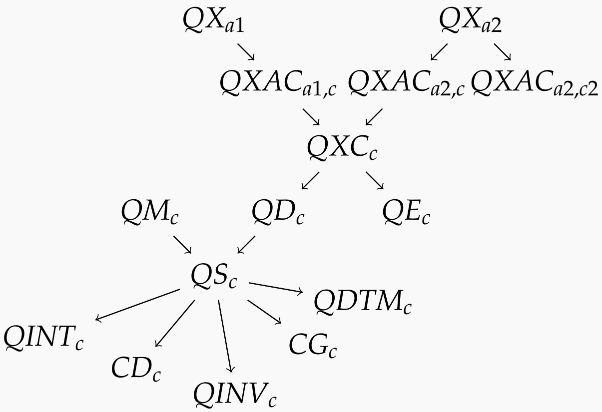


Production, except for Electricity Producers



Electricity Production

Multi-product Production



Link between Activities and Commodities in I3E

ETS vs non-ETS

- Ireland applies two policies simultaneously.
  1. Firms subject to the EU ETS legislation are exempted from paying the Irish carbon tax on their ETS emissions.
  2. Since the *incurred* unit cost of energy commodities differs across sectors, the optimality condition of firms' intermediate input demand must be adjusted.
  3. The *incurred* unit cost: purchaser price (common to all agents, inclusive of all taxes) plus the net cost of EU ETS minus the carbon tax exemption

Labour Market

The labour market includes three labour types, low-, medium-, and high-skilled, and is characterised by

1. involuntary unemployment with wage equations,
2. international migration, half of which is high-skilled labour,
3. endogenous labour force participation, and
4. endogenous allocation of total labour supply across sectors based on a wage income maximisation problem
5. Data: LFS, SILC, COSMO & NiGEM

Government

- Income: direct taxes (from labour incomes and sectoral profits), indirect taxes on commodities (value-added tax, carbon tax, and export tax) and a production tax on production activities. Half of the total cost of the ETS goes to the government, whereas the second half goes to the EU Commission due to the legislation.
- Expenditure: consumption of commodities, transfers to households (welfare transfers and pensions), and interest payments over its debt stock.
- Policy variables are set without any objective function, but
  1. the total budget of welfare transfers is a positive function of both the unemployment rate and consumer price index
  2. it can borrow from the rest of the world without limitation, but the public savings-to-GDP ratio determines the risk premium.
- Data: National accounts

Equilibrium

As a dynamic model, the equilibrium in I3E is characterised by both intratemporal and intertemporal equilibrium.

The intratemporal equilibrium requires no excess demand (or supply) in all markets, i.e. the Walras law holds in every period.

The intertemporal equilibrium, on the other hand, is achieved by imposing a couple of restrictions to ensure that the value of firms, capital stock, government debt stock and foreign asset holdings that govern the model's intertemporal dynamics remain constant in the terminal period.

In order to calibrate the model, we constructed an Energy Social Accounting Matrix (ESAM) by using the following data sources:

- Supply and Use Tables
- Government accounts
- National accounts
- HBS, SILC, and LFS
- Energy Balance, BEUS, EXIOBASE, emissions inventory

SAM

Aggregated ESAM of Ireland for the year 2014, € billion

	ACT	COM	MAR	CAP	LSL	MSL	HSL	PT	ST	CT	DT	ENT	GOV	HH	S–I	RoW	Total
ACT		417.95															417.95
COM	240.95		25.22										26.24	87.08	45.16	216.90	641.56
MAR		25.22															25.22
CAP	102.99																102.99
LSL	8.07																8.07
MSL	28.75																28.75
HSL	36.42																36.42
PT	0.74																0.74
ST		17.14															17.14
CT		0.39															0.39
DT					0.72	10.40	17.02					15.52					43.66
ENT				102.99													102.99
GOV								0.74	17.14	0.39	43.66						61.92
HH					7.35	18.35	19.40					48.94	28.08			-28.41	93.71
S-I												38.53		6.62			45.16
RoW	0.04	180.85											7.60				188.49
Total	417.95	641.56	25.22	102.99	8.07	28.75	36.42	0.74	17.14	0.39	43.66	102.99	61.92	93.71	45.16	188.49	

ACT: Activities; **COM**: Commodities, **CAP**: Capital; **LSL**: Low-skilled labour; **MSL**: Medium-skilled labour; **HSL**: High-skilled labour; **MAR**: Trade and transportation margins; **PT**: Production tax; **ST**: Sales tax; **CT**: Carbon tax; **DT**: Direct tax; **GOV**: Government; **HH**: Households; **ENT**: Enterprises; **S-I**: Saving–Investment; **RoW**: Rest of the world.

Dynamic BaU

Although the model parameters are calibrated by using single-year data, the business-as-usual (*BaU*) path of the model is dynamic such that it includes the changes in

- international energy prices
- the composition of energy demand by sectors
- the levels of EU ETS price and carbon tax
- the EU ETS legislation
- the economic activity due to the COVID impact

between 2014 and the latest year.

The model can provide results for the following variables:

- **Activities**: Levels of output and value-added, labour demand by type, investment expenditures, physical investment and capital stock, production tax paid to the government, and the cost of ETS.
- **Households**: Disposable income and its components (nominal and real terms), consumption by commodities, savings, HH-specific CPI and their variants (energy vs non-energy).
- **Government**: Revenues and expenditures, savings, and foreign debt stock.
- **Macroeconomy**: Nominal and real values of GDP, GNP, trade balance, total investment, total domestic demand, CPI and its variants.

- **Labour market**: Levels of employment, unemployment, labour supply, wage rate, LFPR, and migration for each type of labour and their aggregates.
- **Prices**: All commodity and factor prices.
- **Emissions**: Commodity emissions, activity emissions in the distinction of ETS and non-ETS emissions, residential and private transport emissions.

Since its first version was launched in November 2018, it has been used to analyse several environmental policies, including

- The effects of an incremental increase in the Irish carbon tax towards 2030, ESRI WP No. 619
- The economic and distributional impacts of an increased carbon tax with different revenue recycling schemes, ESRI Research Series No. 95
- The impacts of removing fossil fuel subsidies and increasing carbon tax in Ireland, ESRI Research Series No. 98
- Transitioning to a low-carbon Irish economy: An analysis of regional labour impacts, ESRI Research Series No. 100

- The environmental and economic impacts of the COVID-19 crisis on the Irish economy: An application of the I3E model, ESRI Research Series No. 106
- The impacts of aviation taxation in Ireland, ESRI Research Series No. 131
- The impacts of electric vehicles uptake and heat pump installation on the Irish economy, ESRI WP No. 717
- Economic and Distributional Impacts of Turning the Value-Added Tax into a Carbon Tax, ESRI WP No. 739
- The Global Emissions Impact of Irish Consumption, ESRI WP No. 740

Some examples of how the I3E model has been used:

- Carbon tax
- Fossil fuel subsidies
- ETS price
- Aviation taxation
- Ukraine energy crisis

In progress

We are currently in the process of major model developments on

- **adding energy efficiency parameters**,
- **adding additional parameters to impose restrictions on the composition of electricity production**,
- **adding a shadow tax to implement the changes in the composition of gross value added across sectors**,
- updating the nested production and consumption structures,
- adding investment tax credits to support investment expenditures of firms,
- updating the economic growth and population growth rates projections.

Planning

The following model developments are in a planning process;

- updating the base year
- disaggregation of the food, beverage, and tobacco sector to better represent the emissions embedded in processed food, e.g., beef.

The base-year update

The ESAM provides a snapshot of the economy in a given year to calibrate parameters – status quo.

Although we apply a dynamic BaU, the nature of the model still heavily depends on the status quo, which makes capturing all economic realisations hard.

For instance, the share of IND (ICT) in the total gross value-added increased from 24% (10%) in 2014 to 38% (18%) in 2021.

As we are able to implement limited increases in the share of ICT, we have to make other assumptions to catch the realised impacts of the sector, especially data centres, on the total electricity demand.

To better represent the current status quo, it should be updated to a recent year. However, there are major issues to be considered, including but not limited to

- data availability, including new versions of HBS, SILC, and LFS,
- unstable economic outlook beyond 2019 (2020/21-COVID, 2022-energy crisis, 2023-inflationary pressures).

Renewables

The share of renewable resources in electricity production increased from 25% in 2014 to around 40% in 2021.

The share of renewables in the total energy supply increased from 7% to 12% in the same period. The energy supply from wind, biodiesel, and renewable waste was doubled.

Due to the low shares of renewables in the total energy supply in 2014, we excluded these commodities from the model. However, currently, we have electricity producer sectors using wind and other renewables in the model.

SEAI HEAT Study

	Baseline		Balanced	DGas	HElec
	2020	2050	2050	2050	2050
OIL	37.52	0.38	0.00	0.00	0.00
C_COA	3.25	0.06	0.00	0.00	0.12
C_NGS	46.52	19.96	0.00	0.00	0.00
C_ELC	7.98	31.40	42.67	19.35	67.93
BioFuel	3.67	3.74	1.89	1.20	1.72
Biomass	1.06	19.73	22.40	3.84	20.33
Hydrogen	0.00	13.28	17.34	56.88	6.33
C_ELC+	0.00	5.31	7.28	12.41	2.56
BioLiquid	0.00	0.20	0.27	0.10	0.41
BioWaste	0.00	0.00	0.00	0.00	0.00
NonBioWaste	0.00	0.00	0.00	0.00	0.00
Biomethane	0.00	5.55	7.61	5.79	0.00
Other	0.00	0.39	0.54	0.41	0.60

The main issues in adding a commodity into a CGE model are having no or limited information on

- the cost of production,
- the composition of supply (domestic production vs imports),
- the composition of demand (intermediate, private, government, exports).

In the case of biomass, we have limited information, whereas there is no data for hydrogen.

We are currently conducting a literature survey to examine possibilities to overcome the issue.

Irish Carbon Budgets: Some Moral Considerations

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June 29, 2023

PREFACE

- Philosophers tell us that we need to be wary of arguments that advance our own interests in uncertain contexts, since the dearth of theory might lead us towards "moral corruption" (Gardiner, 2010, 10.1093/oso/9780195399622.003.0012)
- Carbon budgets depend on "irreducibly normative" assumptions (Dooley et al., 2021, 10.1038/s41558-021-01015-8; Schulen et al., 2023, 10.1002/wcc.847)
- Emissions are not themselves morally important—they only allow us to access morally important things (capabilities/welfare)
- Broadly speaking, we have a variety of equity reasons to be more ambitious, rather than less, since CBDR-RC and the Climate Act require following Paris Agreement (PA) steps (Jackson, 2022)

METHODOLOGY

- Ireland has two legally binding targets: 51% reduction by 2030 and net-zero by 2050 (sources and sinks balanced)
- System boundaries: My purpose here is to discuss Paul Price's Paris Test (PT), draw attention to some morally important assumptions, and to synthesise relevant philosophical discussions
- My intention is mostly not to evaluate the discussions, but instead to present the various arguments and reasons (Schulen et al., 2023, 10.1002/wcc.847)
- Main takeaway: the bulk of assumptions are generous to Ireland, so PT outputs should be seen as conservative, meaning budgets should be seen as upper bounds

TARGET

- Climate Act 2021 requires ("shall") action consistent with PA, i.e. "well below 2°C above pre-industrial levels" and aiming to limit "increase to 1.5°C"
- 50% of not exceeding 1.5°C was used in CCAC 2021 PT, implying $>$ 95% not exceeding 2 degrees ("prudence")
  - Gardiner (2023) argues that we wouldn't think this was "on track" in daily life
  - (**Reasonable assumption**)

REFERENCE YEAR

- Reference/baseline year: 2015 "last conceivable year" (year PA entered into force)
  - When informed observers should reasonably have been expected to know: Intergovernmental Panel on Climate Change First Assessment Report (IPCC FAR) (1990)
  - (**Generous assumption**)

Mass or Temperature?

- What are we aiming at?: 2030: emissions reductions (mass), 7% to 51% by 2030 and net-zero
  - PT: Net-zero, in line with PA should be assessed in Global Warming Potential (GWP*) to stabilise 1.5°C as opposed to (GWP-100)
  - Not really discussed in the climate ethics literature
  - For using GWP*: This does not overestimate or underestimate the warming dynamics the way GWP-100 does
  - For using GWP-100: Net-zero is our legal national goal, and AR6-WG1 (Cross-Chapter Box 1.1) explains that: "Net zero CO_2 emissions will approximately lead to a stabilization of CO_2-induced global warming"
  - For using GWP-100: This would make our 2050 targets more easily comparable, both with 2030 and, more importantly, with peer nations

EQUITY PRINCIPLES

- PT adopts an Equal per capita metric, downscaling the global budget for the population of Ireland
  - For EPC: Simple and with fewer choice points
  - Defended by various philosophers (Singer, 2002; Jamieson, 2005, 10.1007/s10892-004-3324-9)
  - Against EPC: Might have odd population implications; Only forward-looking (Vanderheiden, 2009)
  - Cf. Polluter Pays principle (or Polluter Pays, Then Receives, Mintz-Woo and Leroux, 2023, 10.1017/s0266267120000449) (historical responsibility), Beneficiary Pays principle or Ability to Pay principle (Grasso, 2012, 10.1111/j.1467-9248.2011.00929.x): Any of these would be more demanding and potentially more justified (Baer et al., 2009)
  - ATP & PPP esp. would increase demands (Jackson, 2022)
- (**(Very) Generous assumption**)

Failure to Achieve Targets

- Cumulative CO_2 debt (McMullin et al., 2020, 597, 10.1007/s11027-019-09881-6)
- Important not to grandfather them in ("to consider it a principle of equity is morally perverse" (Dooley et al., 2021))
- Having various trajectories for meeting (or excess emissions, etc.) can give pathways without endorsing any of them

Takeaways

1. PA target 50% of not exceeding 1.5°C: Reasonable assumption
2. Reference year: 2015: Generous assumption
3. Mass or temperature: Somewhat indeterminate
4. Equity principles: EPC: Very generous assumption