Climate Change Advisory Council Secretariat

CB WG Workshop

13th September 2023

Agenda

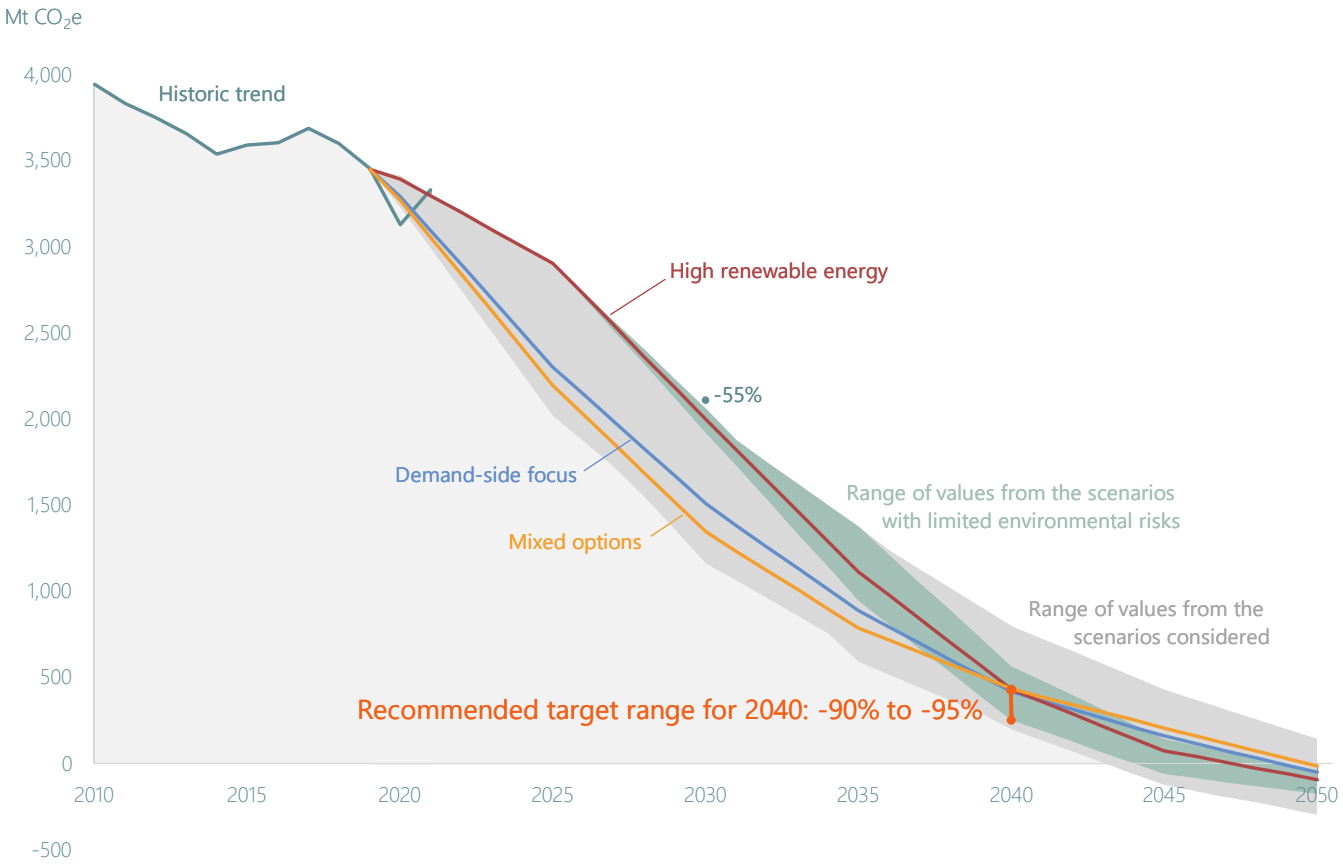
Time	Agenda Item
13:30	1. Building Blocks for scenarios for CB3 and CB4
14:15	2. Scenario development for 2nd Carbon Budget Programme
15:30	3. Competing Land Use Requirements
16:00	4. Timeline for Modelling/Analysis Iteration 1
16:20	5. Next Steps
16:30	Workshop Finish

1. Building Blocks for scenarios for CB3 and CB4

Building blocks for scenarios for CB3 and CB4			
Start point in 2030	(1) staying within carbon budgets 1 and 2	(2) overperformance against carbon budgets 1 and 2 and	(3) underperformance against carbon budgets 1 and 2
Target for 2050		(1) based on an emissions trajectory consistent with specific temperature outcomes	(2) based on an emissions trajectory towards net zero greenhouse gas emissions in 2050.

- 2030 starting points: staying within carbon budget 1 and 2, underperformance (EPA WAM), overperformance (sensitivity)
- Targets for 2050: based on an emissions trajectory consistent with specific temperature outcomes and based on an emissions trajectory towards net zero GHG emissions in 2050

1. Building Blocks for scenarios for CB3 and CB4



ESAB recommends keeping the EU's GHG emissions budget for the period 2030 to 2050 within a limit of 11-14 Gt CO_2e, in line with limiting global warming to 1.5 °C (with no or only limited and temporary exceedance of that temperature). To achieve this, the EU must strive for net emissions reductions of 90-95% by 2040, relative to 1990 levels.

1. Building Blocks for scenarios for CB3 and CB4

2030 starting points:

1. Staying within carbon budget 1 and 2
   - ➢ Achievement of Sectoral Emissions Ceilings
   - ➢ Treatment of unallocated emissions savings for CB2 (2026-2030): (a) assigned to the energy sector and (b) assigned on a pro rata basis based on emissions
2. Underperformance on the basis of the 2023 EPA WAM projections
3. 5% overperformance as a sensitivity analysis

Targets for 2050:

1. Based on an emissions trajectory consistent with specific temperature outcomes
2. Based on an emissions trajectory towards net zero GHG emissions in 2050

➢ Can’t be determined at the outset. The aim of the initial modelling is to provide a baseline

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2. Scenario development for 2nd Carbon Budget Programme

- Shared understandings to inform scenario development by UCC (TIMES), SEAI (NEMF), Teagasc (FAPRI) and NUIG (GOBLIN)
  - the proposed set of scenarios to be developed, taking into account the building blocks outlined under agenda item 1
  - an outline of input assumptions that will have to be made, noting the potential for commonality or discrepancies with other models
  - an example set of model outputs for the purpose of demonstrating the kinds of outputs that the models will produce

2. Scenario development for 2nd Carbon Budget Programme

Approximately 80 minutes available for presentation and discussion:

- 10 minute presentations from UCC (TIMES), SEAI (NEMF), Teagasc (FAPRI) and NUIG (GOBLIN)
- Followed by 10 minutes of Q&A each for UCC (TIMES), SEAI (NEMF), Teagasc (FAPRI) and NUIG (GOBLIN)

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3. Competing Land Use Requirements

- Land use and model representations of biodiversity constraints
- Afforestation, Biomethane, Nitrogen demand (water quality/air quality)

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4. Timeline for Modelling/Analysis Iteration 1

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																						

4. Timeline for Modelling/Analysis Iteration 1

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1.5	Post-hoc analysis																						

- Scenario results from UCC (TIMES), SEAI (NEMF), Teagasc (FAPRI) and NUIG (GOBLIN) to be circulated on 8th December for presentation and discussion at the CB WG meeting on 15th December
- Paris Test Assessment to be conducted during December – January and presented at the January CB WG meeting (*TBC - Thursday 18th January 2024, 13:30 – 16:30*)
- Macroeconomic / economic analysis also to be presented at the January CB WG meeting (TBC)
- Additional modelling and testing of results to follow

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5. Next Steps

- Secretariat to prepare an outcome report for the upcoming CCAC meeting on the 28th of September
- Modelling/Analysis Iteration 1 commences following CB WG meeting No. 7 19th Oct.

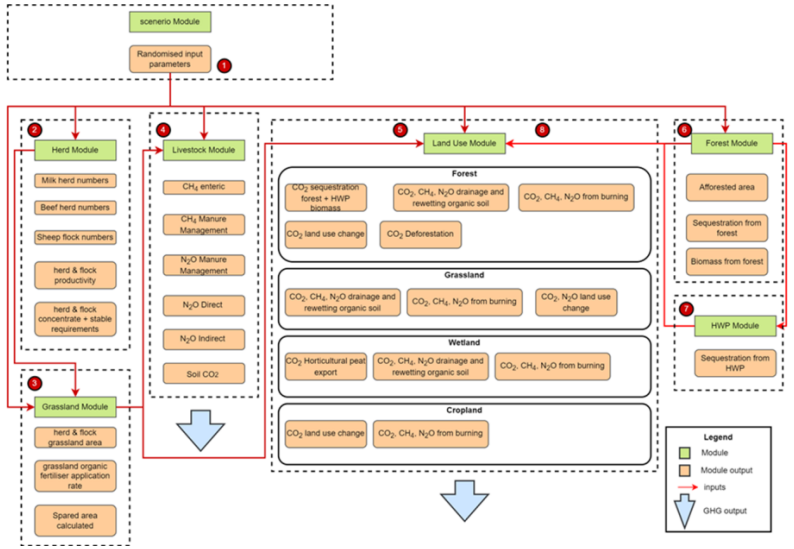
GOBLIN Scenarios for carbon budgets towards 2050

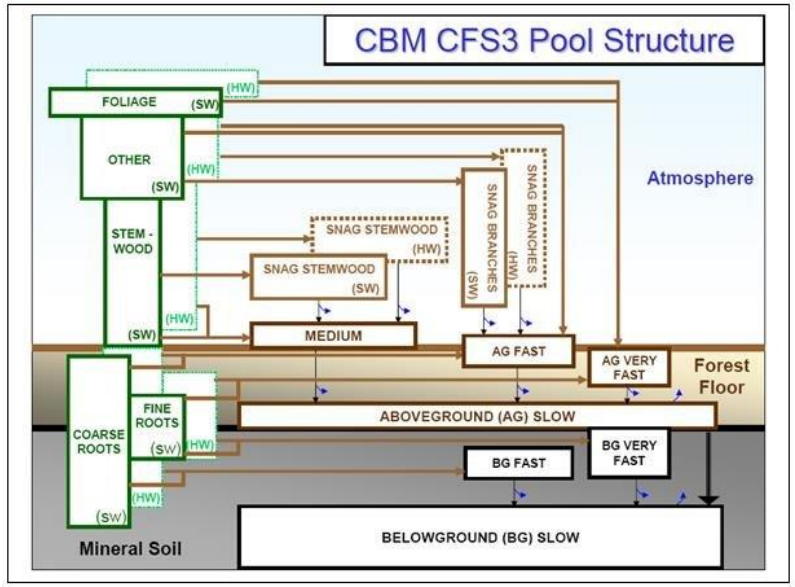
David Styles, Colm Duffy, Daniel Henn

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

Modelling Approach

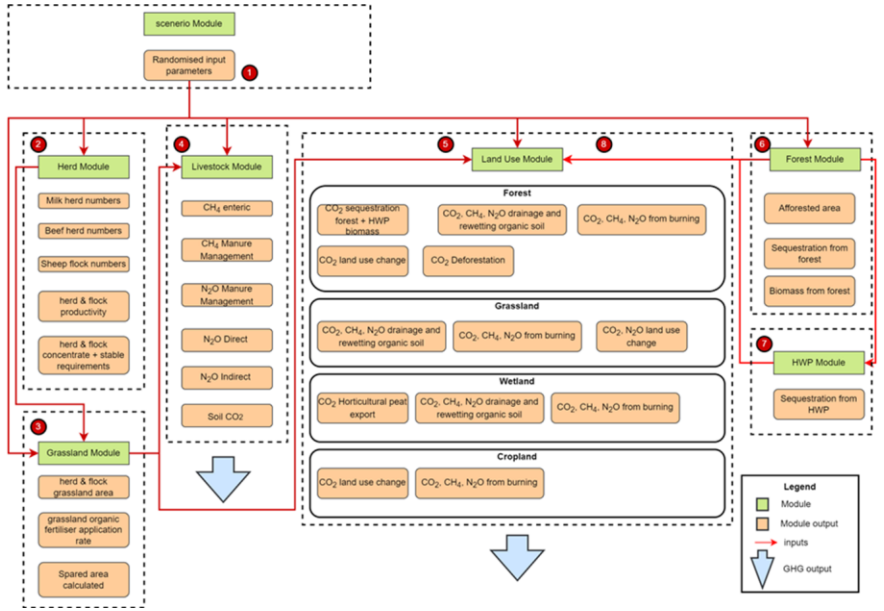
- Sequential model runs & aggregation
- GOBLIN: agricultural activities, outputs, emissions and land use (change) to 2050, aligned with NIR
- CBM-CFS3 Forest model: updated forest GHG balance and productivity out to 2050 (existing & new forest), aligned with NIR
  - Includes basic representation of HWP (C storage)
- LCAD EcoScreen model: Anaerobic digestion expanded boundary LCA
  - Process emissions
  - Avoided emissions (manure management, fossil energy, fertiliser)
  - Outputs: digestate, energy

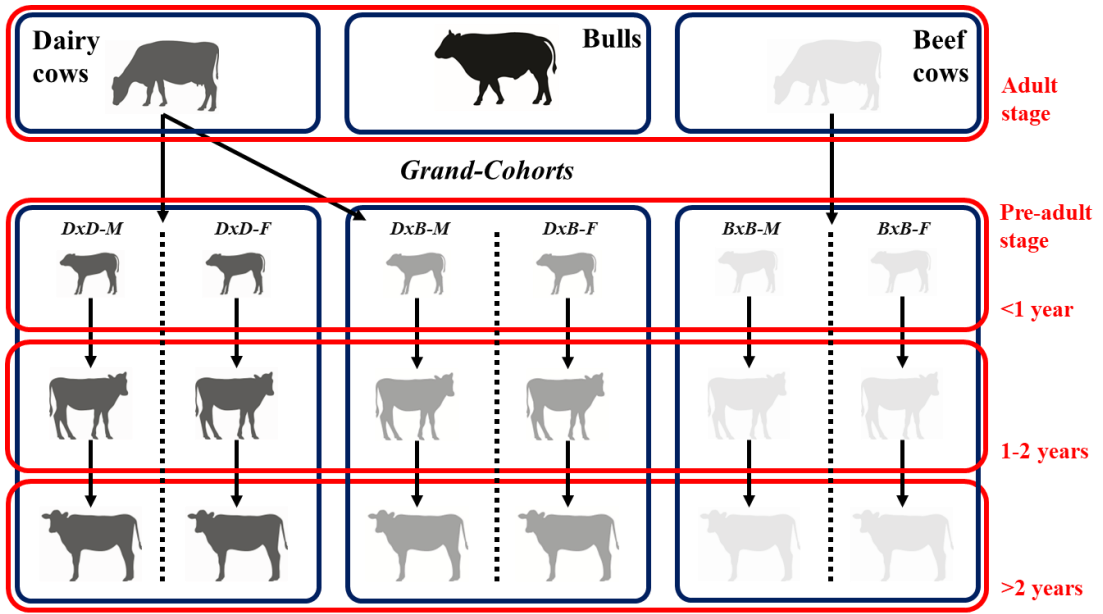




Step 1: Agriculture

- Dairy & beef cow numbers
  - Current
  - MACC high & low
  - Dairy specialisation – constant protein
  - 30% reduction dairy & beef
- Production
  - MACC 2030 milk output & LWG
  - + 20% animal productivity
- Grass utilisation
  - Increase beef from circa 55% to 65%
- Crop production
  - Hold area constant





Ollscoil na Gaillimhe
University of Galway

Step 2: Land use change

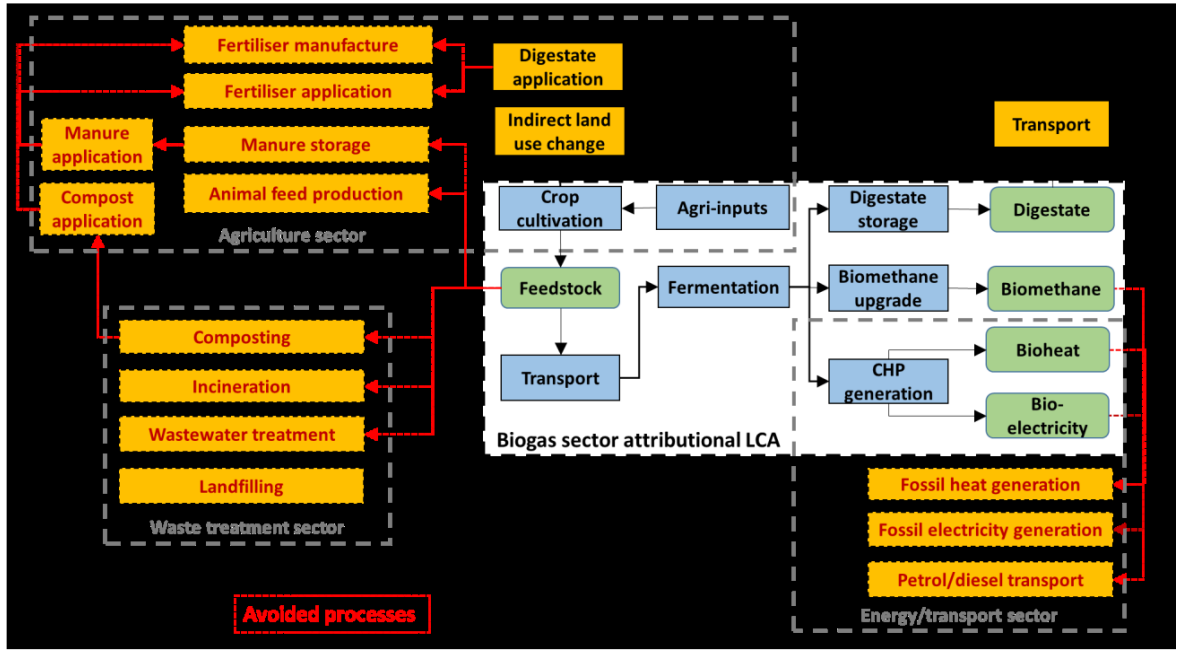
- Spared land areas assigned to:

Scenario	Rewetting	AD	Forestry
1	90% of spared organic soils minus new forest area	c.200kha (mineral soils)	BAU mix, inc. 25% on organic-organo-mineral (160 kha 2030-2050, 8 kha per year planting)
2	90% of spared organic soils	0	70:30 conifer:broadleaf mix on mineral soils (c.200 kha)
3	90% of spared organic soils	c.200kha (mineral soils)	BAU mix, inc. 25% on organic-organo-mineral (residual spared area)
4	90% of spared organic soils	c.200kha (mineral soils)	70:30 conifer:broadleaf mix on mineral soils (residual spared area)
5…?			

NB: Residual area permutations depending on Step 1 combinations

Step 3: AD configuration

- Main permutations:
  - Varying %s food waste and manures
  - Biomethane for transport, CHP or heat
  - Digestate used locally or upgraded to pellet fertiliser (NH_3 emission consequences!)
  - Progressive deployment of CCS for CHP/heat? 2040 onwards? Apply equally to HWP bioenergy
  - Or flow biomethane straight to TIM-Ireland?

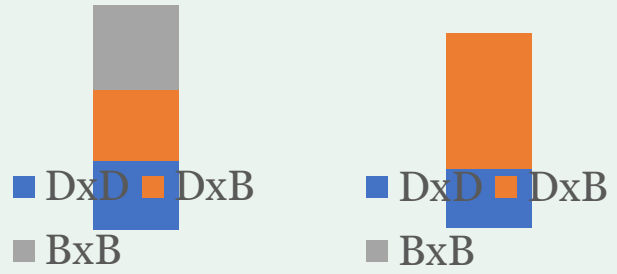


Step 4: Data aggregation

- csv files
- Production
  - kg milk, beef, lamb (intermediate animal numbers, fertiliser application, areas…)
  - MJ LHV biomethane (or kWh electricity/heat or vkm)
  - m^3 wood harvest (by primary HWP product breakout)
- Emissions
  - GHGs split gas, 2050 with interpolated time series (except forestry)
  - GWP_{100} & warming equivalents?
  - NH_3, N & P losses to water
  - See spreadsheet…

Outputs: climate, water & air quality

6.76 million ↘ 5.69 million



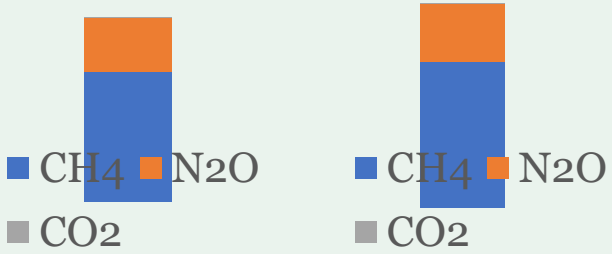
443 kt ↗ 543 kt

N – 362 kt ↘ N – 295 kt

P – 47 kt ↘ P – 39 kt

K – 122 kt ↘ K – 99 kt

20.3 Mt CO_2e ↘ 18.8 Mt CO_2e

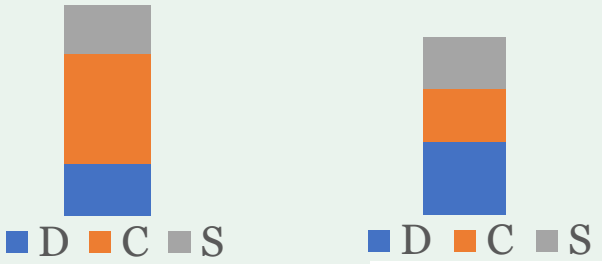


NH_3 – 131 kt ↘ NH_3 – 116 kt

N_{leach} – 87 kt ↘ N_{leach} – 76 kt

P_{leach} – 6.9 kt ↘ P_{leach} – 6.1 kt

4.01 million ha ↘ 3.26 million ha



Henn et al. (in prep.)

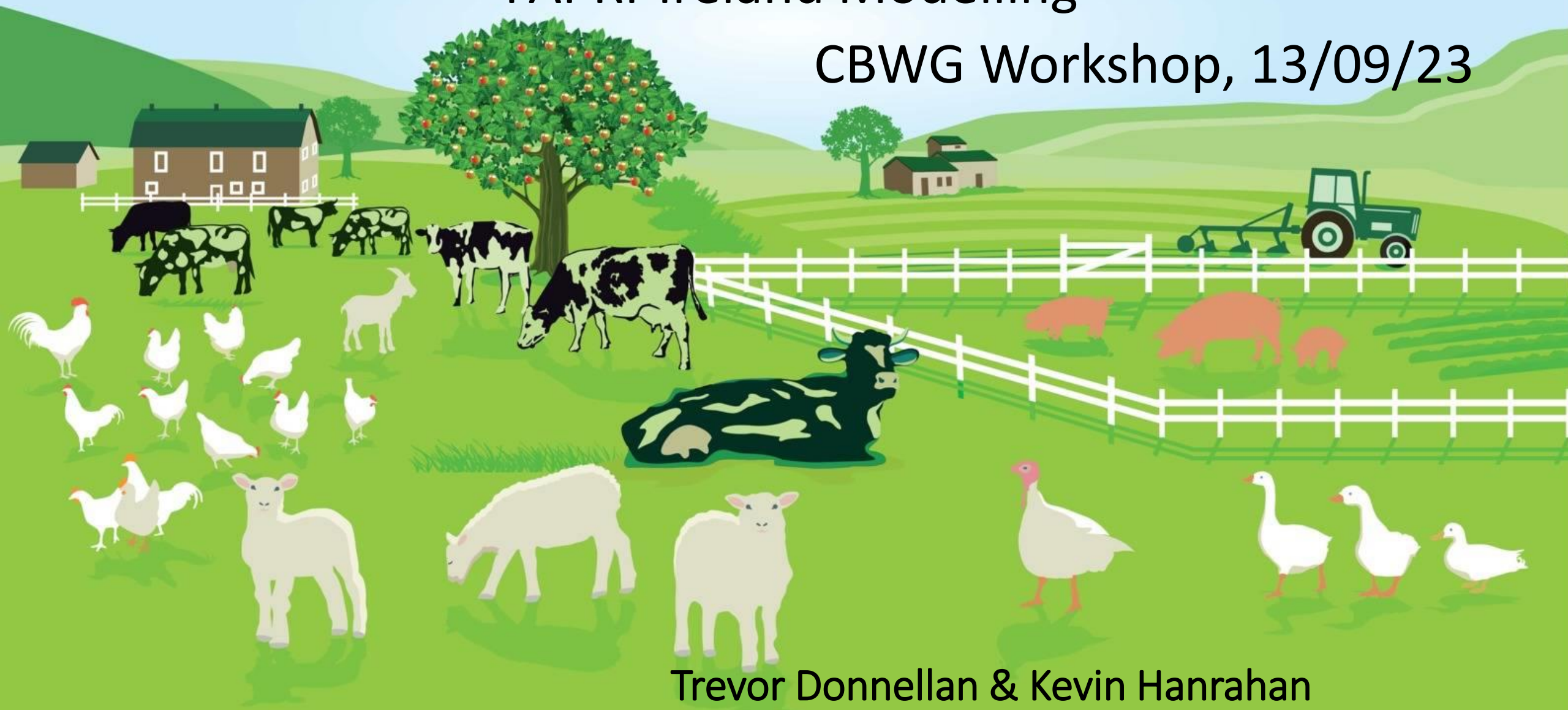
AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

The Irish Agriculture and Food Development Authority

eagasc
AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

Scenario Development for 2nd Carbon Budget Programme
FAPRI-Ireland Modelling

CBWG Workshop, 13/09/23



Trevor Donnellan & Kevin Hanrahan
Agricultural Economics and Farm Surveys Department Teagasc

Overview of methodology

- **FAPRI-Ireland model is a Dynamic PE** model of the Irish agricultural economy
- **Global dimension:** International S & D critical for understanding medium term evolution of Irish agri-food economy
  - Domestic (i.e. Irish) consumers are relatively unimportant
- Irish Model linked to the **FAPRI EU & FAPRI global agricultural market modelling** systems
- Uses **exogenous macroeconomic** projections from **domestic** and **international sources** as well as exogenous data on **ag and trade policies**
- Simulates commodity **market supply and use balances** and associated agricultural **activity levels and land use activities** to a medium term horizon

Model scope and complexity

Economic Modelling Outputs

- Ag sector and **Sub-sectors** modelling
  a) agricultural activity
  b) related commodity supply and use
  c) input demands
- **Market prices** for outputs and inputs
- Developments at sub-sectoral level
  - linked via competition for land, feed use, consumer demand and biology (e.g. milk and beef)
- Modelling trade is obviously critical in terms of Irish agriculture

Environmental Modelling and Output

- EPA Agriculture inventory
  - currently built on 75 agricultural activity levels and associated EF
  - GHG = $\sum_i$ GHG_i = Ag Activity_i*EF_i
- Model provides economically meaningful projections for most of these activity levels
- Model development has followed EPA GHG inventory developments
  - One of the reasons why high detail is vital

FAPRI-Ireland Synergies & complementarities with other models

- **TIM Model**
  - FAPRI Model has previously soft linked with the Irish TIMES model
- **EPA**
  - FAPRI Model output used by the EPA for their GHG inventory projections
- **ESRI MACRO models**
  - Previously provided projections of ag output & Ag GVA evolution to HERMES model
  - Currently obtain medium term macro projections from COSMO
  - Model could be used to calibrate output shocks evaluated with CGE models such as the ESRI I3E model
- **Goblin (Land Use)**
  - Scenarios about land use change and assumption about e.g. levels of afforestation.
  - In our current modelling work we make assumption about land use change out of agriculture and into forestry

Output: Agricultural Activity Level Projections

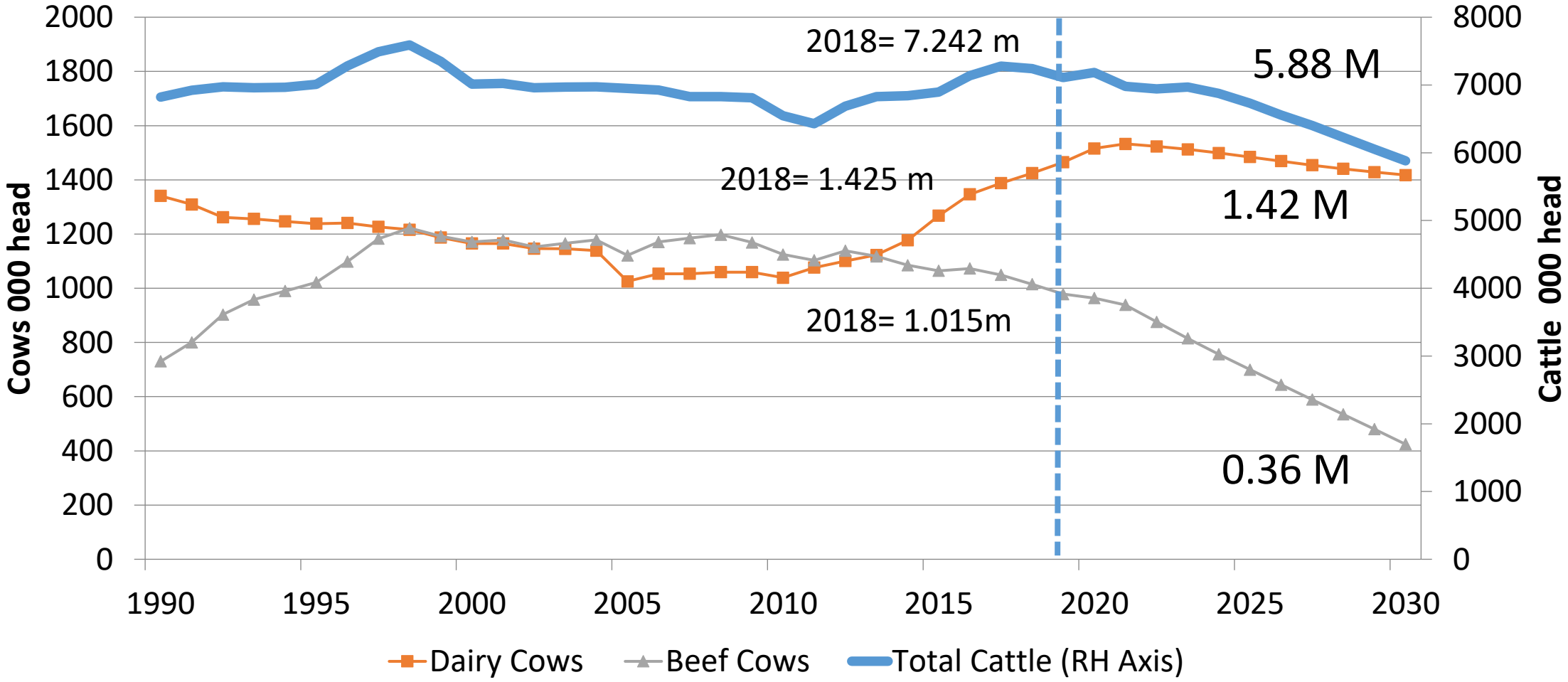
A	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
from Bernard August 2022	Projected	Projected	Projected	Projected	Projected	Projected	Projected	Projected	Projected	Projected
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total Cattle	7,010.1	7,056.6	7,057.5	6,995.8	6,930.6	6,867.7	6,830.1	6,785.1	6,746.3	6,734.1
Dairy Cows	1,616.6	1,608.6	1,608.9	1,623.7	1,643.4	1,662.9	1,679.3	1,691.8	1,701.0	1,705.6
All Other Cattle	5,393.5	5,448.0	5,448.6	5,372.0	5,287.2	5,204.8	5,150.8	5,093.3	5,045.3	5,028.5
Other Cows	847.8	802.6	764.4	735.1	709.0	682.9	657.7	632.0	605.0	577.9
Dairy Heifers	304.9	305.1	308.3	312.7	316.9	320.5	323.3	325.3	326.3	325.4
Other Heifers	130.6	124.3	119.6	116.9	114.4	111.5	108.2	104.7	101.1	97.3
Cattle < 1 yrs	2,087.4	2,143.6	2,165.7	2,141.4	2,111.1	2,082.3	2,069.0	2,054.2	2,045.7	2,052.8
Cattle < 1 yrs - male	1,038.4	1,062.8	1,072.7	1,062.7	1,050.1	1,039.1	1,032.4	1,027.9	1,021.4	1,021.0
Cattle < 1 yrs - female	1,049.0	1,080.9	1,093.0	1,078.7	1,060.9	1,043.2	1,036.6	1,026.3	1,024.3	1,031.8
Cattle 1 - 2 yrs	1,409.4	1,446.8	1,461.5	1,445.4	1,425.3	1,406.4	1,397.4	1,387.9	1,383.1	1,391.1
Cattle 1 - 2 yrs - male	781.7	800.0	807.4	799.9	790.4	782.2	777.1	773.7	770.1	773.7
Cattle 1 - 2 yrs - female	627.7	646.8	654.1	645.5	634.9	624.3	620.3	614.2	612.9	617.4
Cattle > 2 yrs	566.2	580.9	586.7	580.4	572.6	565.3	561.7	558.2	556.1	559.6
Cattle > 2 yrs - male	366.0	374.5	378.0	374.5	370.1	366.2	363.8	362.2	360.6	362.6
Cattle > 2 yrs - female	200.2	206.3	208.7	205.9	202.5	199.1	197.9	195.9	195.5	197.0
Bulls	47.2	44.8	42.3	40.1	38.0	35.8	33.5	31.1	28.1	24.5
Total Sheep	5,090.7	4,881.6	4,833.8	4,837.5	4,835.3	4,812.2	4,761.0	4,656.3	4,770.0	4,780.0
Ewes Lowland	1,909.2	1,828.0	1,718.6	1,713.9	1,753.2	1,797.9	1,833.1	1,851.2	1,833.4	1,961.3

S1_Base_Revised_2023 | S2_Low_Revised_2023 | S3_High_Revised_2023

teagasc
Agriculture and Food Development Authority

Output - EXAMPLES

Scenario D (-25% GHG with measures).

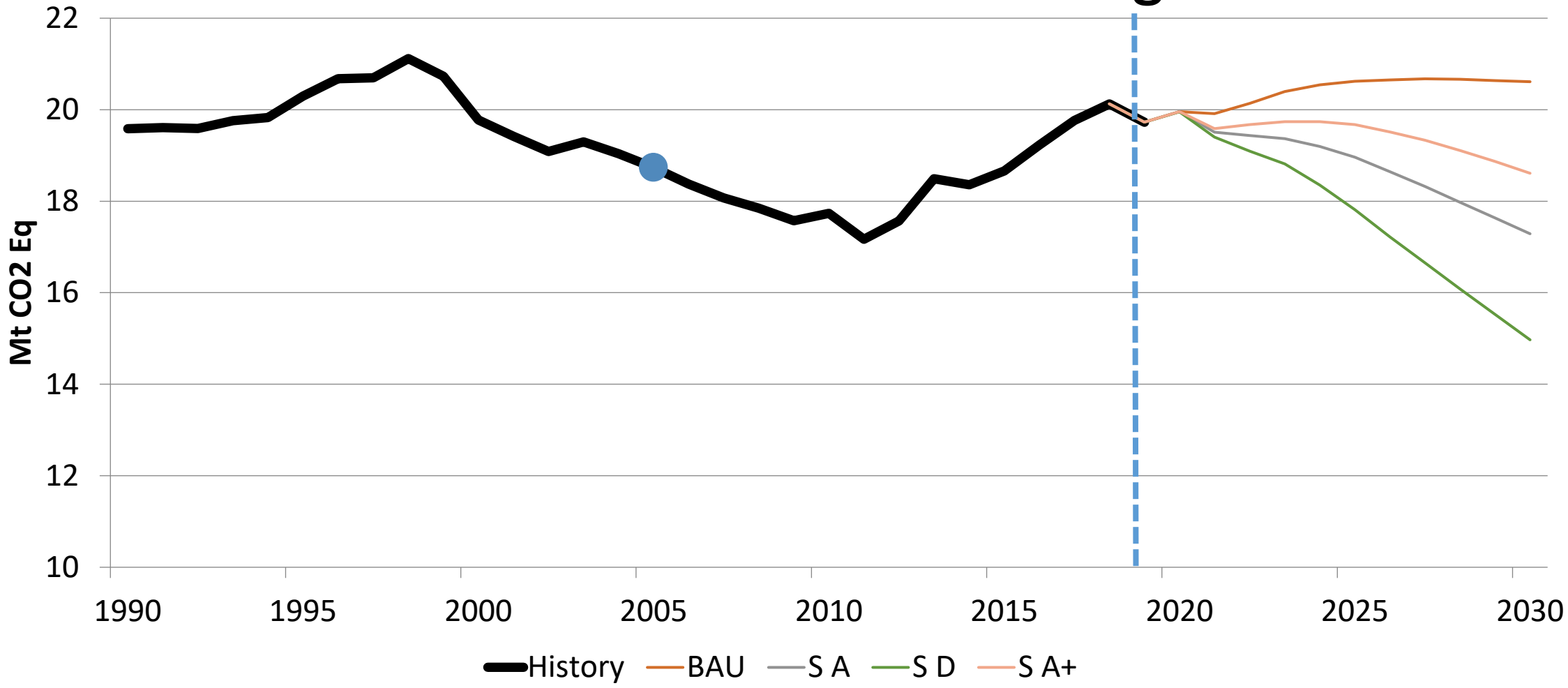


Source: FAPRI-Ireland Model

Output - EXAMPLES

Summary: GHG emissions

NB: All Scenarios other than BAU include mitigation actions



Source: FAPRI-Ireland Model

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Challenges extending to/towards 2050

- Developing coherent global macroeconomic and international commodity price projections
  - Energy and Agricultural price paths are related
  - How will these relationships change in the future ?
- Agricultural policy developing coherent agricultural policy assumptions for long term
- How to reflect impact of new emissions mitigation technologies and practice changes (known unknown) within model projections

CAPACITY
CLIMATE ACTION PATHWAYS & ABSORPTIVE CAPACITY

MaREI
Energy · Climate · Marine

Carbon budget scenario development with TIMES-Ireland Model

Scenario development for 2nd Carbon Budget Programme workshop

Climate Change Advisory Council – Carbon Budgets Committee

Hannah Daly, UCC

13th September, 2023

Reflections on the use of TIM for informing Carbon Budgets

MaREI
Energy · Climate · Marine

What questions can TIM inform?

- What energy system changes would be needed to meet given decarbonisation targets (carbon budget or annual target)
- Trade-off across options; identifying blind-spots
- What is the total & marginal cost of different abatement levels for energy, how is this distributed across sectors?
- What is the "effort gap" between current measures and what is needed, sector-by-sector?
- What is the impact of excluding mitigation options, technology breakthroughs, different demands?

What can TIM not (directly) inform?

- Who pays? What (detailed) policies can deliver the change? What are the distributional impacts?
- What is societally/politically feasible?
- What is an appropriate/fair/just response to Paris Agreemeny
- What are the interactions and trade-offs between energy, land-use and food systems for mitigation?

Additional considerations

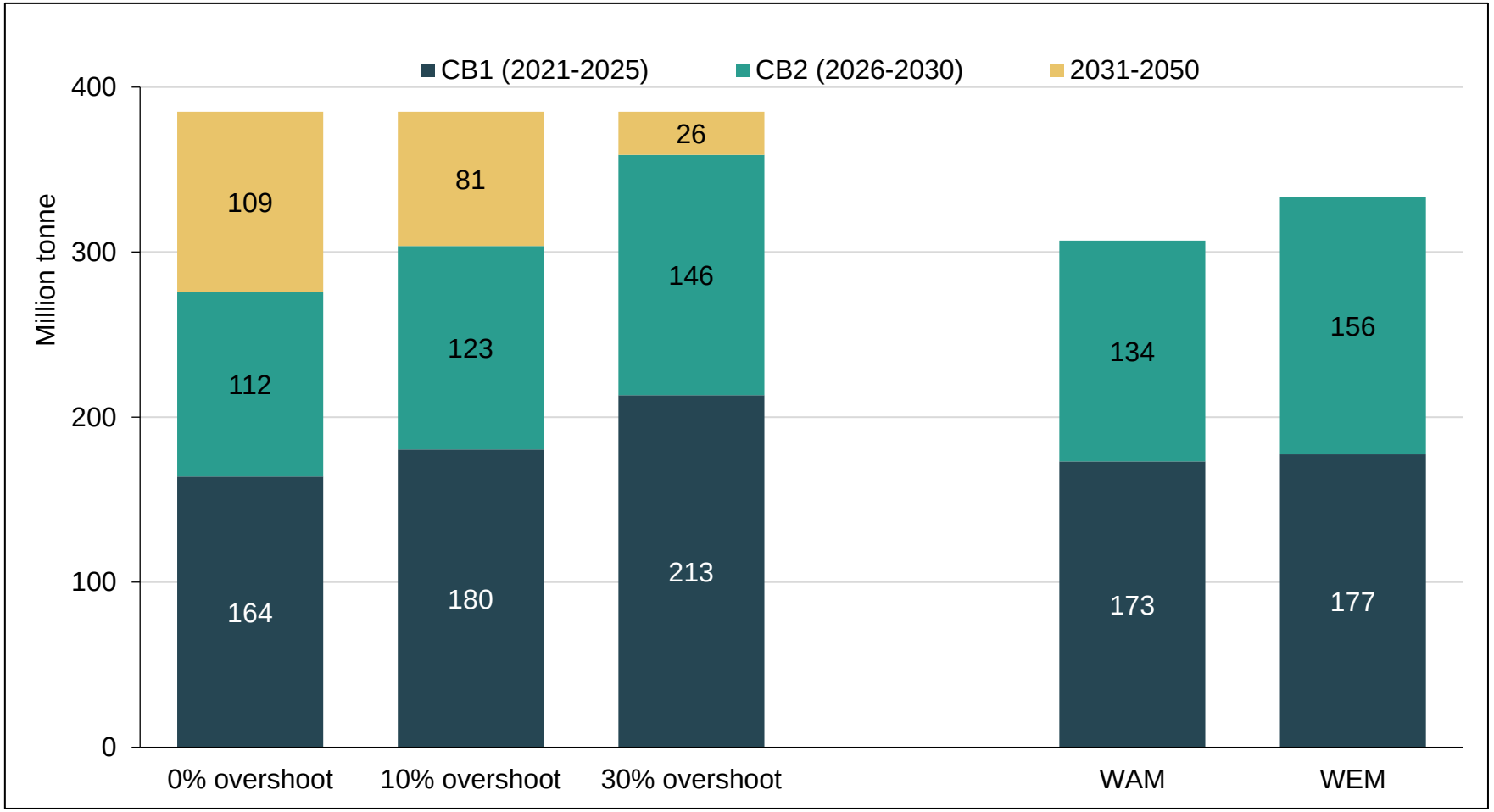
- We can provide and run the tool – but the "recipe" (constraints, assumptions, etc.) need wider discussion – non-trivial
- Expertise and more detailed sectoral models needed for deep dives on different sectors and topics
- Long-term model maintenance, updating and development requires stable funding base, long planning horizon, and the ability to attract and retain top modellers.

Proposed scenario dimensions

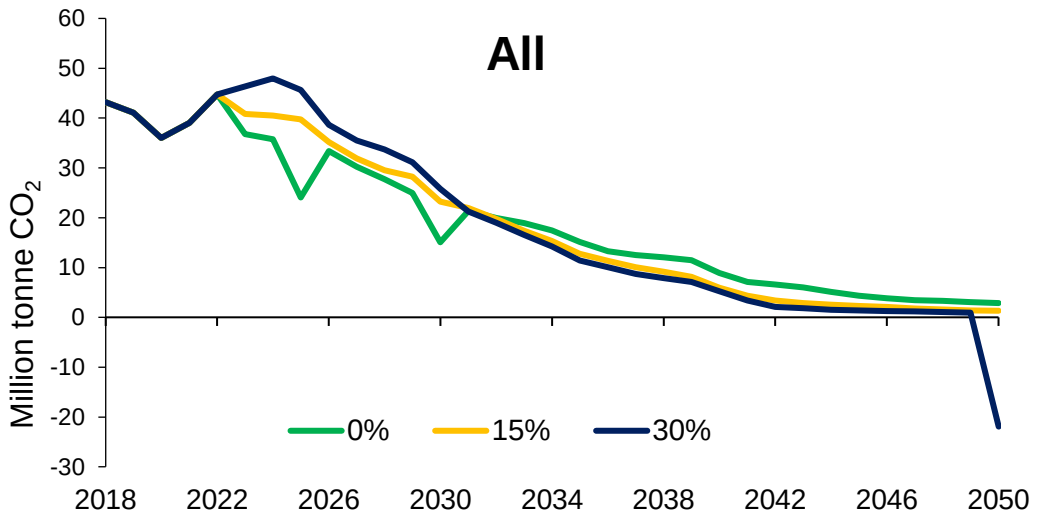
- Energy system carbon budget:
  - Currently working with 344 MtCO2 (2021-2050) – to be informed by Council
    - Reference: SECs for these sectors: 269Mt (2021-30).
    - inclusive of all fossil fuels and industrial process emissions
    - excluding intl. aviation & shipping
  - Overshoot of CB1 & CB2
    - Scenarios assuming WEM & WAM level of CB overshoot which must be brought forward

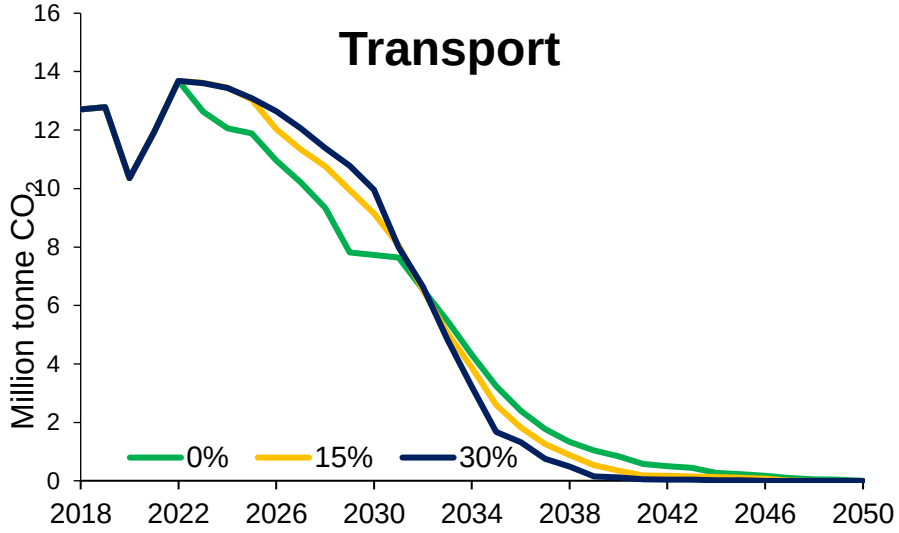
- Other dimensions
  - Technology cost
  - Social discount rate – considering revising downwards
  - Level of future energy demand (BAU; LED)
    - full alignment with new population/GDP projections unlikely to be
  - Level of domestic bioenergy
  - Availability of Negative Emissions Technologies (NETs – BECCS, DACS)

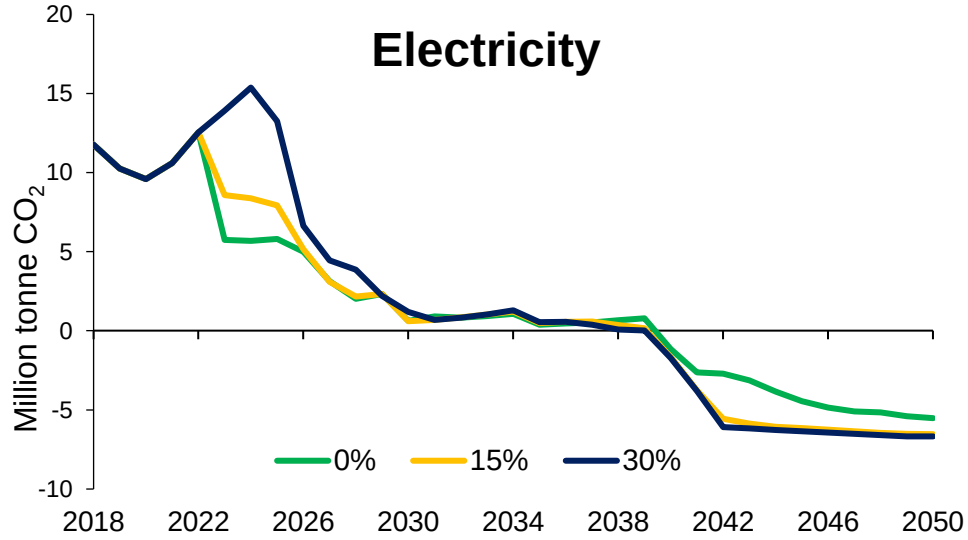
In-progress analysis: Overshoot scenarios

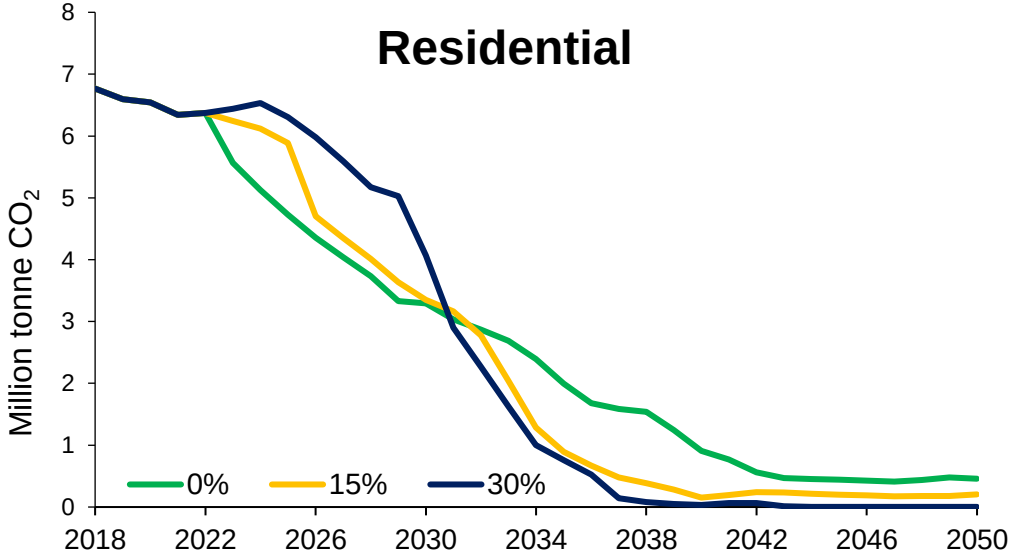


In-progress analysis: Overshoot scenarios









Model development

- Team status:
  - Funding in place from DECC through Climate Action Modelling Grouop
  - Dr. Vahid Aryanpur as senior postdoctoral researcher in place
  - Appointed Bakytzhan Suleimenov as senior model coordinator
  - Several PhDs and other researchers working with TIM on parallel projects
- Model priorities:
  - Calibrate 2021 & 2022 energy balances
  - Improve range of mitigation options for industry, aviation & shipping
  - Reflecting bioenergy availability & land use consequences
  - More resolution on energy system at close-to-zero carbon (hydrogen, storage, DAC)
- Available to produce scenarios to support other analyses

Sample outputs

- E.g., https://epmg.netlify.app/tim-carbon-budgets-2022

SEAI NEMF Carbon Budgets Modelling Input

CBWG Modelling Workshop

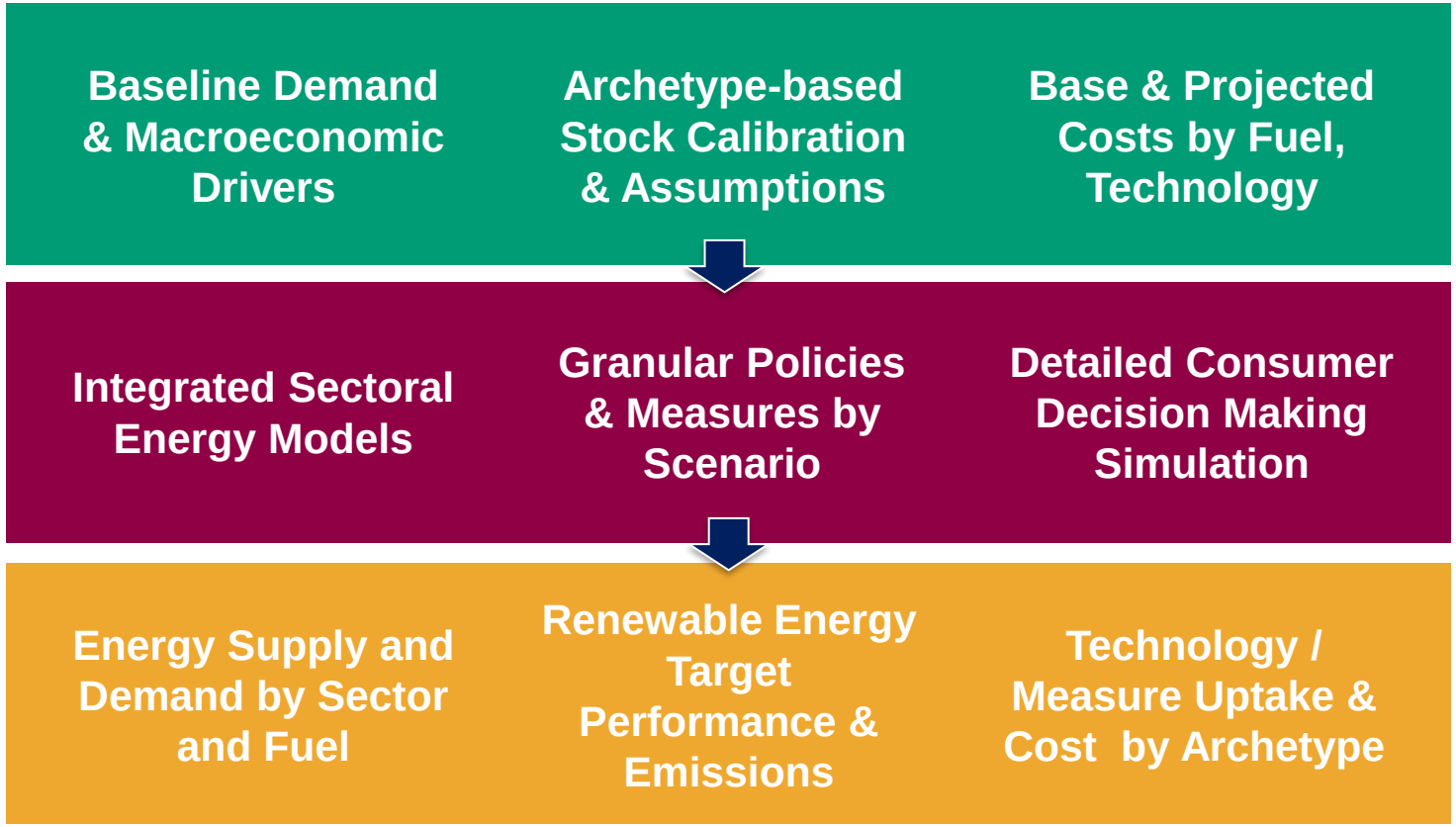
September 2023

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

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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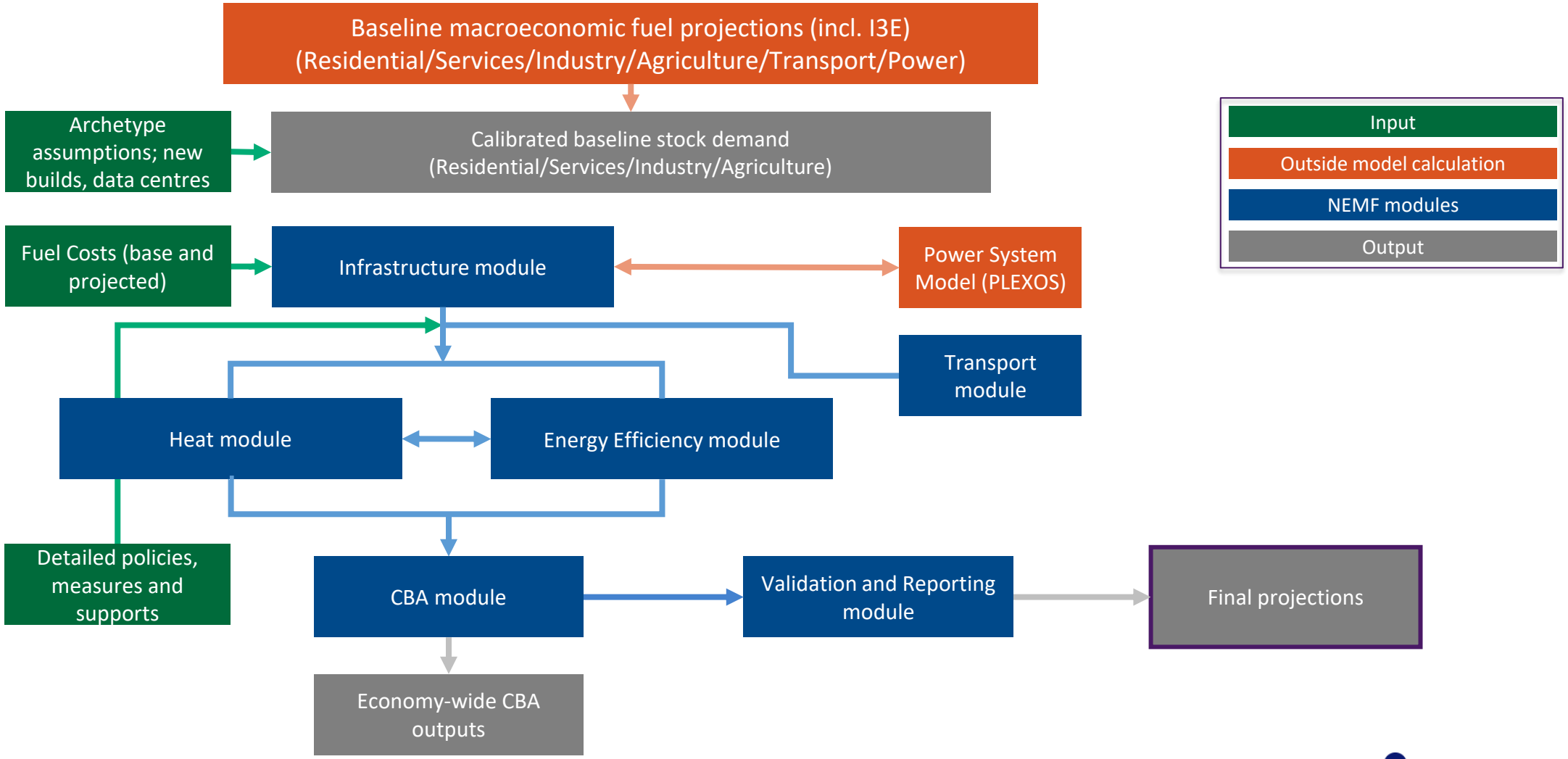
SEAI NEMF Modular Structure and Inputs



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 out to 2050?
- 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)
- Detailed estimated **implementation trajectories post 2030** 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**

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NEMF Scenario Building – Starting Point

- 2030 Underperformance: The **WAM scenario** is a projection of future energy supply and use based on the measures outlined in the latest Government plans at the time the National Energy Projections are compiled.
  - This includes all policies and measures included in the WEM scenario, **plus** those included in the latest Government plans but not yet fully implemented.
  - **WAM-CAP23** used in EPA WAM scenario, broadly assume targets set out in CAP 23 will be met
  - Adjusted WAM or WEM to capture risk of delays in implementation

- 2030 Carbon Budget Compliance: Key levers to close the gap to the underperformance scenario
  - Adapt input assumptions behind WAM trajectory to reach carbon budgets
  - Iterative process optimal here, using levers from optimisation approach

- 2030 Overperformance (Sensitivity): Further levering of input assumptions from carbon budget compliance scenario
  - Significant stretching of existing input assumptions likely to yield unreasonable NEMF outputs

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NEMF Scenario Building - Targets

- NEMF primarily used in simulation mode with designed scenarios, so solving for a target is not the main function of the model
- However, model can take inputs for scenarios designed to reach particular targets (e.g. National Heat Study) and sense-check the outcome

- Adjust input assumptions to align with least-cost optimisation model scenarios solving for set of outcomes
  - 2050 Emissions Trajectories: Temperature outcomes in European Climate Law
  - 2050 Emissions Trajectories: Net Zero GHG emissions in 2050 in climate-neutral EU 2050 long-term strategy
  - EU 2040 Climate Target (ESAB): EU emission reductions of 90–95% by 2040, relative to 1990

NEMF Input Assumptions

- Policies and Measures
  - Detailed representation of support schemes for energy targets (grants, loans, tariffs, etc.) influencing uptake decisions
  - Packages of policies and measures can be varied by scenario for multiple scenario runs

- Targets where Centralised Decision-making needed
  - Climate action plan targets for District Heating, Biomethane, Renewable power generation installed capacities

- Technology
  - Suitability, efficiency, availability and resource constraints
  - Speed of deployment as informed by planning, market activity, research on future deployment

- Costs
  - Technology and associated installation
  - Fuel costs, import/export for power generation
  - Retail fuel costs, construction, hidden costs for building upgrades and technology switching

- Baseline Demand
  - Energy demand and potential growth given macroeconomic growth (pop, GDP), wholesale fuel, ETS prices, carbon tax
  - National Energy Projections take into account ESRI I3E macro projections

Full set of key input assumptions published as part of EPA's emissions projections

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NEMF Model Features

Commonalities with Other Energy Models

- Produces projections of primary and final energy across sectors
- Power module approach unit commitment and economic dispatch integrated with other sectors
- Horizon out to 2050
- Accounts for macroeconomic drivers in baseline

Ideal Use for Carbon Budgets

- Alignment of input assumptions with TIM scenario that complies with target and assess outcome
- Adjustment of key levers through input assumptions from base case such as WAM

Distinct Elements of NEMF

- Energy-focused, not covering agriculture and land use beyond energy consumption and resource assumptions
- Consumer Uptake Modelling used in built environment
  - Granularity in technology and building upgrades
- Basis of EPA emissions projections for energy
- Energy Policy focus
  - Detailed policy inputs including support schemes and regulations to assess against targets

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NEMF Model Outputs

Main Outputs: Energy Data | SEAI Statistics | SEAI

- Primary Energy Demand by fuel and fuel use in electricity generation
- Total Final Energy Consumption by sector and by fuel (in line with Energy Balance and EPA Inventory / Projections)
- Renewable Energy Share by Source
- C02 energy-related emissions by sector and by fuel

Additional Outputs

- Uptake curves for technology adoption
- Alternative renewable deployment trajectories by scenarios
- Cumulative and annual assess

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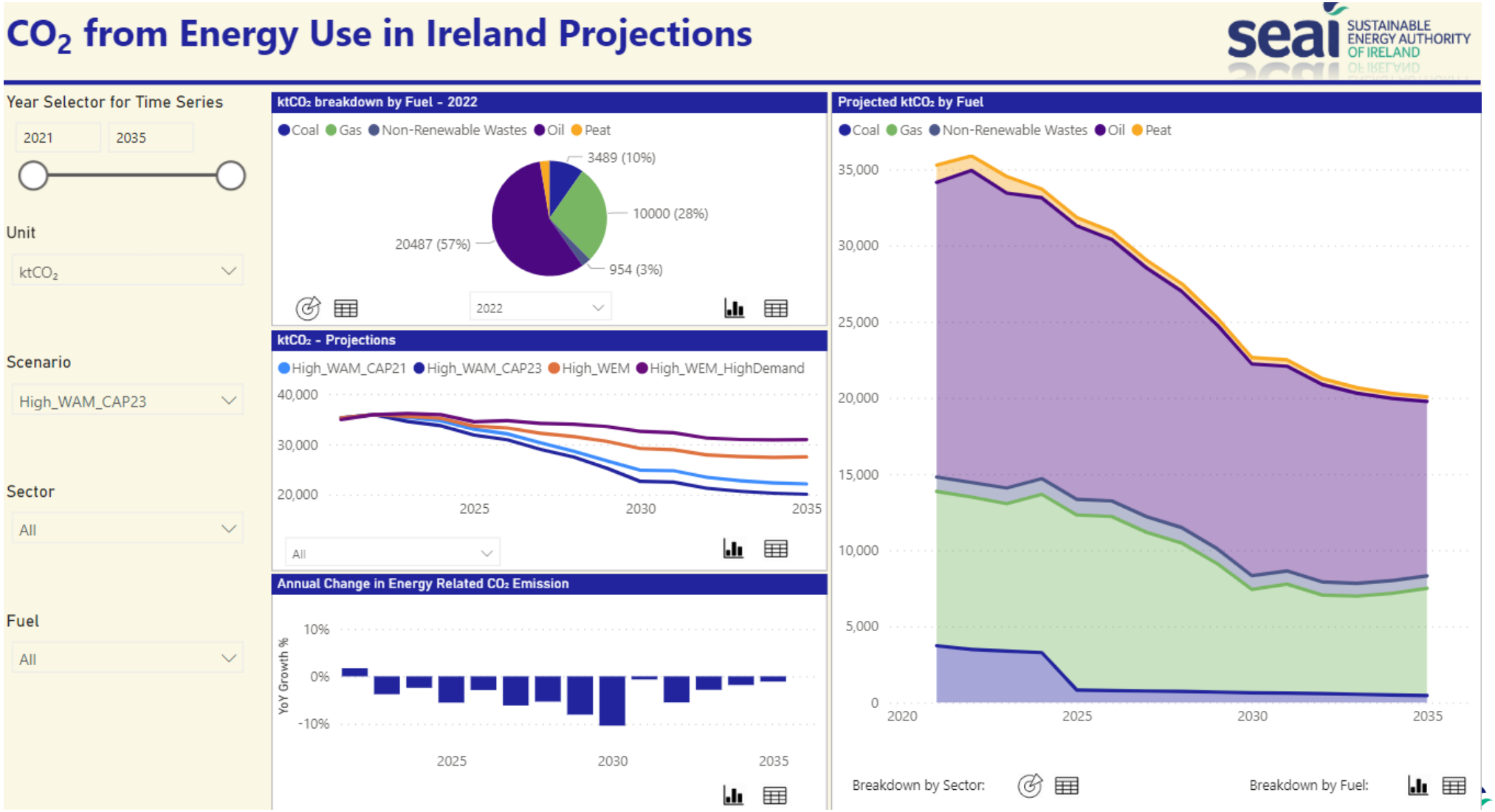
NEMF Model Outputs - Examples



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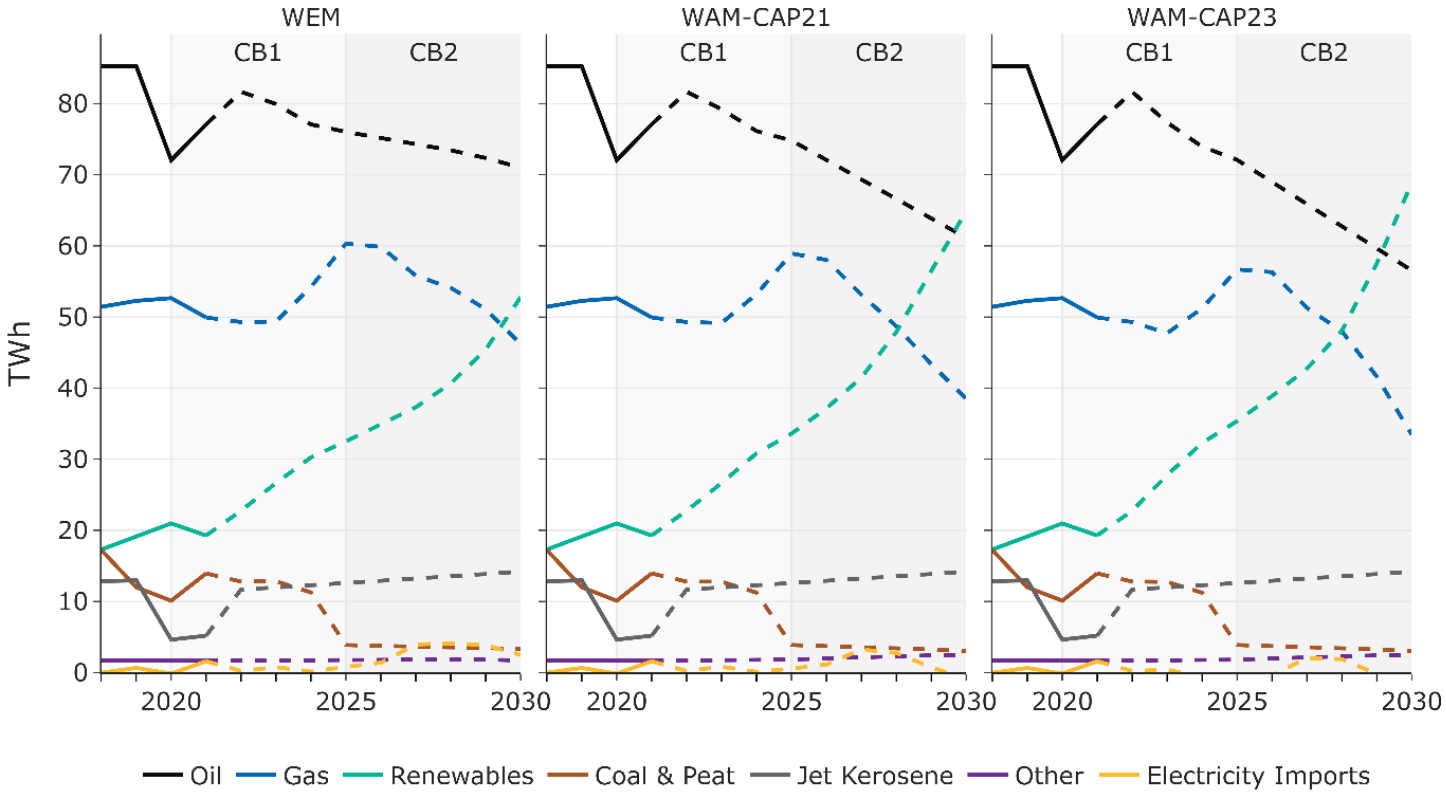
NEMF Model Outputs - Examples



Total Energy Use by Scenario

- Also available out to 2050
- Available by sector
- Can show detail underlying Renewables figures on installed capacity deployment rates

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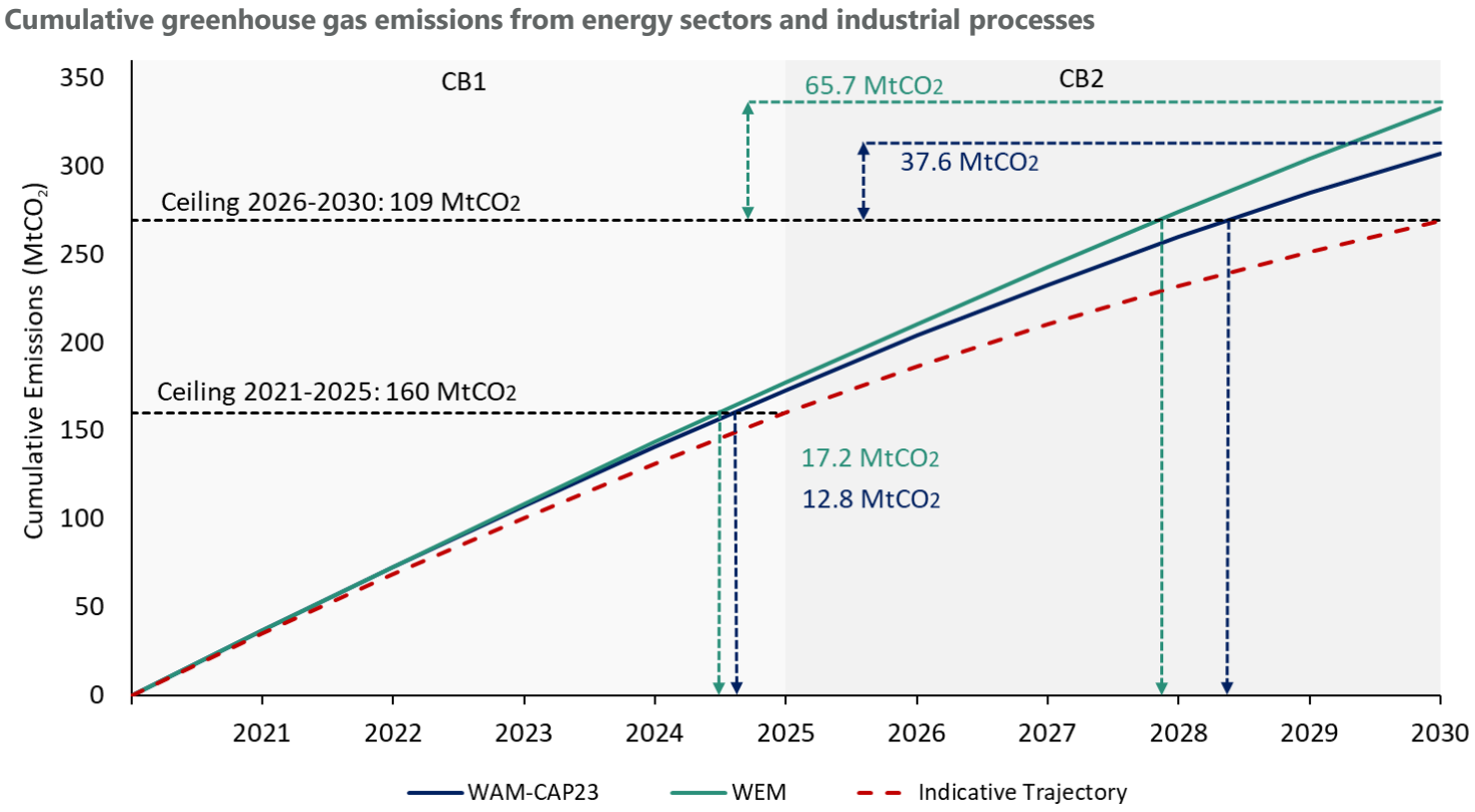
NEMF Model Outputs - Examples



Cumulative Emissions Outputs for sets of scenarios assessed against carbon budgets

- Also available out to 2050 with assessment against prospective CB3 and CB4
- Also available by sector to assess on sectoral ceiling basis

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