TIM, time and tide wait for no one: long-term modelling in an environment of constant flux

Andrew ZP Smith

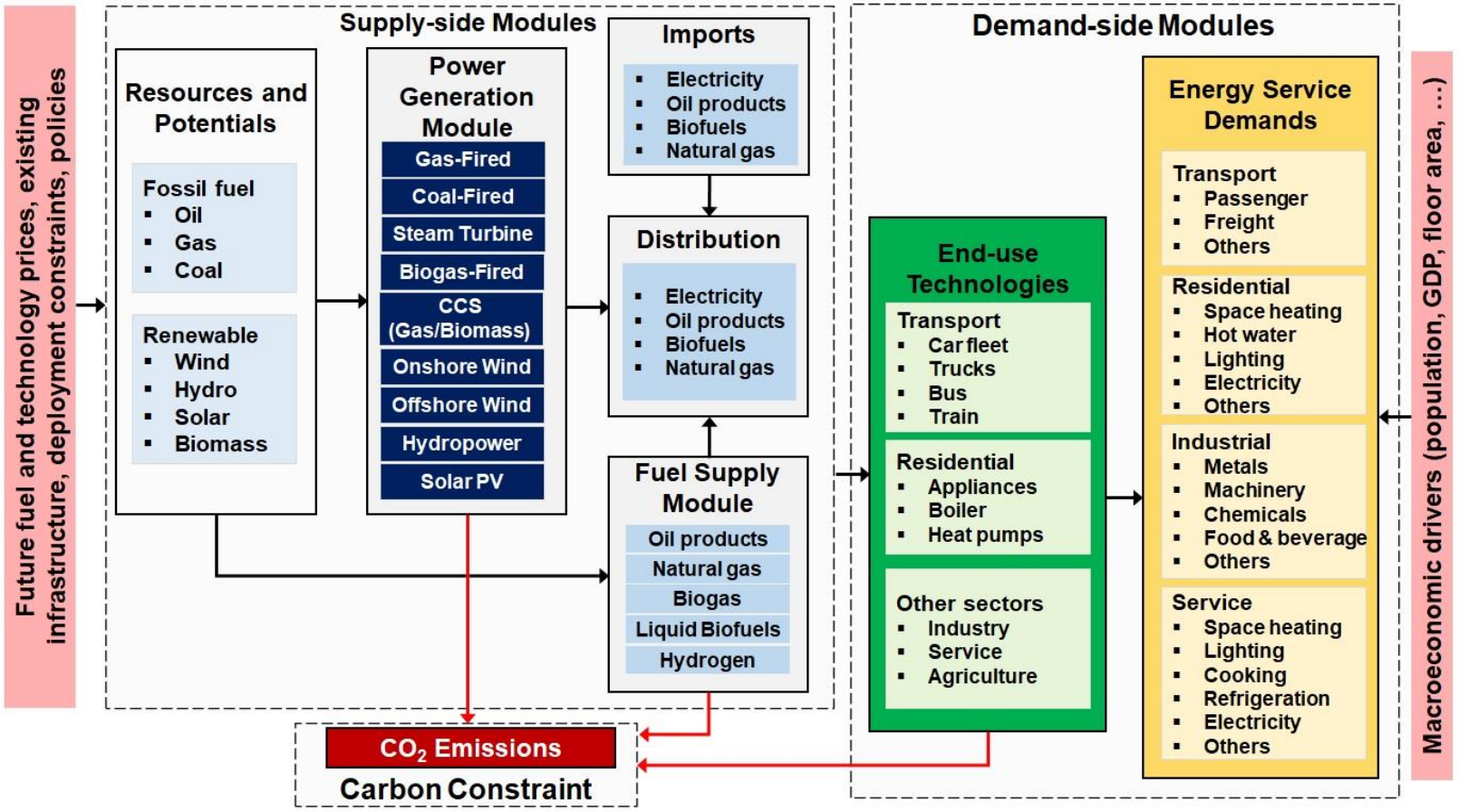
MaREI

Introduction

- First assessment of energy system pathways meeting very deep 2030 decarbonisation target with the TIMES-Ireland Model (TIM), calculating the investment and technology deployment required across demand and supply sectors
- The TIMES-Ireland model can be used as a tool for decision making, exploring different futures for sectoral ambitions, technologies, demands and fuels
- Explore results for scenarios with different levels of abatement ambition for the energy sector and alternative technology and demand outlooks: https://tim-carbon-budgets-2021.netlify.app/
- The short time-horizon to 2030 requires a faster energy system transition than the natural renewal of many technologies, so early retirement may be needed, implying “stranded assets” and lost investments if growth in fossil fuel infrastructure continues

TIMES-Ireland Model (TIM)

TIM is an Energy Systems Optimisation Model (ESOM) which calculates the "least-cost" configuration of the energy system which meets future energy demands, respecting technical, environmental, social & policy constraints defined by the user.



Given

- Final energy demands
  - e.g., passenger kms, home heating
- CO_2 constraints on energy
  - e.g., carbon budget, annual target
- Technology, fuel costs & efficiency
  - Existing & future cost and performance
- Resource availability
  - e.g., on/offshore wind, bioenergy
- User-defined constraints
  - e.g., speed of technology uptake, policies

TIM calculates

- "Least-cost" energy system meeting all constraints
- Investment and operation of energy technologies
- Emissions trajectories
- Total system cost
- Imports/exports
- Marginal energy prices

What questions can TIM inform in the short term?

- What energy system changes would be needed to meet given decarbonisation targets (budget or given year)
- For an “all-time carbon budget”, what is the “optimal” energy decarbonisation pathway over time and 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 (or adding new options)? “Feasibility”

What can TIM not (yet) inform?

- What should the carbon budget for energy vs. agriculture emissions be?
- Who pays?
- What policies should be used to achieve the target?
- What are the interactions and trade-offs between energy, land-use and food systems for mitigation?
- Services and industry sectors in TIM are currently low-resolution

Additional considerations

- We can provide and run the tool – but the “recipe” (constraints, assumptions, etc.) need wider discussion – non-trivial
- Expertise 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.

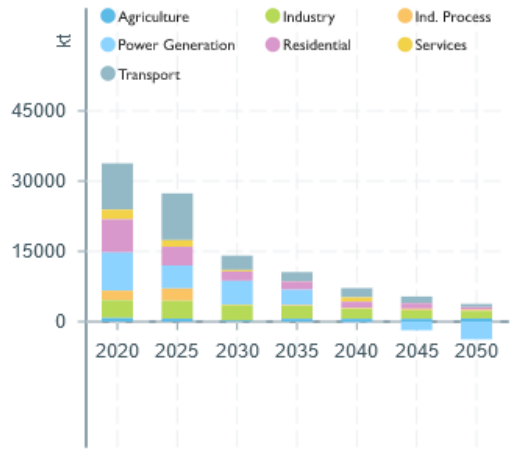
- Model is fully **open-source**
- "Best-practice" **development approach** – Git used for version control and integration, open web app for results analysis & diagnostics
- Developers with **international expertise** and links with global TIMES community, allowing knowledge-sharing
- Using **TIMES framework** – well-proven, high quality, continuously developed/maintained, open source code
- **Flexible integration** – Simultaneously maintaining "stable, policy-ready" model and development of research variants, allowing innovations in ESOMs, pushing state-of-the-art – leveraging across projects
- Strength of **systems approach** – automatic "sector coupling" by design – where is the best use of resources? What are sectoral trade-offs?
- Extensive **stakeholder review**
- Training PhDs, interns etc. & wider engagement integral for national **capacity-building**
- A focus on **alternate scenarios**, sensitivities, "what if" analyses
- **Dynamic integration** with national data sources and other national models (where possible)
  - Will allow for "low-effort" updates going forward
  - I3E/COSMO (macro-economy), PLEXOS (power system), LEAP/Car Stock Model (transport & residential sectors)

Scenarios

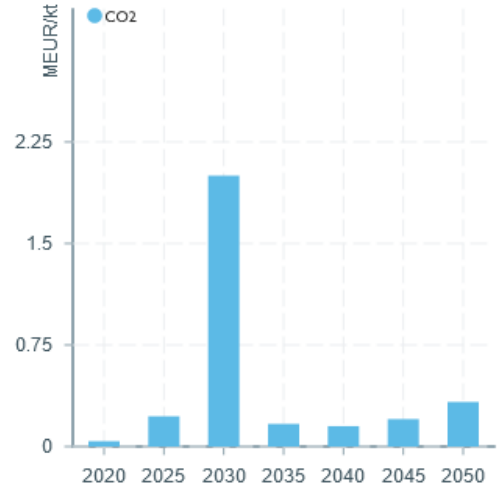
- A25-E65
- A25-E65 Early Action
- A25-E65 Late Action
- A25-E65 LED
- A25-E65 Tech-Optimism
- A33-E61
- A33-E61 Early Action
- A33-E61 Late Action
- A33-E61 LED
- A33-E61 Tech-Optimism
- A40-E57
- A40-E57 Early Action
- A40-E57 Late Action
- A40-E57 LED
- A40-E57 Tech-Optimism
- A51-E51
- A51-E51 Early Action
- A51-E51 Late Action
- A51-E51 LED
- A51-E51 Tech-Optimism
- A55-E49
- A55-E49 Early Action
- A55-E49 Late Action
- A55-E49 LED
- A55-E49 Tech-Optimism
- WAM

Select 2nd scenario
None

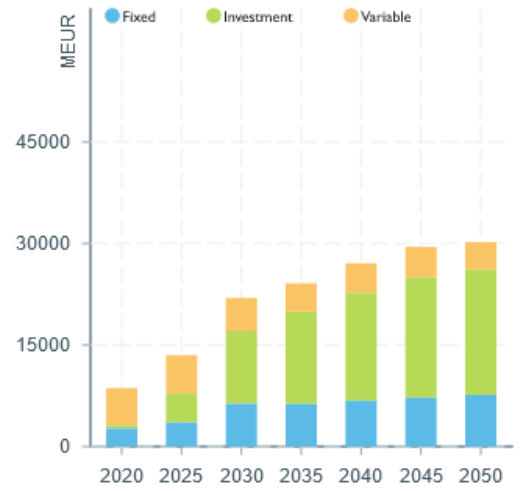
Domestic CO2 Emissions by Sector



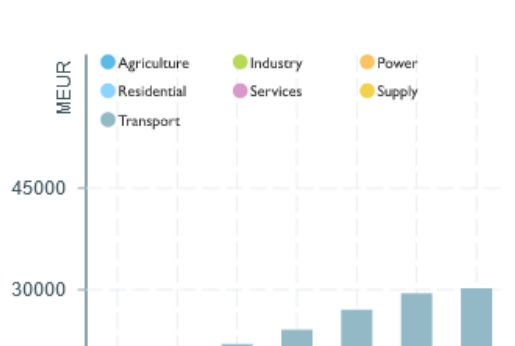
Marginal Emission Price



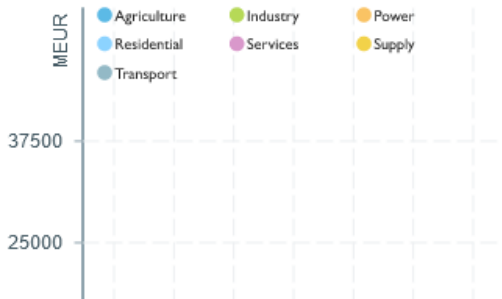
Annualised System Costs by Type



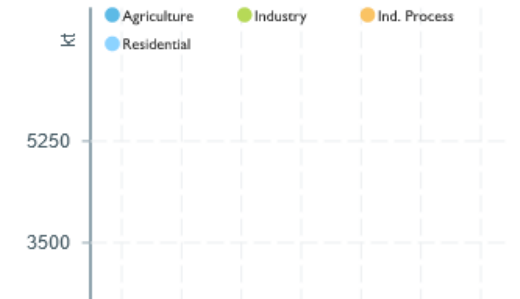
Annualised System Costs by Sector

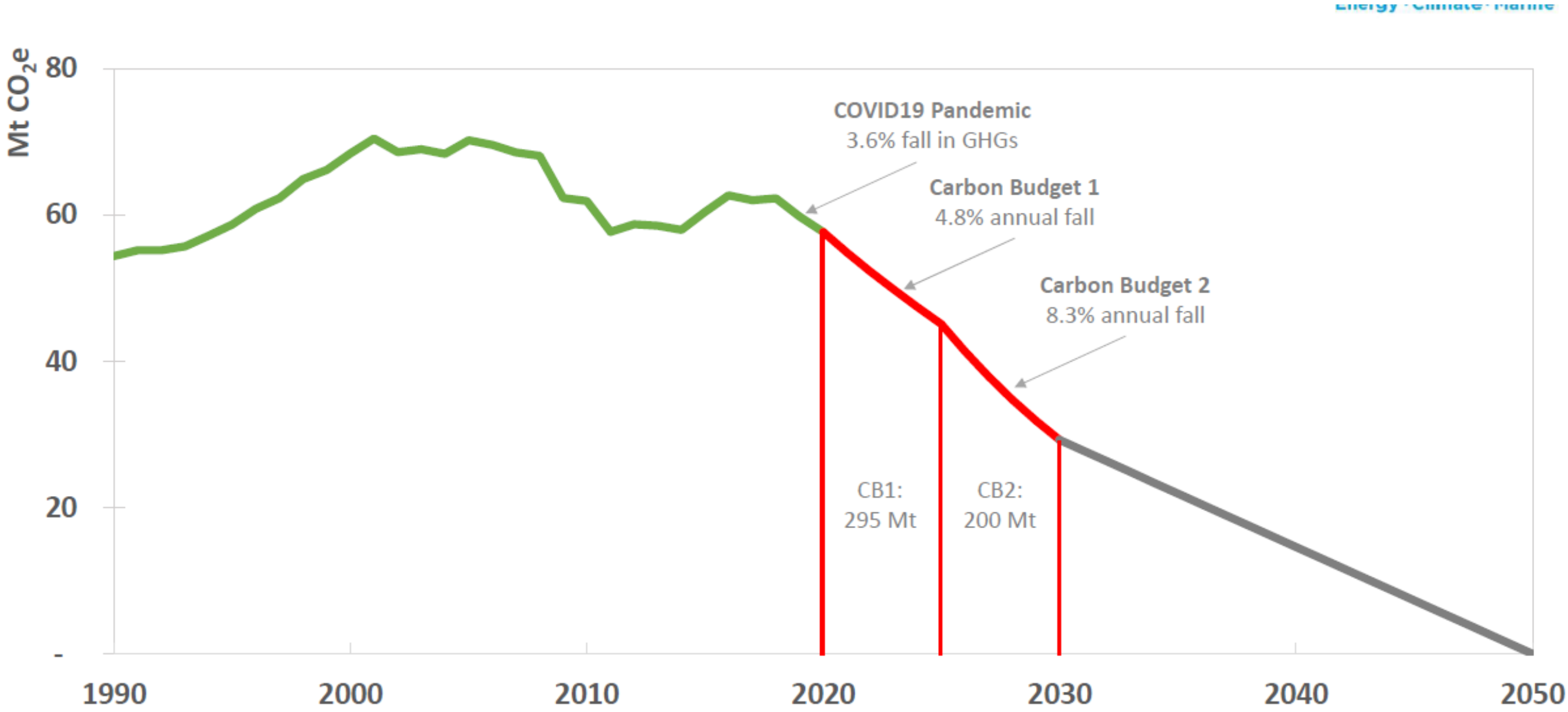


Lump Sum Investment Cost by Sector



Unmitigated CO2/backstop



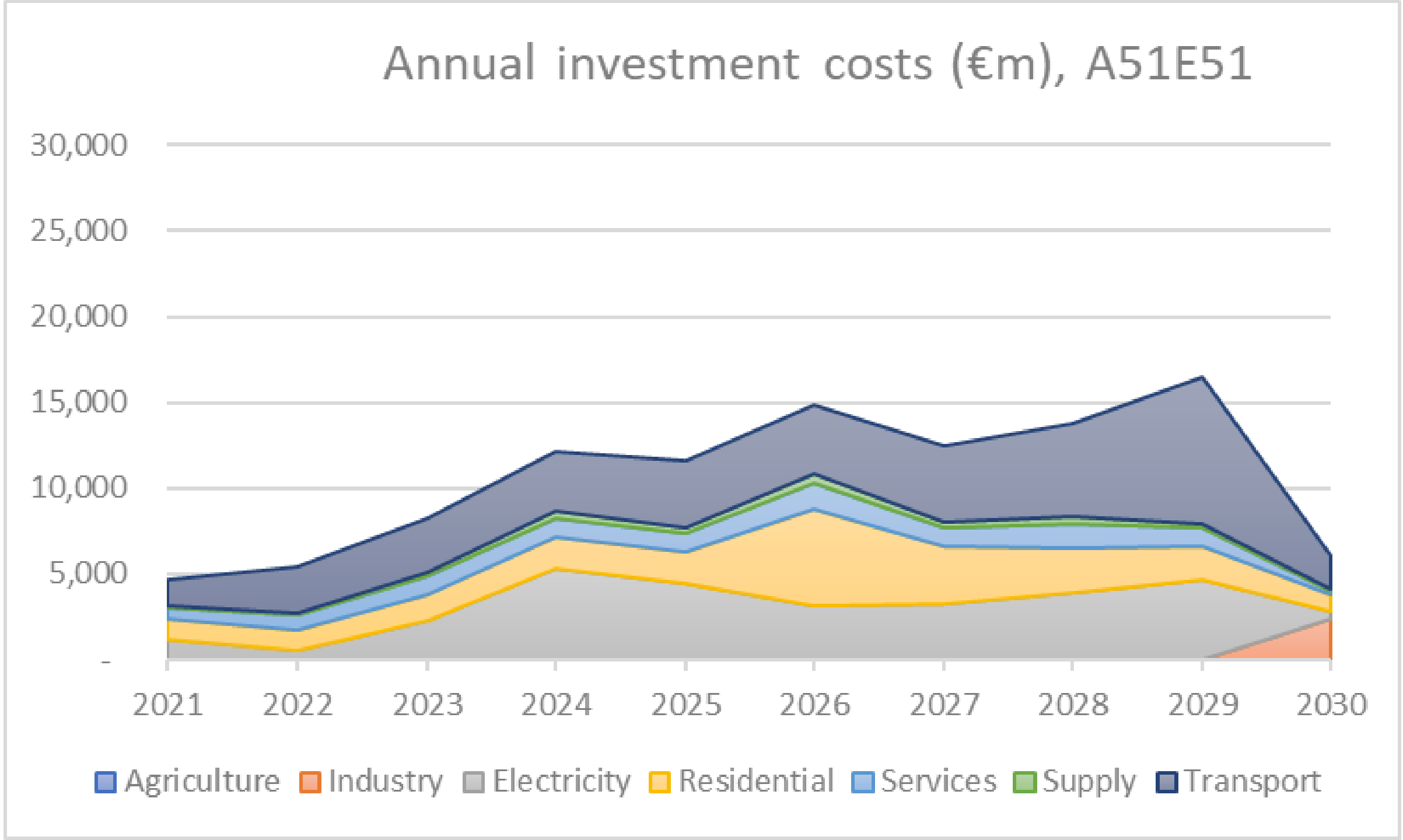


Dr. Hannah E. Daly, Feb 9th 2022

Marginal Abatement Cost (2025-30 average) in core mitigation scenarios and scenario variants

		A-51%,E-51%	A-40%,E-57%	A-33%,E-61%	A-25%,E-65%
Core	"BAU" demands, no bioenergy imports, 4-times 2018 indigenous bioenergy, no power-CCS available, no H2 import, ~74% RES-E	€674	€1,100	€1,292	€1,485
Low Energy Demand (LED)	Decoupling energy service demands: mobility shifting; dematerialisation; lower heating	€128	€403	€545	€757
Tech-Optimism	Up to 25GW VAR-RE by 2030; additional H2 & Bioenergy, 400 MW CCS available from 2027. >90% zero-carbon power generation	€436	€639	€812	€1,284
LED + Tech-optimism		€76	€125	€202	€317

The Marginal Abatement Cost represents the cost of mitigating the most expensive tonne of CO_2 in each scenario for the energy sector


Annual investment costs (€m), A51E51
30,000
25,000
20,000
15,000
10,000
5,000
-
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Agriculture
Industry
Electricity
Residential
Services
Supply
Transport

How do we normally develop long-term scenarios?

- A back-and-forth between modelling team and client over months
- Establish the assumptions, test the model's resilience, develop the outputs
- Analyse the scenarios over subsequent years, augmenting as circumstances allow

How did TIM support the Carbon Budget Committee?

- A back-and-forth between modelling team and client over 2-week periods
- Model was developed in parallel with scenarios, with new functionality added weekly
- Analyse the scenarios over subsequent weeks, completely revising as circumstances require

Can you change tyres on a moving car?

- Set the client’s expectations early on

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How did the Council see our work?

- “Without modelled projections, we would not have been able to have sensible discussions about what the budgets should be”

- “it was crucial for understanding the linkages between different parts of the system, to understand where the constraints are”

Mission-Oriented Research & Innovation

"Missions lay behind some of the biggest innovative leaps forward of the last century and can offer the transformative approach needed today."

Mariana Mazzucato

Professor in the Economics of Innovation and Public Value
UCL Institute for Innovation and Public Purpose

What does Mission-oriented mean?

- There remains a role for competition to drive out inefficiencies at the tactical level
- But the strategic level is about cultivating co-operation and collaboration
- Capacity-building takes precedence over competition

How do we build capacity?

- Long-term funding X
- Plenty of advance notice for changes in funding X
- Top-level messaging is aligned with funding incentives and systems X
- Funding incentives collaboration X