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# Modelling low-carbon energy transition scenarios with the TIMES-Ireland Model (TIM)

**Hannah Daly, Andrew Smith, Olexandr Balyk**

Climate Change Advisory Council Carbon Budget Committee  
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# Terms of reference for developing carbon budgets

**Top-down:** Estimate an appropriate carbon budget for Ireland for the period 2021 – 2050 based on consideration of the global carbon budget [addressing criteria: national climate objective, UN, Paris Agreement, **science**, climate justice]

- a. The **potential for negative emissions**
- b. The **role of different gases**
- c. The global carbon budget

**Bottom-up:** Consider what legislative requirements at national and EU level mean for emissions up to 2030, covering the first two carbon budgets. [addressing criteria: national climate objective, 51%, **EU, inventories and projections, science**, reporting, **economy**, and **climate justice**]

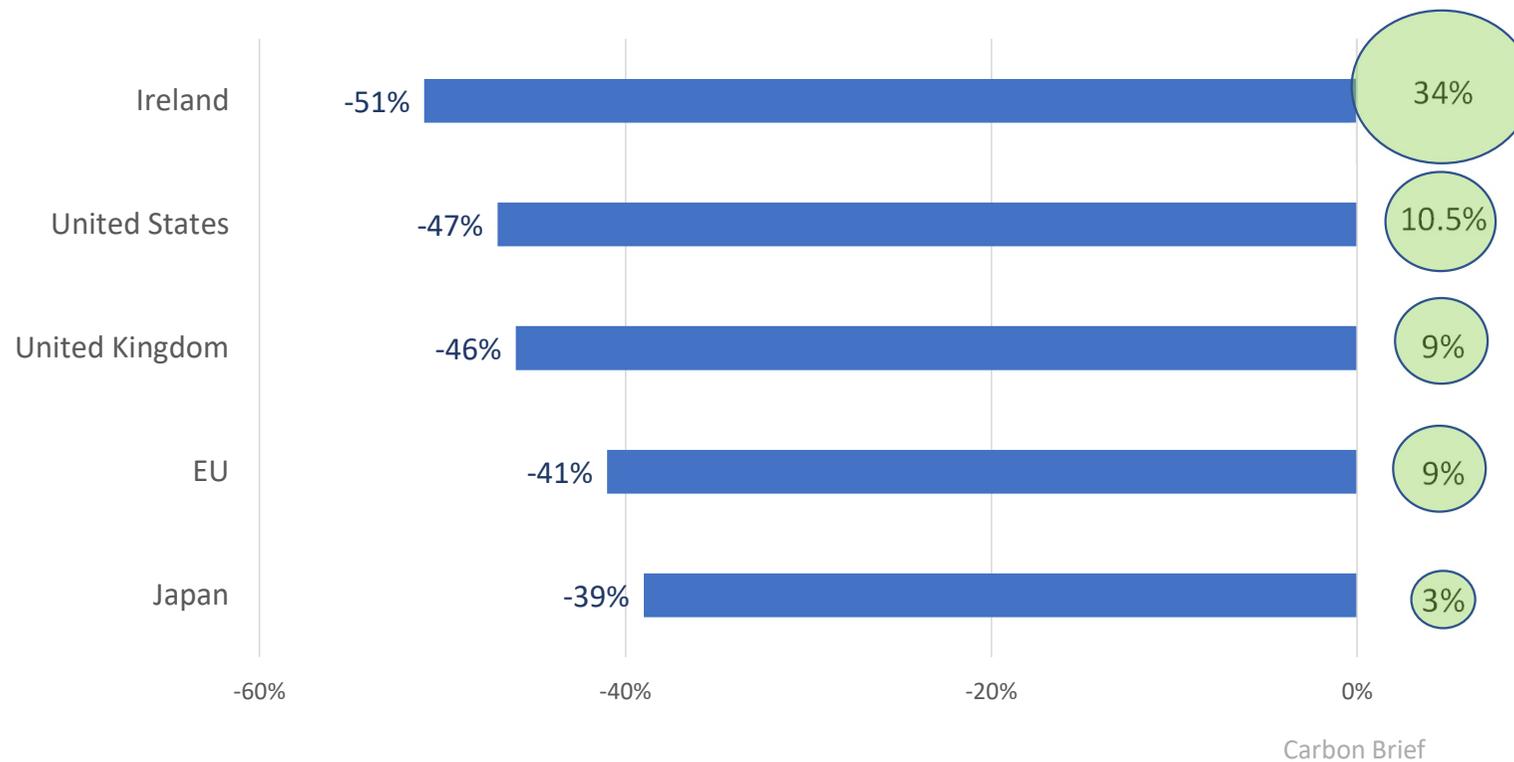
- a. The implication of required compliance with **EU and National Targets** (e.g. 51%) incl. treatment/inclusion of LULUCF
- b. **Feasibility, competitiveness impacts, implications for investment**
- c. **Distributional impacts, jobs**

**Factors in green require a consideration of not just what size is the carbon budget, but how it is allocated over time and over sectors and how policies and measures deliver mitigation**

# Ireland has the highest 2030 decarbonisation target

## Agriculture share of emissions

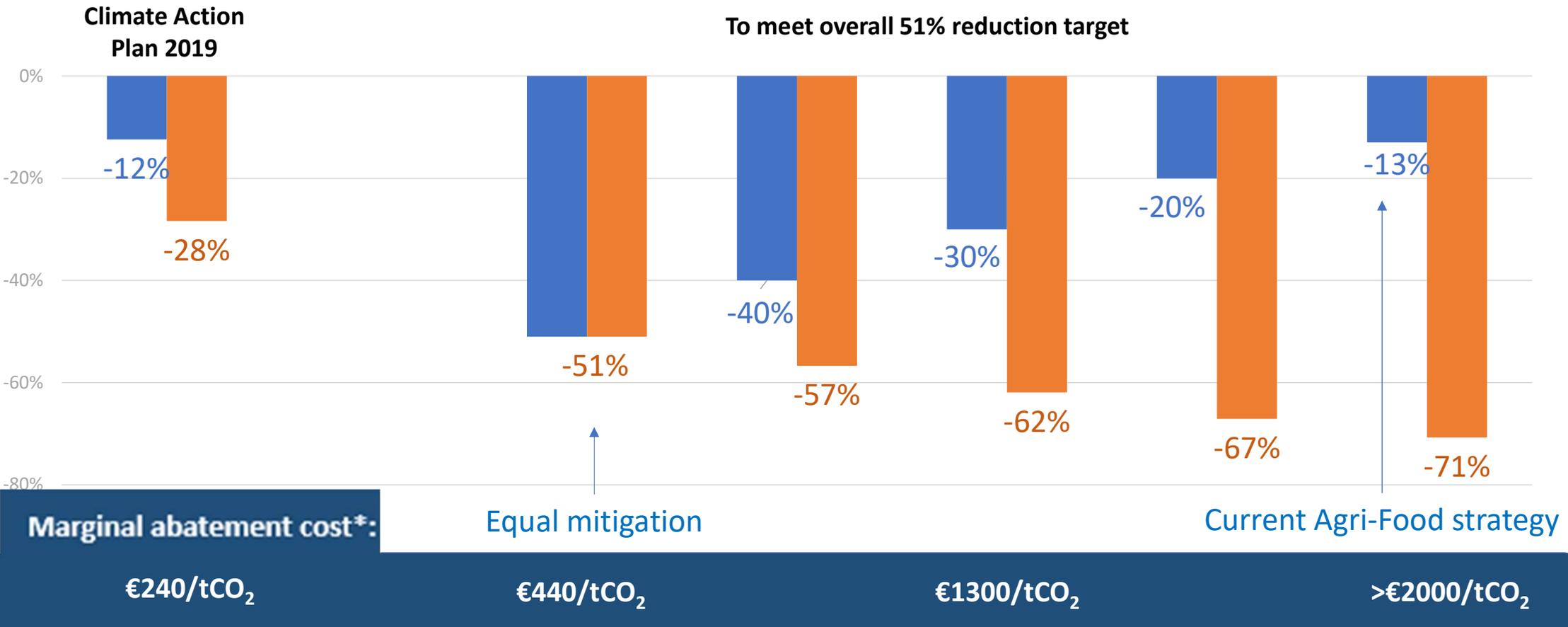
Mitigation targets for 2030, % relative to 2018



Ireland's high share of emissions from agriculture make this target even more challenging

# Low agriculture abatement requires other sectors to do more

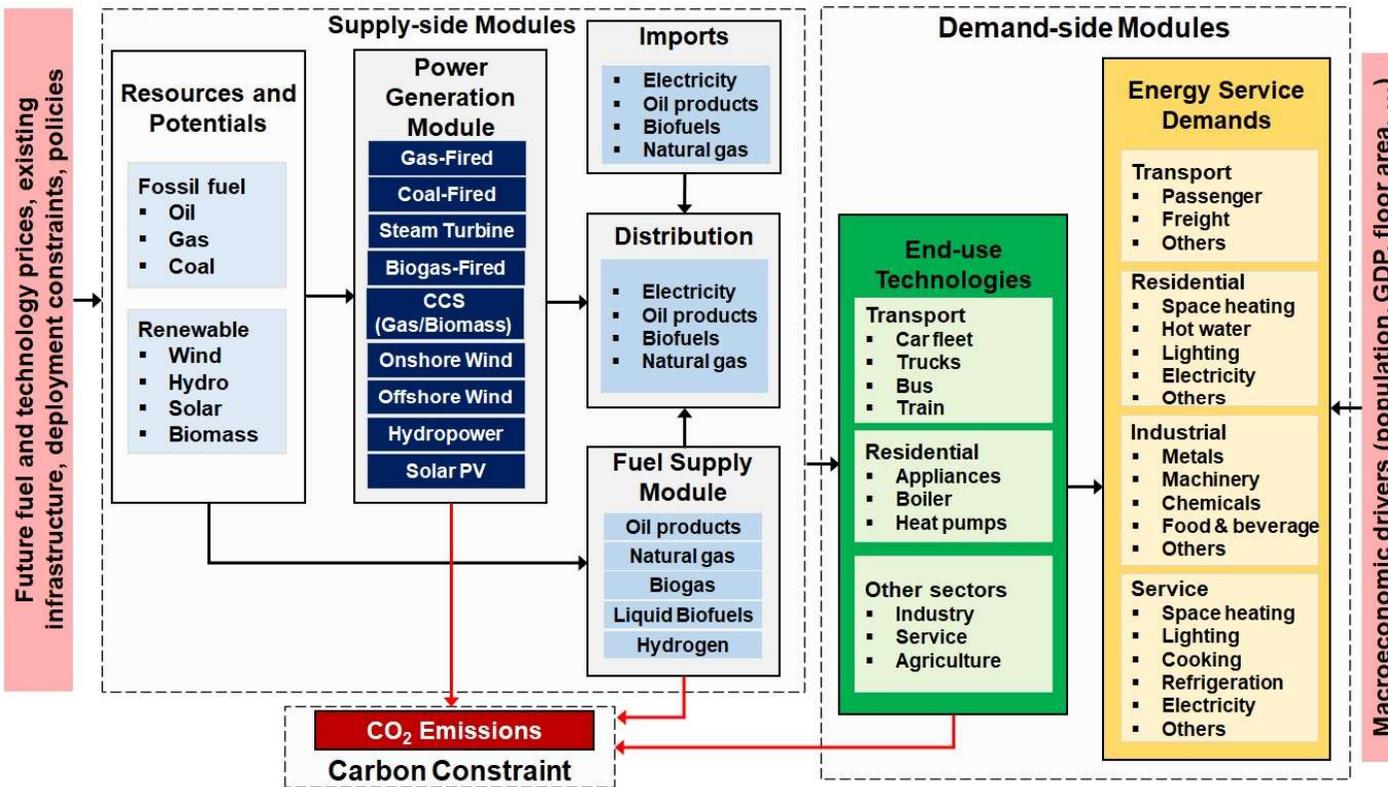
## GHG reduction 2018-2030



\*Preliminary analysis on energy & process emissions marginal abatement cost with TIMES-Ireland Model

# 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

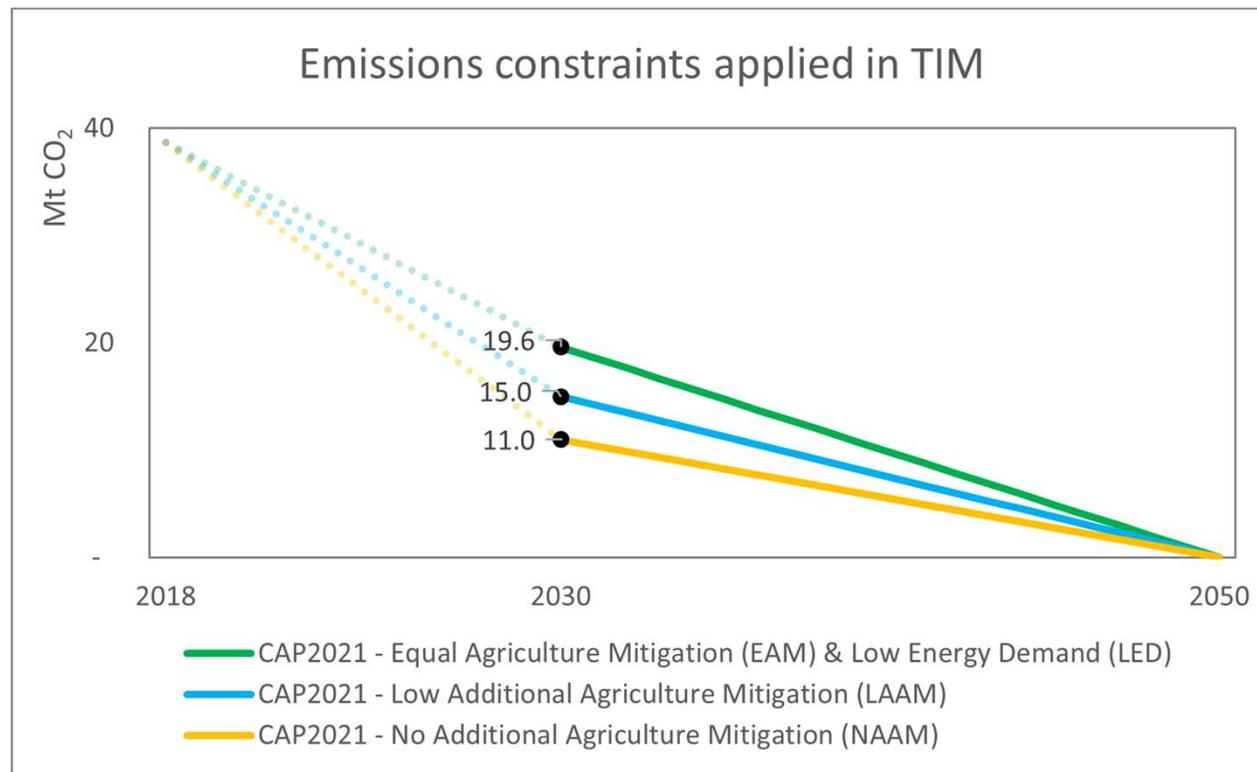
- Final energy demands
  - e.g., passenger kms, home heating
- CO<sub>2</sub> constraints on energy
  - e.g., carbon budget, annual target
- Technology, fuel costs & efficiency
  - Existing & future cost and performance
- Resource availability
  - e.g., on/offshore wind, bioenergy
- User-defined constraints
  - 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

# Demonstration of current (in-progress) results

Review version of model: <https://27-04-2021--meet-tim.netlify.app/results>



## Additional considerations

- ❖ The speed and scale of change needed across the energy system required to meet even a 51% reduction target stretches the model to the limits
  - “Here be dragons”
- ❖ Feasibility is very highly dependent on the assumed cost, availability and speed of deployment of **new** low-carbon technologies and fuels
  - CCS for cement & power, hydrogen and bioenergy (production or import), electric freight
  - Domestic bioenergy & Bio-CCS interact with agriculture, compete for land-use & negative emission credits
- ❖ Lower energy service demands can’t be modelled “endogenously”
  - Lowering transport demand, mode shift, lowering household temperatures, economic structure
  - But lowering energy demands in the “Low Energy Demand” scenario makes decarbonisation more feasible
- ❖ TIM considers costs to the system, but not all costs related to infrastructure, but does not consider who pays or what policies can achieve the target

## Key questions for scenario development

- ❖ What level of mitigation for energy vs agriculture?
- ❖ What target for 2025 – front- or backloading?
- ❖ What level of bioenergy availability (domestic and imports)? H2?
- ❖ Timing of availability of CCS & bio-CCS?
- ❖ What speed of deployment of EVs, heat pumps etc?
- ❖ What (if any) level of demand reduction?

**Thank you**

[h.daly@ucc.ie](mailto:h.daly@ucc.ie)



# Additional slides

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# TIM development team

- ❖ **Dr. Hannah Daly**
  - Lecturer in Energy Systems Modelling, UCC & Funded Investigator, MaREI
  - Co-PI CAPACITY project, PI/Supervisor of CCAC Carbon Budget Fellowship
- ❖ **Dr. Olexandr Balyk**
  - Senior postdoctoral researcher, CAPACITY project - Model coordination & integration
- ❖ **Jason McGuire**
  - PhD researcher with CAPACITY project – residential sector
- ❖ **Andrew Smith**
  - Climate Change Advisory Council & EPA Fellowship on Carbon Budgets
- ❖ **Dr. James Glynn**
  - Research Fellow & lead, CHIMERA project
- ❖ **Vahid Aryanpur**
  - PhD researcher with CHIMERA project – transport sector
- ❖ **Dr. Xiufeng Yue**
  - Former postdoc, CHIMERA project, lecturer Dalian University of Technology
- ❖ **Ankita Gaur**
  - MaREI PhD researcher – energy demand drivers



*With support from wider Energy Policy & Modelling Group at UCC & E4sma*

# Reflections on the use of TIM for informing the National Climate Objective

## 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.

# Strengths of TIM & development process

- ❖ Model to be fully **open-source** – documentation can be downloaded here: <https://tim-review1.netlify.app/documentation>
- ❖ “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** (<https://tim-review1.netlify.app/>)
- ❖ 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)

# Why model?

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- One model doesn't give a prescriptive answer, in the same way a map doesn't tell us which route to take along a journey, or what the destination is. However, models (like maps) are indispensable for considering options & routes, as tools to collect best evidence, facilitating discussion and decision-making.

## **Models help us to make meaningful, consistent narratives of energy system transformation**

- Achieving net-zero GHG energy systems require each sector to go as low as possible. Energy systems optimisation models provide a “big-picture approach”:
  - Help prevent blind-spots
  - Ensure that the best of all options are considered, respecting national constraints
  - Important to consider system-wide dynamics and trade-offs

# Near-term development timeline

- ❖ March 12-26<sup>th</sup> Expert review stage
- ❖ March 29<sup>th</sup>-April 16<sup>th</sup> Model developments in response to review comments
- ❖ By April 16<sup>th</sup> Finalised scenario results
- ❖ By April 30<sup>th</sup> Draft report to DECC
- ❖ Early May Publication of final report with interactive website
- ❖ May onwards Further model enhancements, developments, collaborations and publications.

# Scenarios for upcoming study

Scenario	Description
A. Core	Mitigation trajectory – can assume linear trajectories to 2030 and 2050 targets, based on different effort-sharing targets for agri & energy, or apply carbon budgets. Key resource and technology availability assumptions for bioenergy, wind, end-use technologies and CCS availability
B. Low Energy Demand	What if we focus on lowering energy demands?
C. High wind	What will it take for the power sector to deliver, and can it go further?
D. How far can we go in energy?	Can the energy system decarbonise deeper, faster, if agriculture does not scale up target?
E. “Green Precedent”	What if key low-carbon technologies fail to diffuse as quickly as hoped?

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