2050 Pathways Calculator for Ireland

Energy Institute

In conjunction with global accords, the European Union has committed to reducing its greenhouse gas emissions by at least 80% by 2050, relative to 1990 levels. For this to happen, we need to transform the Irish economy while ensuring access to secure and affordable low-carbon energy supplies to 2050.

We face major choices about how to move to a secure, low carbon economy over this period. Should we do more to cut demand, or rely more on increasing and decarbonising the energy supply? How will we produce our electricity? Which technologies will we adopt?

The analysis in the 2050 Pathways Model presents a framework through which to consider some of the choices and trade-offs which we will have to make over the next thirty-five years. It is system-wide, covering all parts of the economy and all greenhouse gas emissions released in Ireland. It shows that it is possible for us to meet the 80% emissions reduction target in a range of ways, and allows people to explore the combinations of effort which meet the emissions target while matching energy supply and demand.

It is rooted in scientific and engineering realities, looking at what is thought to be physically and technically possible in each sector. It allows you, as the user of the Calculator, to explore all the available options and some of their key implications.

For each choice four trajectories have been developed, ranging from little or no effort to reduce emissions (trajectory 1) to extremely ambitious changes that push towards the physical or technical limits of what can be achieved (trajectory 4). The choices for each lever should be viewed along the lines of:

1. Very little or no effort, advances toward greater efficiency are purely market driven.
2. This trajectory reflects current trends and achieves targets which require medium effort.
3. This trajectory assumes significantly more effort is applied to decarbonisation and reducing energy demand, ambitious targets are achieved and medium effort targets are exceeded.
4. Extremely ambitious, maximum physical and technical potential.

Trajectory Design

In each sector, up to four trajectories were developed to cover a broad range of possibilities and to test the boundaries of what might be possible. The trajectories have drawn on existing work undertaken by the Department of Energy and Climate Change in the UK (DECC) and publically available Irish data and research from sources such as the Sustainable Energy Authority of Ireland (SEAI), the Energy Policy and Modelling Unit in University College Cork, Eirgrid, the Environmental Protection Agency (EPA), and the Irish Central Statistics Office (CSO). References to the specific sources of data for each sector are included in the text and can be found in the endnotes in the final pages of the document.

Upon completion of the first version of the 2050 Pathways Model for Ireland we hosted a series of workshops and conducted targeted discussions to invite feedback from Irish experts in the field. A diverse range of views and expertise has been included and we are grateful for the input we have so far received. This is only the start of the conversation however and we hope that ongoing feedback will continue to refine the assumptions and the trajectory pathways in line with the latest technological developments going forward.

We aim to achieve a level of consistency across the different sectors in terms of 'level of change', so that a 'level 2' effort in one sector would be broadly comparable to a 'level 2' effort elsewhere. Although by necessity this is something of a subjective judgement, particularly when comparing very different sectors, for example offshore wind power and thermal comfort levels in buildings. In exploring pathways, it is also important to bear in mind that the 'level 4' trajectories represent heroic levels of effort or change, and as a result it might be expected that the trade-offs associated with a pathway containing level 4 ambition in one or more sectors would be particularly difficult.

Energy Demand

In determining the energy demand trajectories in the model, three key input assumptions are:

Population growth: Population grows by 0.6% on average per year in all of the demand trajectories, consistent with projections by the CSO up to 2050 under a median inward migration and low fertility scenario.[1]

Building stock growth: Housing stock and commercial buildings grow at rate of 1% on average per year in all the demand trajectories. Household growth projections typically depend on population growth, occupancy rates, and obsolescence. In this analysis we have used the population growth scenario above, with occupancy rates falling from 2.75 people per property to 2.5 in 2050, and a low (0.3%) obsolescence rate in line with latest estimates.[2]

Gross Domestic Product: The demand trajectories have been developed to be consistent with 2.5% average annual growth in Gross Domestic Product (GDP). Long term macroeconomic forecasts for Ireland range from 2% to 2.5% according to the OECD[3] and the European Commission[4] respectively. The rate of economic growth has a significant direct impact on the level of effort required to reduce emissions related to consumption of goods and services, and passenger and freight transport in the model. A higher GDP growth rate implies a high energy demand projection, increasing the level of effort required to reach an 80% reduction in emissions. The rate of change in demand for passenger transport and lighting and appliances in the commercial and residential sector under a 2.5% GDP growth assumption have been developed by the Department of Energy and Climate Change using income elasticities of demand from the UK and applied to the Irish case. Change in freight transport has been calculated separately under a 2.5% GDP growth assumption to reflect Irish haulage patterns. Change in demand for heating and cooling in the residential and commercial sector has a weaker relationship with economic growth, driven instead by varying rates of compliance with the latest building regulations, behaviour change, technology type, and the change in building stock in Ireland.

In selecting a trajectory, users can decide upon the level of effort across:

Levels of behavioural and lifestyle change: The trajectories 1-4 capture increasing levels of behavioural change to reduce energy demand and emissions such as utilisation of smart meters to manage household and commercial energy use, wasting less food, and modal shifts in passenger transport from private to public.
Levels of technological improvement and change: Reflects the development and penetration of less carbon intensive technologies, such as LED lighting or ground source heat pumps, technological advances such as new industrial processes, and improvements in transport efficiency. More ambitious trajectories may be dependent on the successful deployment of technologies still in development.
Different technological or fuel choices: Examples include choices between district heating or ground source heat pumps, or between fuel cells and batteries for cars.
Structural change: Reflects possible changes in the structure of the economy, for example a decline or resurgence in manufacturing.

Where these factors can be considered as changing levels of effort or ambition, these are described in the analysis as levels 1–4 on a similar basis to the supply side sectors. Where the changes described reflect a choice rather than a scale (for example choices of fuel or industrial activity), they are described as trajectories A, B, C, D; these choices cannot be compared between sectors.

Level 1: Assumes little to no effort to change behaviour with consumption and transport trends that we see today continuing up to 2050. Current regulations aimed at reducing emissions such as new building standards are not fully complied with. Efficiency gains in transport, lighting and appliances are purely market driven as technology develops over time.
Level 2: Level 2 broadly reflects current trends toward emission reduction. Effort to reduce emissions continue in line with short-to-medium term efficiency targets. Compliance with existing building regulations is high and some behaviour change and shifts to renewable transport occurs. While ambitious, this level of effort is considered reasonable by most experts.
Level 3: This trajectory assumes significantly more effort is applied to reducing energy demand. Significant technological breakthroughs reduce energy demand for electronic goods and structural change enable behavioural changes in transport and energy use in the home and workplace. Current targets are met and exceeded beyond 2030.
Level 4: Extremely ambitious, reflects the physical and technical potential of what could be achieved with maximum effort to reduce demand. Maximum electrification of the transport and heat sectors. For full carbon neutrality, the user should select renewable sources of electricity generation in the supply levers.

Energy Supply

The energy supply trajectories examine different energy generation sectors. These trajectories have been presented as four levels of potential roll-out of energy supply infrastructure (trajectories 1–4), representing increasing levels of effort. The levels depend on the lead time and build rate of new energy infrastructure, and different assumptions about how quickly and on what scale the infrastructure can be rolled out. The higher trajectories for electricity supply options also depend on improvements in technology, such as carbon capture and storage, and developments to address current issues associated with large scale deployment of renewable intermittent electricity sources such as non-dispatchability (the inability to turn on and off generation as with most types of thermal plants), reduced predictability, system inertia and grid frequency stability, and overall system security.[5] In practice the build rate will depend not only on the physical and technical possibilities, but also on investment decisions by the companies involved, as well as wider international developments and public acceptance.

While the Irish electricity system is technically part of a deregulated Single Electricity Market (SEM), which includes the jurisdictions of the Republic of Ireland and Northern Ireland, electricity generation (and associated emissions) in the pathways tool is for the Republic of Ireland only; electricity used domestically from the North of Ireland is captured in the electricity imports lever.

Trajectory 1: Assumes little or no attempt to decarbonise or only short run efforts. Trajectory 1 assumes no renewable energy deployment in a specific lever by 2050 offering users the option of selecting no further deployment of an un-preferred technology, to be compensated by increased effort in other sectors. Unproven low carbon technologies are not developed and coal and peat power stations in Ireland are decommissioned by 2030 with no further transition towards bioenergy.
Trajectory 2: Describes what might be achieved by applying a level of effort that is likely to be viewed as ambitious but reasonable by most or all experts. For some sectors this would be similar to the build rate expected with the successful implementation of the programmes or projects currently in progress. Renewable electricity targets up to 2020 are met, with some additional growth up to 2050. New technologies such as wave and tidal stream power come online post 2020 and carbon capture and storage is introduced in 2040.
Trajectory 3: Describes what might be achieved by applying a very ambitious level of effort that is unlikely to happen without significant change from the current system and technological breakthroughs; it assumes widespread adoption of carbon capture and storage (CCS), considerable domestic production of bio-fuel, domestic solar thermal and electricity, wave power, tidal stream devices, and offshore wind farms.
Trajectory 4: Describes a level of change that could be achieved with effort at the extreme upper end of what is thought to be physically plausible by the most optimistic observer. This level pushes towards the physical or technical limits of what can be achieved.

Other points to note

Given the need to ensure that the functioning and content of the model is manageable, it has been necessary to keep it as simple as possible. Therefore, the 2050 Pathways Calculator model does not itself make 'intelligent' judgments about which trajectories in different sectors can sensibly be combined together: the users of the model must make these judgments. A few examples of combinations unlikely to be plausible include:

- very high levels of both solar PV and solar thermal at the same time – because in practice these technologies may be competing for the same roof space;
- a thriving manufacturing industry and high levels of additional construction at the same time as a reducing demand for freight transport;
- generating electricity through non-thermal processes, while at the same time rolling out use of district heating.

Similarly, the model does not account for all possible feedbacks between trajectory levels in different sectors. Changes in one sector might be expected to have a knock-on effect in another sector, and not all of these are reflected.

Unlike some other models such as the Irish TIMES energy model, the 2050 Pathways analysis does not adopt a cost-optimisation approach, i.e. the Pathways Calculator does not identify the least costly way of meeting the 2050 target. The aim instead is to look at what might be practically and physically deliverable in each sector over the next 35 years under different assumptions.

While this analysis helps us look ahead, there are some limitations to the approach. It is not possible to predict the future and none of the pathways that this analysis describes is an optimal or preferred route. The aim of this 2050 pathways analysis is to demonstrate the scale of the changes that will be required, and the choices and trade-offs which are likely to be available to us as a society. In addition to cost, criteria such as public acceptability, land use impacts, wider environmental impacts, practical deliverability, technological risk, international dependency, business investment behaviour, and fiscal, competitive, and socioeconomic impacts are important considerations in understanding which of the potential pathways to 2050 is most desirable and most deliverable.

Finally, the model does not take account of the emissions from growing biofuels abroad, from electricity generated in other countries, or from the overseas manufacture of products which Ireland imports, as our 2050 emissions target excludes these emissions. If Ireland were to rely increasingly on imports of food, fuel, and products, it would become even more important to consider the potential global emissions impacts.

Table of Contents

Table of Figures