This note sets out a description of the Scottish TIMES milestone runs that have informed development of the draft Climate Change Plan. It discusses the main facets of each of the model milestones that were developed.

It is not possible to make comparisons across these development runs, due to technical changes to parameters which were made throughout the process, and changes in the categorisation of variables within sectors. These changes can be broadly categorised as follows, and as a result it is not possible to isolate the impact of individual changes between runs.

- BASELINE DATA: Incorporates the key statistics and information on the current energy system in Scotland, and the broader underlying drivers of future energy demand and supply. Over the course of the year these variables were updated in the model to reflect the publication of more timely information.

- FUTURE TRENDS: Reflects feedback from stakeholders and sector experts on future developments in the model's key sectors, the model's assumptions about the expected evolution and cost of new technologies and information outputted from key sector specific models that act as a point of Quality Assurance.

- POLICY ISSUES: Key policy and delivery assumptions in the model reflect the specific characteristics of the Scottish energy system and existing Scottish Government policies.

- MODELLING IMPROVEMENTS: Reflects continued refinements to the model's underlying architecture and assumptions by the contractors.

January 2016

The first model run was based on an early development version of the model delivered by E4 Tech, and was the basis for on-going model development.

February 2016

This version of the model was a 'proof of concept' in order to test the complex inter-relationships between the main energy sectors and end users but still included some placeholder data, particularly regarding agriculture and land use.

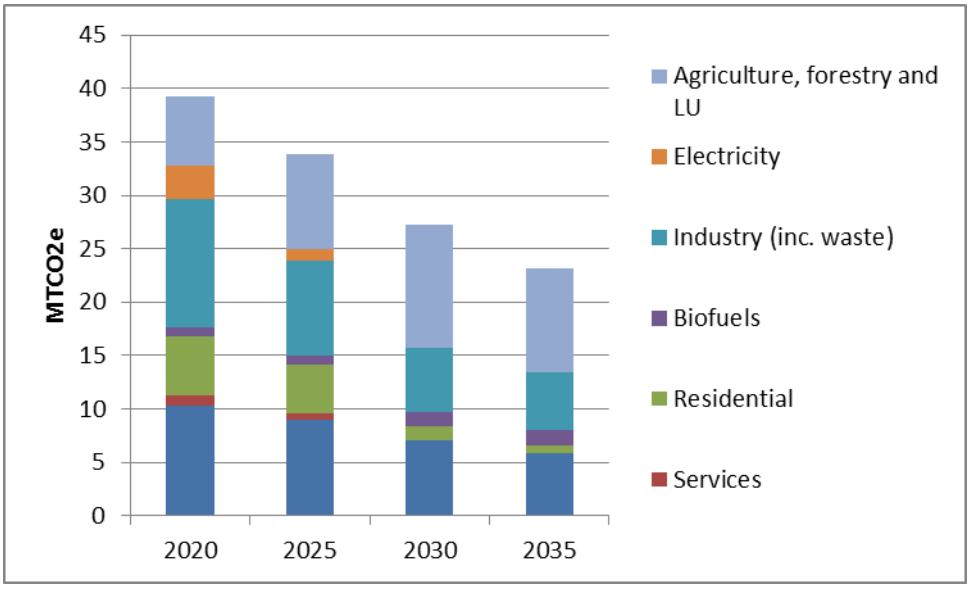
This version of the model allowed traded sector emissions to be capped at the EU Emissions Trading Scheme cap until 2020, consistent with the methodology employed in the Scottish Government's Greenhouse Gas Statistics.

Revised assumptions around GDP growth were incorporated in this model version (consistent with the Scottish Government's ambition to raise the GDP growth rate to the UK level). Scottish specific population and household growth projections were incorporated (consistent with official population and household projections); and demand projections were reviewed by sector experts and amended where appropriate. Also factored into this version was a review of the model by contractors, including all cost and efficiency data, and savings from and potential for conservation measures'. Inputs for iron & steel, food and drink and 'other' industries were updated using data from a study of Scottish industry performed by Parsons Brinkerhoff, and calibrated with sectoral emissions[1].

[1] http://www.resourceefficientscotland.com/content/decarbonisation-industry-roadmaps-scotland

District heating data on potential schemes was revised in terms of both figures and structure to make use of output from the UK National Comprehensive Assessment of District Heating and Cooling (2015), conducted by Ricardo AEA[2]. Agricultural mitigation options were sourced from SRUC's agricultural MACC[3].

The trade balance of electricity was constrained at this stage to ensure that in any given period Scotland would not be a net importer of electricity. This constraint was included so that the model could not choose to import energy in the form of electricity in order to meet Scottish territorial climate change targets.



May 2016

This version of the model reflected on-going review of input data with sectoral policy teams to ensure base data from UK TIMES is applicable in the Scottish context, and continuing quality assurance of the data inputs carried out by modelling consultants. included updating a number of technical parameters.

A number of changes to installed 2015 capacity and technical potential constraints were made, the latter via upper capacity bounds in later years. Offshore wind capacity was set at an upper bound of 0.9GW in 2020 and 1.4GW in 2025. Both solar PV and tidal capacity were constrained to a maximum 2GW in 2030, while onshore wind had an upper bound of 7.5GW in 2020, and 9.3GW in 2025. Hydro was set an upper capacity limit of 1.7GW in 2020, and 2.5GW in 2030. Finally, geothermal capacity was set an upper bound of 0.1GW by 2030.

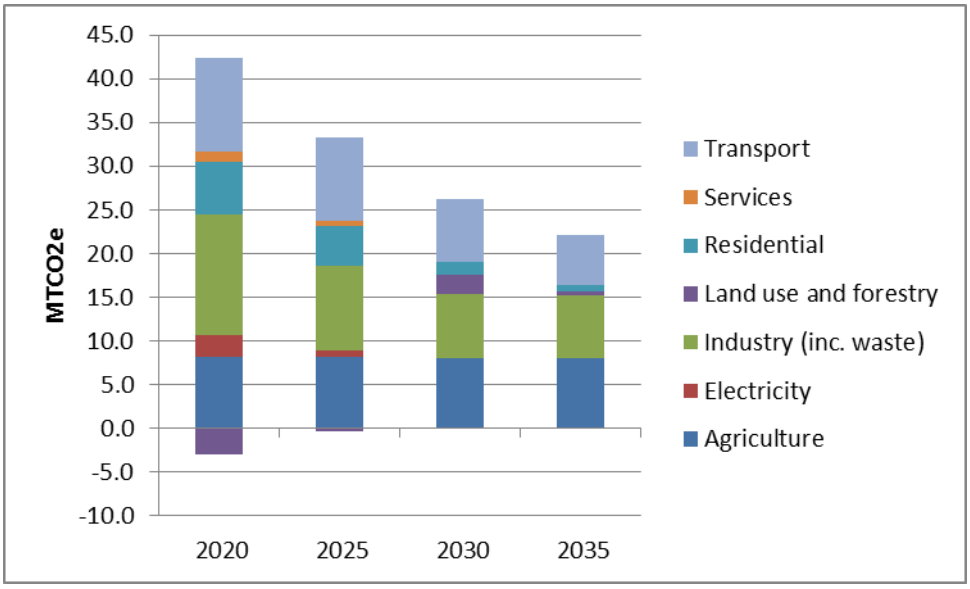
Annual planting rates were set at 10,000 hectares per annum between 2017 and 2020, increased to 12,500 for the next five years, and set at 15,000 from 2025 onwards. Peatland

[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499417/Final_NCA_Report_for_publication.pdf

[3] 'Review and update the UK Agriculture Marginal Abatement Cost Curve to assess the greenhouse gas abatement potential for the 5th carbon budget period and to 2050', Scottish Rural College (2015), https://www.theccc.org.uk/wp-content/uploads/2016/02/MACCUpdate2015_FinalReport-16Dec2015.pdf

restoration rates were fixed to a maximum of 8,600 hectares in 2015 to reflect the current status, with a 20,000 hectares per year maximum restoration rate thereafter.

Adjustments were also made to prevent measures being retired before the end of their operational life cycle, as well as to exclude prohibited measures, such as new coal without CCS – prohibited by Emissions Performance Standard (EPS).

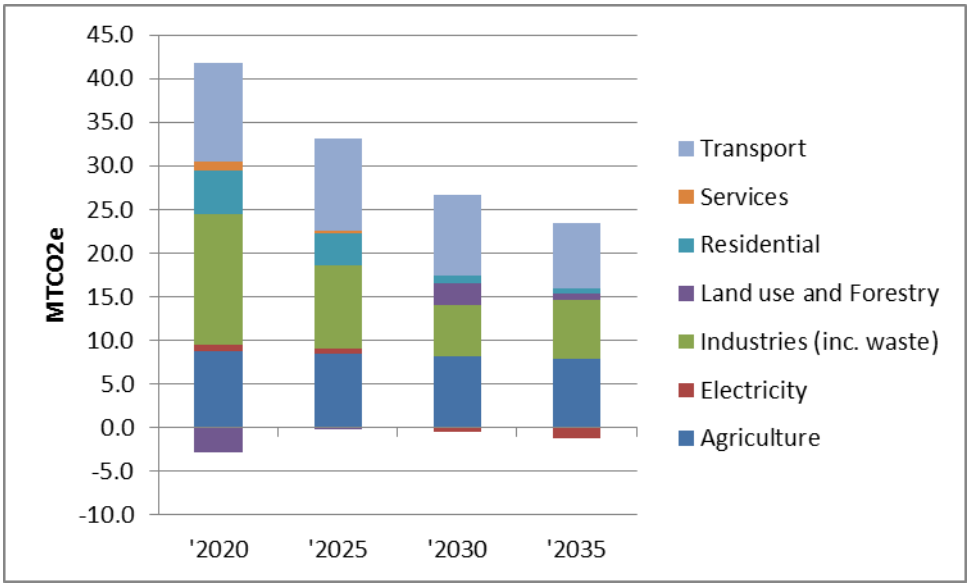


June 2016

The next iteration of the model was developed in June, and it saw a number of substantial technical changes from previous versions. These included updates in biomass availability assumptions (in particular, for grassy energy crops, straw, bio-oil, vegetable oils, wet biomass waste, biogas from landfill waste, sewage sludge and animal slurry), which were used to ensure consistency with UK TIMES, and subsequently scaled down to a Scottish level. Updated data referred to the resource used for energy purposes in the base year and future potentials (for example, grassy energy crops used for energy purposes in 2012 were updated to 0.66 PJ, straw to nearly 12 PJ, biogas from landfill waste to 4.90 PJ, and wet biomass waste to 2.94 PJ).

This run also included further changes to installed renewable electricity capacity, to reflect the data published in the same month[4]. Hydrogen data was also integrated in the model, to allow for a maximum 33% of hydrogen to be supplied via the gas grid for residential heating and hot water[5] – in addition to the pure high-pressure hydrogen networks included by default in later model versions. Assumptions inherited from UK TIMES regarding CCS potential in the electricity sector were also updated.

[4] http://www.gov.scot/Topics/Statistics/Browse/Business/Energy/energysumjun2016
[5] http://www.hse.gov.uk/research/rrhtm/rr1047.htm



September 2016

Building on model development work with sectoral teams, a further run was developed in September.

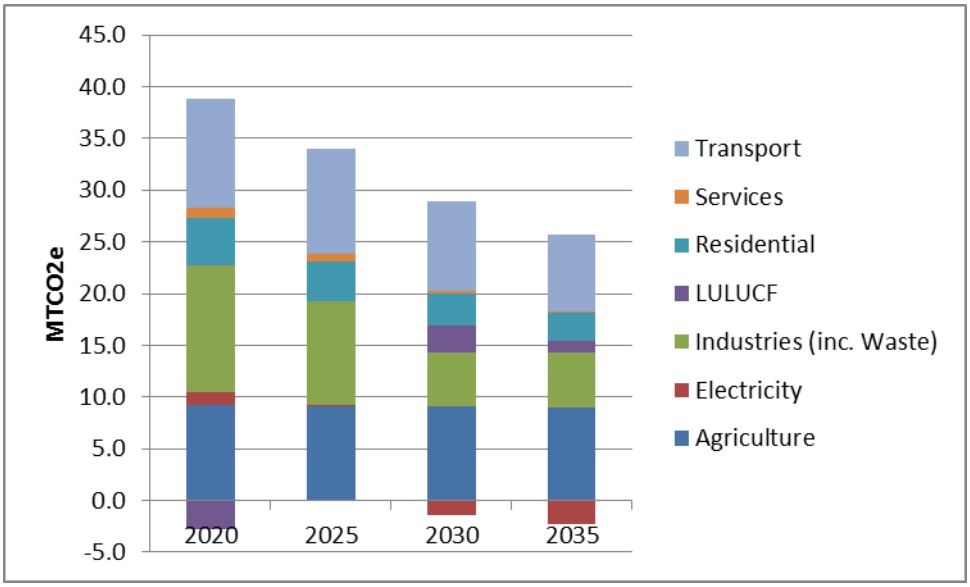
This model run adopted a number of changes in comparison with the previous model version. These included updated GHG targets that reflected CCC advice, and the requirement to make up a historic 3 MT shortfall. A further update to the agricultural mitigation options was made, based on an updated MACC from Scotland's Rural College (SRUC). The removal of peatland sequestration was also included.

There were also updates to district heating, limiting its growth between the base year and 2015 to more accurately reflect the actual level of deployment to date.

In addition, the previous model update allowing 33% Hydrogen into the gas network was further refined in this version, allowing only a 10% share of Hydrogen in the gas network mix (alongside natural gas and bio-methane). This change reflected updated information from the H21 Leeds City Gate Project[6].

This run also saw a change in fuel shares and transport efficiencies in line with Element Energy research which supported Transport sector modelling. Transport growth drivers were lowered by 50% throughout the period. This fixed an emission trajectory for Transport that saw 7.4MTCO2e emitted in 2035. A constraint was also applied to delay the shift from gas boilers in the residential and service sectors, limiting the switch of use of natural gas in boilers to 2.5% per year from the base year onwards.

[6] http://www.northerngasnetworks.co.uk/wp-content/ uploads/2016/07/H21-Report-Interactive-PDF-July-2016.pdf



October 2016

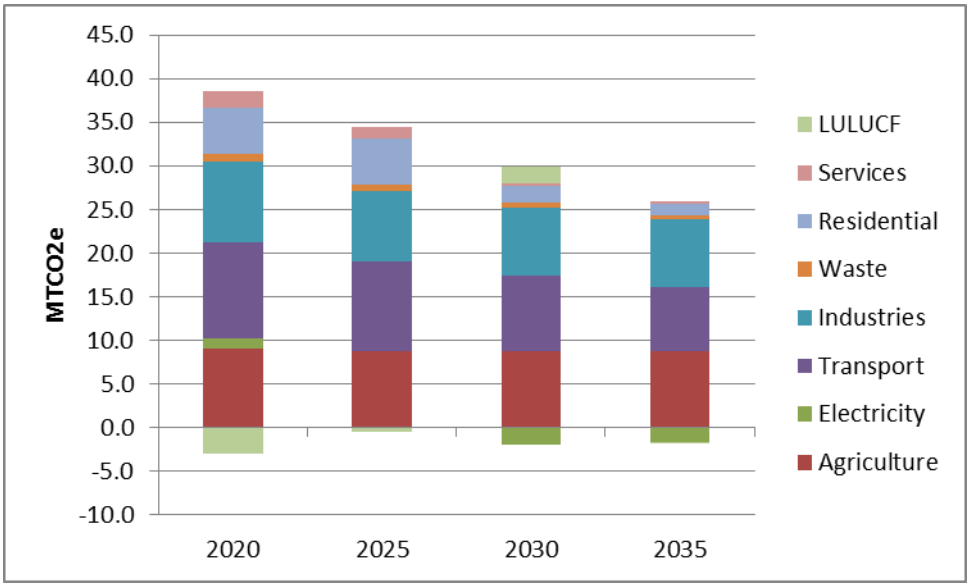
The run produced in October was based on the previous run from September, and included a revision to the overall Greenhouse Gas cap, to better reflect the CCC advice. Emissions arising from hydrogen production were also included within the cap. In LULUCF, there were updates to peatland restoration, including updating the 2012 base year peatland emission savings to nearly 0.5MTCO2e. Meanwhile, the maximum build rate of peatland restoration was set to 10,000 hectares per annum in 2017, increasing to 20,000 hectares per annum in 2020 and reforestation rates were also updated.

A revised trajectory for agriculture was incorporated following extensive review by sector experts to better reflect achievable abatement within the sector.

Within the residential and services sectors, the shares of building types that can accept conservation measures were updated, and the model was allowed to shift away from the use of natural gas in boilers for heat and hot water provision only after 2025, and then at a maximum rate of 20% per annum. This was carried out to reflect practical limitations upon how rapidly alternative technological solutions could be implemented, resulting in more proven approaches, such as conservation measures, being prioritised in earlier years of study period.

The industrial sector also saw technical revisions, with refinery efficiency altered to reflect updated data from UK TIMES. This saw the efficiency of new Combined Heat and Power plants in the refinery increase to 81% and its annual availability increase from 50% to 70%. Refining sector output was held constant over the study period to reflect economies of scale inherent in the refining sector, and the inability to scale output up and down beyond thresholds. Landfill waste management was allocated as a separate pathway from this point onwards, reflecting SG waste projections and inputted into the model.

Due to the number of technical revisions to the underlying model parameters between this run and previous runs, this run is not directly comparable with earlier runs.



December 2016

A further run was developed to reflect model development to date, and formed the basis for the final emissions envelopes set out in the draft Climate Change Plan.

This run included revised agricultural abatement figures resulting from discussions with sector leads reflecting the most recently available data. This additional abatement amounted to 1MTCO2e in 2020, increasing to 1.5MTCO2e in 2035.

This version also reverted to the original TIMES model efficiencies for transport, re-establishing consistency with UK TIMES. The fixing of transport fuel shares and the trajectory of transport emissions from Element Energy were retained in the model. The final model run also included new transport figures, with a sectoral pathway allowing for higher emissions each year, culminating in 7.9MTCO2e by 2035. This run was derived from the latest Element Energy data.