Overview of SSAT (Scenario Sustainability Assessment Tool)

Introduction

The SSAT spreadsheet tool allows estimation of the techno-economic, environmental and social impacts of potential future electricity mixes for the UK. The technologies within the user-defined electricity mixes are currently limited to coal (with and without carbon capture and storage), natural gas, nuclear, offshore wind, solar PV and large-scale biomass (wood and miscanthus).

SSAT enables evaluation of the following characteristics:

Techno-economic indicators

- Levelised cost (capital, O&M, fuel and total)
- Fuel price sensitivity
- Lifetime of fuel reserves
- Financial incentives at current rates
- Technical and economic load-following ability
- Capacity factor
- Availability factor
- Technological lock-in resistance
- Construction time

Environmental indicators

- Carbon footprint (global warming potential)
- Ozone layer depletion potential
- Acidification potential
- Eutrophication potential
- Photochemical smog potential
- Water eco-toxicity potentials (freshwater and marine)
- Terrestrial eco-toxicity potential
- Land occupation
- Recyclability

Social indicators

- Employment (total and direct)
- Human toxicity potential
- Human health impacts from radiation
- Worker injuries
- Large accident fatalities
- Waste needing long-term storage (radioactive waste and CO_2 from CCS)
- Nuclear proliferation
- Depletion of resources (elements and fossil fuels)
- Diversity of fuel supply
- Fuel storage capabilities
- Fossil fuel avoided

The tool has been developed with the following objectives in mind:

- to enable formulation of user-defined future electricity mixes for the UK to 2070, with the option of using the SPRIng scenarios as a basis;
- to enable easy calculation of the life cycle techno-economic, environmental and social impacts of potential electricity mixes;
- to identify trade-offs between the sustainability impacts of each defined scenario.

SSAT overview

The tool has been developed in Microsoft Excel. Macros must be enabled for certain features to work. The initial worksheet, labelled 'START HERE', can be edited by the user, while all other worksheets are locked and inaccessible in order to prevent accidental changes to the database and formulae in the tool. If access to the locked sheets is desired, the password is 'SPRIng' (case sensitive).

The sustainability impacts in the SSAT database were calculated as part of the SPRIng project [1] using the methodology developed by Stamford & Azapagic [2]. The life cycle assessment impacts within the tool use the CML methodology [3].

Defining scenarios in SSAT

Figure 1 shows the initial worksheet, 'START HERE'. This worksheet is where scenarios are defined, including electricity consumption and the electricity mix in each reference year (2020, 2035, 2050 and 2070). Up to five scenarios can be defined by the user. An approximated mix[1] is also given for 2009 to be used as a baseline.

	Year		Annual electricity consumption (GWh)	Contribution of each technology to the electricity mix (%)								
				Coal	*Natural gas*	*Nuclear*	*Offshore wind*	*Domestic solar*	*Coal CCS*	*Biomass (wood pellets, large-scale)*	*Biomass (miscanthus pellets, large-scale)*	*TOTAL*
Base year	2009		375,663	29.4%	45.3%	19.4%	2.6%	0.0%	0.0%	1.6%	1.6%	100.0%
Electricity mix 1	2020	Base on SPRIng scenario... A B C D	336,375	34.00%	51.50%	8.12%	3.00%	0.40%	0.00%	1.50%	1.50%	100.02%
	2035		376,729	21.00%	49.60%	2.35%	9.00%	2.00%	13.00%	1.50%	1.50%	99.95%
	2050		407,855	4.00%	33.00%	2.17%	15.80%	3.00%	39.00%	1.50%	1.50%	99.97%
	2070		455,539	2.00%	11.00%	0.00%	22.00%	7.00%	55.00%	1.50%	1.50%	100.00%
Electricity mix 2	2020	Base on SPRIng scenario... A B C D	336,375	32.00%	50.00%	11.66%	3.00%	0.30%	0.00%	1.50%	1.50%	99.96%
	2035		376,729	23.00%	39.15%	18.17%	6.00%	1.50%	8.00%	2.10%	2.10%	100.02%
	2050		407,855	8.00%	23.00%	28.48%	10.00%	3.00%	22.00%	2.75%	2.75%	99.98%
	2070		455,539	3.00%	14.00%	30.10%	20.00%	8.00%	20.00%	2.45%	2.45%	100.00%
Electricity mix 3	2020	Base on SPRIng scenario... A B C D	352,339	23.00%	50.00%	7.75%	11.00%	1.00%	2.75%	2.25%	2.25%	100.00%
	2035		383,940	0.00%	10.00%	2.31%	38.00%	20.00%	20.00%	4.85%	4.85%	100.01%
	2050		535,115	0.00%	0.00%	1.65%	39.00%	34.00%	0.40%	12.45%	12.45%	99.95%
	2070		483,676	0.00%	0.00%	0.00%	41.00%	41.00%	0.20%	8.90%	8.90%	100.00%
Electricity mix 4	2020	Base on SPRIng scenario... A B C D	352,339	23.00%	46.00%	14.52%	9.00%	1.00%	3.00%	1.75%	1.75%	100.02%
	2035		383,940	1.00%	11.00%	42.09%	25.00%	6.90%	6.00%	4.00%	4.00%	99.99%
	2050		535,115	0.00%	0.00%	46.91%	30.00%	12.70%	0.40%	5.00%	5.00%	100.01%
	2070		483,676	0.00%	0.00%	50.07%	26.00%	13.90%	0.00%	5.00%	5.00%	99.97%
Electricity mix 5	2020	Base on SPRIng scenario... A B C D	352,339	21.00%	54.40%	11.14%	9.00%	1.00%	0.00%	1.75%	1.75%	100.04%
	2035		383,940	14.90%	30.00%	22.10%	19.00%	3.00%	5.00%	3.00%	3.00%	100.00%
	2050		535,115	2.00%	14.00%	27.83%	31.00%	10.00%	8.00%	3.60%	3.60%	100.03%
	2070		483,676	0.00%	1.00%	28.96%	36.00%	16.00%	9.00%	4.50%	4.50%	99.96%

Figure 1: The 'START HERE' worksheet in SSAT

In each scenario, the electricity mix from 2020 to 2070 is entered manually by the user. Electricity consumption levels can also be defined by the user or alternatively taken from the SPRIng scenarios by

[1] The 2009 mix is approximated due to the limited number of technologies available in SSAT: the contribution of each available technology is linearly scaled upwards to replace the output from technologies that have not been modelled in SSAT (such as hydro and biogas). Thus natural gas, for instance, provided 44.6% of electricity in 2009, but this is upscaled to 45.3% in the approximated mix.

clicking the appropriate button (A, B, C or D). In the latter case, the resulting electricity demand profiles are based on the following storylines:

A largely business as usual; limited action is taken to mitigate climate change

B UK carbon targets are met by electrifying some services; electricity demand increases

C UK carbon targets are met, but electricity (and overall energy) demand is extremely high

D very aggressive decarbonisation; electricity demand increases initially then subsides

Assessing the impacts of the defined scenarios

Worksheets are labelled so that each scenario is referred to as 'ETMix': for example, worksheets labelled 'ETMix1' refer to electricity mix 1, 'ETMix2' to electricity mix 2, etc.

Once a scenario has been defined, the impacts are shown in the corresponding worksheet labelled 'graphs over time' (e.g. 'ETMix1 graphs over time'). As shown in Figure 2, these worksheets begin by showing the electricity produced by each technology over time, followed by graphs of each impact from 2009 to 2070. Error bars on these graphs, where applicable, illustrate the potential range of values under differing assumptions, while the solid line represents the best estimate. The tabulated results that underpin the graphs can be found to the right of the graph area.

Electricity mix (TWh)	Nuclear	Coal	Coal CCS	Gas	Offshore wind	Solar PV	Biomass wood	Biomass miscanthus
2009	73.01	110.53	0.00	170.10	9.83	0.02	6.08	6.08
2020	27.31	114.37	0.00	173.23	10.09	1.35	5.05	5.05
2035	8.85	79.11	48.97	186.86	33.91	7.53	5.65	5.65
2050	8.85	16.31	159.06	134.59	64.44	12.24	6.12	6.12
2070	0.00	9.11	250.55	50.11	100.22	31.89	6.83	6.83

Figure 2: The 'ETMix1 graphs over time' worksheet in SSAT

Once several scenarios have been defined, the 'Comparison of scenarios' worksheet can be used to identify their relative strengths and weaknesses and the trade-offs made in choosing one scenario over another. As shown in Figure 3, the electricity mix over time is shown for each scenario at the top of the worksheet. Underneath are graphical plots comparing the indicator results for each scenario. The tabulated results that underpin the graphs can be found to the right of the graph area.

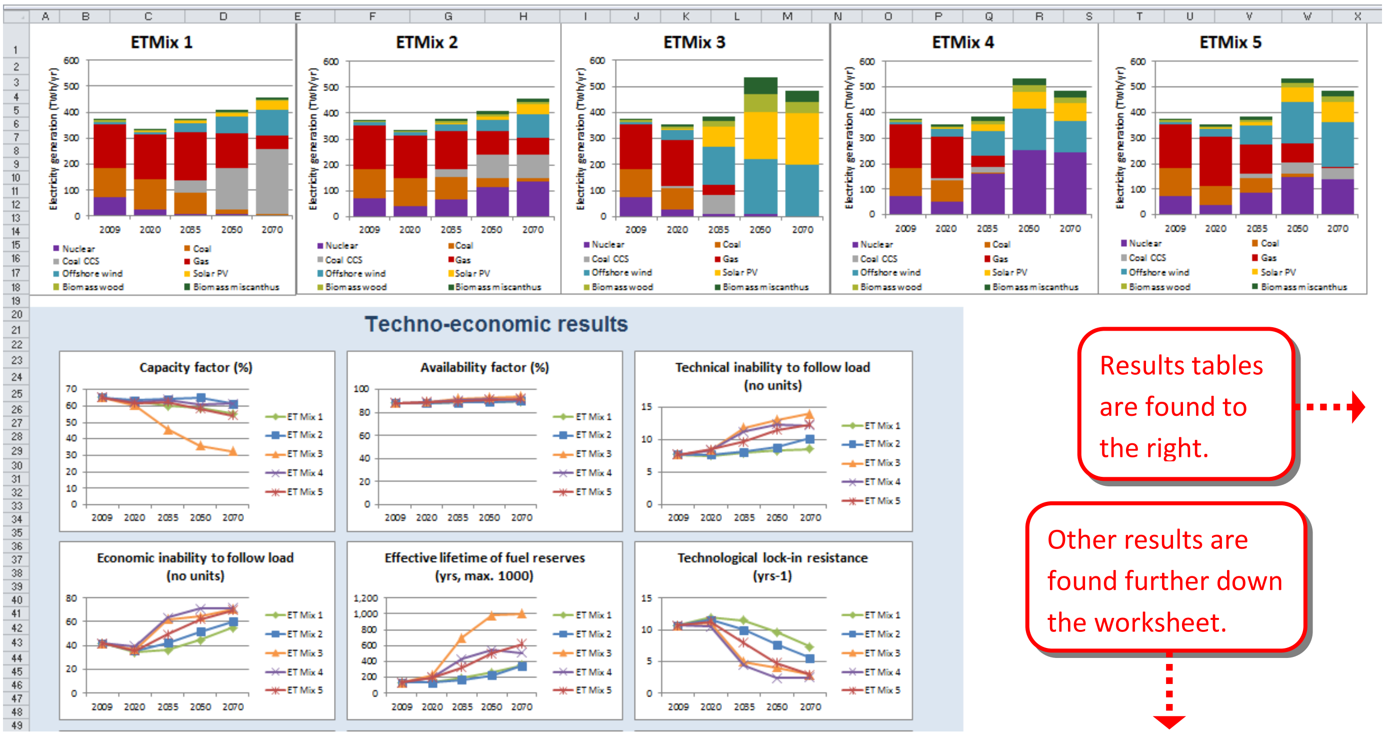

Figure 3: The 'Comparison of scenarios' spreadsheet in SSAT

Acknowledgements

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References

1. *SPRIng: Sustainability Assessment of Nuclear Power: An Integrated Approach*. 2008-2011, University of Manchester: http://www.springsustainability.org/.
2. Stamford, L. and Azapagic, A., *Sustainability indicators for the assessment of nuclear power.* Energy, 2011. **36**(10): p. 6037-6057.
3. Guinée, J.B., Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., Koning, A.d., Oers, L.v., Wegener Sleeswijk, A., Suh, S., Udo de Haes, H.A., Bruijn, H.d., Duin, R.v., and Huijbregts, M.A.J., *Handbook on life cycle assessment: Operational guide to the ISO standards.* 2002, Dordrecht: Kluwer Academic Publishers,. 692.