Overview of the ETLCA tool (Energy Technologies Life Cycle Assessment)

Introduction

The ETLCA spreadsheet tool allows quick and easy estimation of the life cycle environmental impacts of potential future electricity mixes for the UK. It enables estimation of:

- Direct carbon emissions;
- 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;
- Human toxicity potential;
- Human health impacts from radiation; and
- Depletion of resources (elements and fossil fuels).

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 and carbon constraints as a basis;
- to enable easy calculation of the life cycle environmental impacts of potential electricity mixes;
- to identify trade-offs between the environmental impacts of each defined scenario.

ETLCA overview

The tool has been developed in Microsoft Excel. The worksheet labelled 'SPRIng scenarios' and all sheets labelled 'ETMix' can be edited by the user. All other worksheets are locked and are 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 direct carbon emissions and life cycle environmental impacts in the ETLCA database were calculated as part of the SPRIng project [1], drawing on the Ecoinvent [2] and NEEDS [3] databases. The LCA impacts use the CML methodology [4].

Defining scenarios in ETLCA

Figure 1 shows the initial worksheet, 'SPRIng scenarios'. This worksheet acts as a reference to the scenarios developed in the SPRIng project, which describe four potential futures with differing electricity demand

profiles and direct carbon emissions[1], spanning the years 2020 to 2070. These scenarios can be altered by the user.

A single ETLCA spreadsheet only describes one of the four scenarios in the 'SPRIng scenarios' worksheet. This is to allow the user to generate several different sub-scenarios, all of which meet the electricity consumption and carbon constraint profiles of the selected scenario, without over-complication. The sub-scenarios are defined in the 'ETMix' worksheets.

	A	B	C	D	E	F	G
1	**Scenario**	**Summary**	**Year**	**Electricity consumption (GWh)**	**Change of electricity consumption relative to today (2008) (%)**	**Direct carbon emissions (Mt C)**	**Carbon reduction relative to 1990 (%)**
2	**A**	Based on the UKERC "Faint hearted" scenario: There is limited action to reduce carbon emissions.	2020	336,375	-11	48.03	17
3			2035	376,729	1	40.36	30
4			2050	407,855	9	20.36	65
5			2070	455,539	18	11.83	80
6	**B**	Based on the UKERC "Carbon Ambition" scenario: Overall carbon emissions are reduced broadly in line with UK targets. Overall energy use is reduced but the use of electricity increases moderately. Electricity is decarbonised by 2050.	2020	352,339	-6	39.31	32
7			2035	383,940	3	5.88	90
8			2050	535,115	30	0.06	100
9			2070	483,676	23	0.03	100
10	**C**	Same as Scenario B but electricity use increases three fold compared to 2008.	2020	409,738	9	37.68	35
11			2035	891,011	58	19.40	67
12			2050	1,099,819	66	0.00	100
13			2070	1,189,303	69	0.02	100
14	**D**	Carbon emissions are reduced at a rate that, if replicated globally, would give a high probability of limiting the global temperature increase to 2 degree C. The use of electricity increases only moderately and it is decarbonised by 2025.	2020	408,772	9	16.07	72
15			2035	499,428	25	0.05	100
16			2050	455,233	18	0.05	100
17			2070	389,221	4	0.05	100
18							
19	The scenarios can be changed according to user needs - click on any of the tabs labelled "ETMix" to enter your own electricity mix and carbon targets.						
20	All other tabs are protected to prevent accidential change. The password for these tabs is "SPRIng" (case sensitive).						
21							
22	The ETLCA model was developed by Victor Kouloumpis, Adisa Azapagic and Laurence Stamford as part of the SPRIng project, funded by the EPSRC and ESRC						
23	(www.springsustainability.org)						

Figure 1: The 'SPRIng scenarios' worksheet in ETLCA

Defining sub-scenarios in ETLCA

The 'ETMix' worksheets allow the user to define sub-scenarios based on the electricity consumption figures and carbon constraints specified in earlier. Four sub-scenarios can be defined, designated (1), (2), (3) and (4). As shown in Figure 2, electricity consumption figures and carbon constraints for each year (2020, 2035, 2050 and 2070, plus the base year, 2008) are inserted in the orange cells. The electricity mix in each year can then be defined by the green cells. Yellow cells at the bottom of the sheet are simply to record the main assumptions of the sub-scenario (whether or not new nuclear power and carbon capture and storage (CCS) are included).

Columns G to K then calculate the electricity produced by each power source in each year.

[1] 'Direct carbon emissions' refers to carbon emitted directly by power stations in the UK. Thus the figures do not include other greenhouse gases or life cycle stages.

1. Enter electricity consumption and carbon limits for each year here, according to the scenario specifications

2. Enter the desired electricity mix for each year in the green cells, checking that the total sums to 100%

	A	B	C	D	E	F	G	H	I	J	K
1	SCENARIO D (1)	Contribution of different technologies to the electricity mix (%)					Electricity supply by technology (GWh)				
2	Year	2008	2020	2035	2050	2070	2008	2020	2035	2050	2070
3	Electricity (GWh)	372160	408772	499428	455233	389221					
4	Carbon limit for direct emissions (Mt C)	54.53	16.07	0.05	0.05	0.05					
5	Nuclear	13.2%	6.3%	1.7%	1.8%	0.0%	49096	26570	8490	8194	0
12	Coal	31.5%	0.0%	0.0%	0.0%	0.0%	117230	0	0	0	0
22	Natural Gas	45.0%	37.0%	0.0%	0.0%	0.0%	167472	151246	0	0	0
28	Oil	1.5%					5707				
29	Wind Onshore	1.5%	14.0%	20.0%	21.8%	21.8%	5418	57228	99886	99241	84850
33	Wind Offshore	0.3%	22.0%	33.4%	35.0%	34.1%	1221	89930	166809	159332	136616
41	Solar	0.0%	0.9%	0.3%	0.3%	0.3%	17	3679	1498	1366	1168
48	Marine	0.0%	1.0%	15.0%	15.0%	15.0%	0	4088	74914	68285	58383
51	Biomass	2.6%	14.0%	25.0%	25.0%	25.0%	9668	57228	124857	113808	97305
57	Hydro	1.3%	1.6%	1.2%	1.2%	1.2%	4834	6540	5993	5463	4671
58	Coal CCS	0.0%	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
61	Gas CCS	0.0%	0.0%	3.0%	1.7%	1.6%	0	0	14983	7739	6228
64	Imports	3.1%	3.0%	0.0%	0.0%	0.0%	11500	12263	0	0	0
65	Total	100.0%	100.0%	99.6%	101.8%	100.0%	372163	408772	497431	463428	389221
66											
67	Assumptions:	New nuclear bu	No								
68		CCS	Yes								

3. Record basic assumptions about whether or not new nuclear build and CCS occur here

4. Electricity production by technology type is calculated here (blue cells)

Figure 2: Defining a sub-scenario in one of the four ETMix worksheets (part one)

After the electricity mix in each year has been defined, direct carbon emissions from electricity generation are calculated in columns L to P (see Figure 3). Based on the carbon constraints specified in the scenario, cells Q3 to U3 will then show whether the electricity mixes that have been entered are acceptable or not by displaying 'accept' or 'problem'. The cells underneath give an indication of how far the electricity mix is from satisfying the carbon constraint in each particular year.

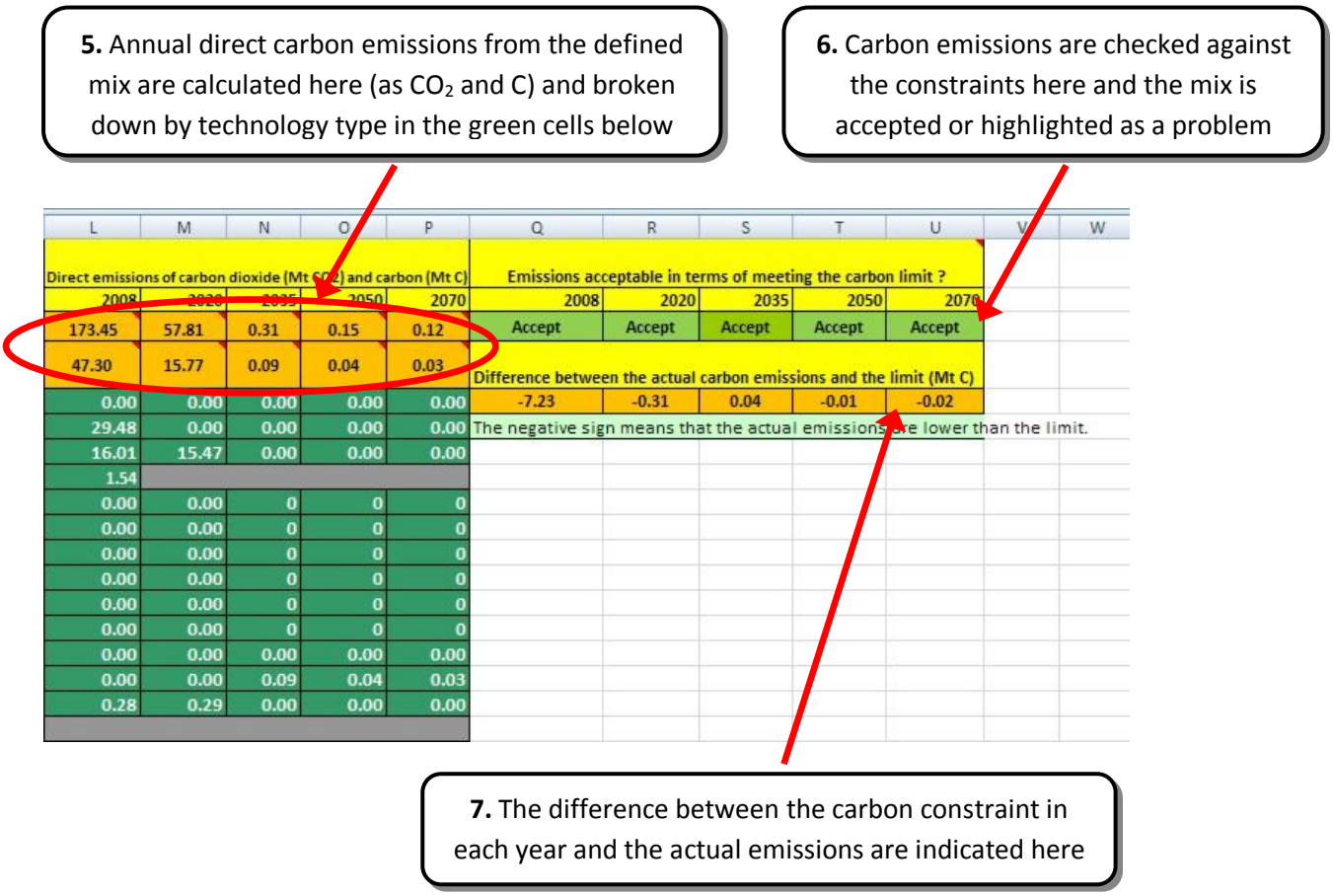

Figure 3: Defining a sub-scenario in one of the four ETMix worksheets (part two)

Assessing the impacts of the defined sub-scenarios

Once the four sub-scenarios have been defined, the worksheets named 'LCA…' provide graphs of each sub-scenario, showing the contribution of each technology to the overall impact in each year.

The final worksheet, 'Scenarios Comparison', provides a graphical representation of how the defined sub-scenarios differ in respect to their environmental impacts over time. This allows the user to identify trade-offs between the defined sub-scenarios and highlights areas of interest which can then be examined in more detail by looking at the relevant 'LCA…' worksheet.

The 'LCA…' worksheets and the 'Scenarios Comparison' worksheet are locked to avoid accidental changes (password: 'SPRIng').

Acknowledgements

The ETLCA model was developed by Victor Kouloumpis, Adisa Azapagic and Laurence Stamford as part of the SPRIng project, funded by the EPSRC and ESRC (www.springsustainability.org).

References

1. *SPRIng: Sustainability Assessment of Nuclear Power: An Integrated Approach*. 2008-2011, University of Manchester: http://www.springsustainability.org/.
2. Ecoinvent Centre, *Ecoinvent database v2.2*. 2010, Swiss Centre for Life Cycle Inventories: St Gallen, Switzerland.
3. NEEDS. *The NEEDS Life Cycle Inventory Database: The European reference life cycle inventory database of future electricity supply systems*. [cited July 2011]; Available from: http://www.needs-project.org/needswebdb/index.php.
4. 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.