European Commission

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WELL-TO-TANK Appendix 2 - Version 4a

Summary of energy and GHG balance of individual pathways

WELL-TO-WHEELS ANALYSIS OF FUTURE AUTOMOTIVE FUELS AND POWERTRAINS IN THE EUROPEAN CONTEXT

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WELL-TO-TANK (WTT) REPORT – APPENDIX 2

VERSION 4a, APRIL 2014

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WTT APPENDIX 2

Summary of energy and GHG balance of individual pathways

This appendix summarises the results for individual pathways.

Energy figures are expressed as net energy *expended* (i.e. excluding the energy transferred to the final fuel) per MJ energy content of the final fuel. "Total" refers to all energy excluding fossil, nuclear and renewable. The shares of fossil, nuclear and renewable energy in the total are indicated separately in the tables. The figures shown for individual steps of a pathway all refer to final fuel i.e. as the contribution of each step to the total.

Note: The use of the EU-mix electricity as a generic power source for e.g. transport or operation of refuelling stations introduces a small amount of renewable energy in most pathways. Statistical data are from 2009 for European electricity production and from 2011 for natural gas production.

GHG figures are expressed in g CO_2eq (per MJ of the final fuel) as the sum of the contributions of CO_2, CH_4 and N_2O taking into account their respective Global Warming Potential (GWP). Individual contributions are also shown. The figures shown for each step of a pathway exclude the CO_2 emissions associated with the combustion of the final fuel which is shown separately. For carbon-containing fuels of renewable origin a credit is given for an amount of CO_2 equivalent to that released during combustion.

The GHG figures transferred to the WTW section of the study include the renewable emissions credit. In the TTW section all fuels are therefore treated in the same way and allocated CO_2 emissions corresponding to their carbon content regardless of its origin.

The best estimate and the range of variability are given for both energy and GHG. The ranges are obtained via a Monte Carlo simulation combining the range of variation of individual processes (see ***WTT Appendix 4***). The minimum value is taken as P20 (20% of observed values will be below that value) and the maximum as P80. The range of energy variation is also indicated for those steps that make a significant contribution.

In order to facilitate comparison of pathways of a different nature the table regroups the actual processes into five standard stages namely:

Stage 1: Production and conditioning at source
Includes all operations required to extract, capture or cultivate the primary energy source. In most cases, the extracted or harvested energy carrier requires some form of treatment or conditioning before it can be conveniently, economically and safely transported.

Stage 2: Transformation at source
Is used for those cases where a major industrial process is carried out at or near the production site of the primary energy (e.g. gas-to-liquids plant).

Stage 3: Transportation to market
Is relevant to energy carriers which are produced outside the EU market and need to be transported over long distances. This step is also used where a significant transport vector is required to move the raw material to a processing plant (e.g. biomass).

Stage 4: Transformation near market
Includes the processing and transformation that takes place near the market place in order to produce a final fuel according to an agreed specification (e.g. oil refineries or hydrogen reformers).

Stage 5: Conditioning and distribution
Relates to the final stages required to distribute the finished fuels from the point of import or production to the individual refuelling points (e.g. road transport) and available to the vehicle tank (e.g. compression in the case of natural gas).

WTT APPENDIX 2

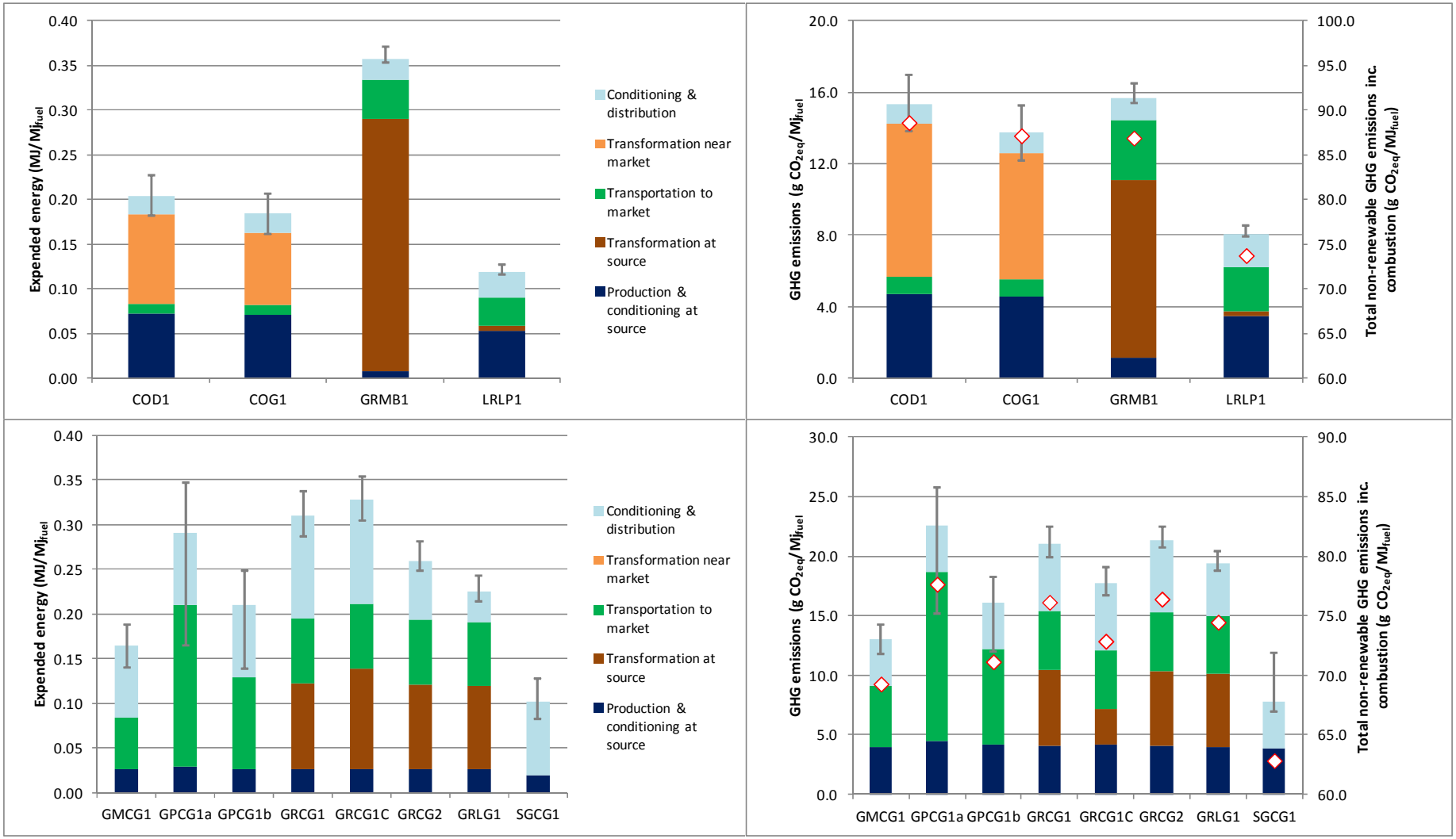
Pathway list

1 Summary of energy and GHG balances

1.1 Oil-based fuels and CNG

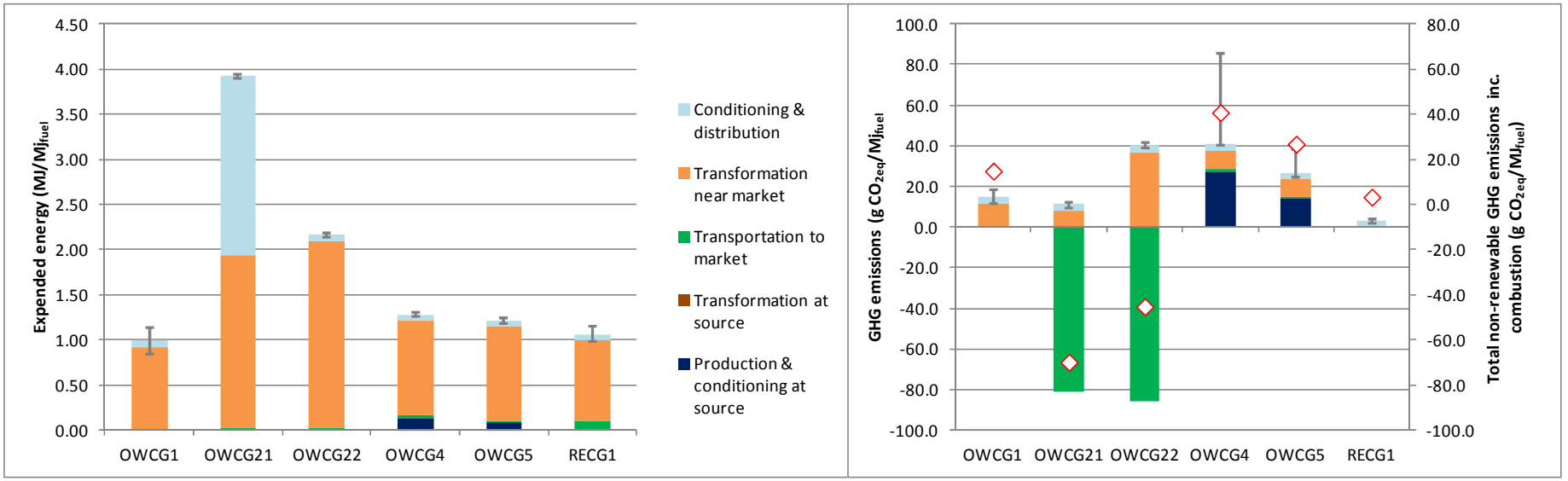
Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	
Conventional fossil fuels																							
COD1	Diesel	**0.20**	0.20	0.01	0.00	*0.7%*	0.07		0.01	0.10	0.02	0.18	0.23	**15.4**	4.7		1.0	8.6	1.1	13.8	17.0	88.6	
COG1	Gasoline	**0.18**	0.18	0.01	0.00	*0.8%*	0.07		0.01	0.08	0.02	0.16	0.21	**13.8**	4.6		1.0	7.0	1.2	12.2	15.3	87.1	
MTBE																							
GRMB1	MTBE: remote plant	**0.36**	0.35	0.01	0.00	*0.5%*	0.01	0.28	0.04		0.02	0.35	0.37	**15.6**	1.1	9.9	3.4		1.2	15.4	16.5	86.9	
LPG																							
LRLP1	LPG (remote)	**0.12**	0.11	0.00	0.00	*1.0%*	0.05	0.00	0.03		0.03	0.12	0.13	**8.0**	3.5	0.3	2.5		1.8	7.9	8.5	73.7	
CNG																							
GMCG1	EU-mix	**0.17**	0.13	0.03	0.01	*4.5%*	0.03		0.06		0.08	0.14	0.19	**13.0**	4.0		5.1		3.9	11.8	14.3	69.3	
GPCG1a	Pipeline 7000 km	**0.29**	0.26	0.03	0.01	*2.5%*	0.03		0.18		0.08	0.17	0.35	**22.6**	4.4		14.3		3.9	15.2	25.7	77.6	
GPCG1b	Pipeline 4000 km	**0.21**	0.18	0.03	0.01	*3.5%*	0.03		0.10		0.08	0.14	0.25	**16.1**	4.1		8.1		3.9	12.0	18.2	71.1	
GRCG1	LNG, vap, pipe	**0.31**	0.28	0.03	0.01	*2.4%*	0.03	0.10	0.07		0.12	0.29	0.34	**21.1**	4.1	6.3	4.9		5.7	19.9	22.4	76.1	
GRCG1C	LNG+CCS, vap, pipe	**0.33**	0.29	0.03	0.01	*2.3%*	0.03	0.11	0.07		0.12	0.31	0.35	**17.8**	4.1	3.0	4.9		5.7	16.7	19.1	72.9	
GRCG2	LNG, road, vap	**0.26**	0.25	0.01	0.00	*0.5%*	0.03	0.10	0.07		0.07	0.25	0.28	**21.3**	4.1	6.3	4.9		6.1	20.7	22.5	76.4	
GRLG1	LNG, road	**0.22**	0.22	0.00	0.00	*0.1%*	0.03	0.09	0.07		0.03	0.21	0.24	**19.4**	4.0	6.2	4.8		4.4	18.8	20.4	74.5	
SGCG1	Shale gas (EU)	**0.10**	0.07	0.03	0.01	*7.3%*	0.02				0.08	0.08	0.13	**7.8**	3.9				3.9	7.0	11.9	62.8	

WTT APPENDIX 2



1.2 Biogas and synthetic methane

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)								Total GHG inc. combustion	% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range			
CBG																							
OWCG1	Municipal waste	**0.99**	0.18	0.15	0.67	*67.3%*				0.92	0.07	0.84	1.13	**14.8**				11.5	3.3	11.3	18.1	14.8	
OWCG21	Liquid manure (closed storage)	**2.01**	0.15	0.09	1.77	*88.3%*	0.00	0.02		1.92	0.07	1.98	2.03	**-69.9**	-82.4	1.4		7.9	3.3	-71.3	-68.8	-69.9	
OWCG22	Liquid manure (open storage)	**2.17**	0.15	0.09	1.93	*88.9%*	0.00	0.02		2.08	0.07	2.14	2.19	**-45.2**	-87.1	1.5		37.1	3.3	-46.6	-44.2	-45.2	
OWCG4	Maize (whole plant)	**1.28**	0.29	0.10	0.89	*69.5%*	0.14	0.02		1.05	0.07	1.25	1.30	**40.8**	27.4	1.4		8.7	3.3	40.4	85.7	40.8	
OWCG5	Barley/maize (double cropping) whole plant	**1.22**	0.23	0.10	0.89	*72.9%*	0.09	0.01		1.05	0.07	1.19	1.24	**26.8**	14.1	0.6		8.7	3.3	24.3	38.4	26.8	
RECG1	Synthetic methane	**1.06**	0.04	0.03	1.00	*94.0%*	0.00		0.10	0.89	0.07	0.98	1.15	**3.3**	0.0		0.0	0.0	3.3	2.2	4.0	3.3	



1.3 Ethanol

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)													% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	
Conventional fossil fuels																											
COG1	Gasoline	**0.18**	0.18	0.01	0.00	*0.8%*	0.07		0.01	0.08	0.02	0.16	0.21	**13.8**	4.6		1.0	7.0	1.2	12.2	15.3	87.1	
Ethanol																											COG1
SBET1a	Sugar beet, pulp to AF, slops not used	**1.45**	0.55	0.05	0.85	*58.7%*	0.12		0.05	1.25	0.03	1.35	1.57	**40.3**	18.1		3.8	16.8	1.6	37.4	42.3	40.3	54%
SBET1b	Sugar beet, pulp to AF, slops to biogas	**1.24**	0.33	0.06	0.85	*69.1%*	0.12		0.05	1.03	0.03	1.13	1.35	**27.2**	18.1		3.8	3.6	1.6	24.4	28.9	27.2	69%
SBET1c	Sugar beet, pulp to fuel, slops to biogas	**0.92**	0.12	-0.03	0.83	*90.4%*	0.12		0.05	0.72	0.03	0.83	1.03	**17.8**	18.1		3.8	-5.7	1.6	15.8	20.1	17.8	80%
WTET1a	Wheat, conv NG boiler, DDGS as AF	**1.74**	0.78	0.09	0.87	*50.2%*	0.32		0.03	1.36	0.03	1.71	1.76	**69.4**	50.5		1.0	16.2	1.6	65.4	71.8	69.4	20%
WTET1b	Wheat, conv NG boiler, DDGS as fuel	**1.17**	0.54	-0.16	0.80	*68.3%*	0.32		0.03	0.79	0.03	1.15	1.20	**58.7**	50.5		1.0	5.5	1.6	55.9	61.0	58.7	33%
WTET2a	Wheat, NG GT+CHP, DDGS as AF	**1.62**	0.75	0.02	0.85	*52.6%*	0.32		0.03	1.24	0.03	1.61	1.63	**64.8**	50.5		1.0	11.7	1.6	61.4	66.9	64.8	26%
WTET2b	Wheat, NG GT+CHP, DDGS as fuel	**1.05**	0.51	-0.23	0.78	*74.1%*	0.32		0.03	0.68	0.03	1.05	1.07	**54.1**	50.5		1.0	1.0	1.6	51.8	56.2	54.1	38%
WTET3a	Wheat, Lignite CHP, DDGS as AF	**1.54**	0.67	0.02	0.85	*55.2%*	0.32		0.03	1.16	0.03	1.54	1.54	**86.0**	50.5		1.0	32.9	1.6	82.9	87.9	86.0	1%
WTET3b	Wheat, Lignite CHP, DDGS as fuel	**0.98**	0.43	-0.23	0.78	*79.8%*	0.32		0.03	0.60	0.03	0.98	0.98	**75.3**	50.5		1.0	22.2	1.6	73.2	77.3	75.3	14%
WTET4a	Wheat, Straw CHP, DDGS as AF	**1.64**	0.22	0.02	1.40	*85.4%*	0.32		0.03	1.26	0.03	1.63	1.65	**33.7**	50.5		1.0	-19.5	1.6	30.7	35.7	33.7	61%
WTET4b	Wheat, Straw CHP, DDGS as fuel	**1.08**	-0.02	-0.23	1.33	*123.5%*	0.32		0.03	0.70	0.03	1.07	1.09	**23.0**	50.5		1.0	-30.2	1.6	21.0	24.9	23.0	74%
WTET5	Wheat, DDGS to biogas	**1.02**	0.14	0.02	0.85	*83.9%*	0.32		0.03	0.64	0.03	1.01	1.02	**35.3**	50.5		1.0	-17.9	1.6	33.0	37.3	35.3	59%
BRET2a	Barley/Rye, NG GT+CHP, DDGS as AF	**1.80**	0.81	0.02	0.98	*54.5%*	0.40		0.03	1.34	0.03	1.79	1.81	**76.0**	63.7		1.1	9.5	1.6	70.3	80.5	76.0	13%
CRET2a	Maize, NG GT+CHP, DDGS as AF	**1.73**	0.92	0.11	0.71	*40.7%*	0.53		0.03	1.15	0.03	1.72	1.74	**80.3**	57.9		0.9	19.9	1.6	76.6	83.3	80.3	8%
CRETus	Corn US, DDGS as AF	**1.65**	0.78	0.14	0.73	*44.1%*	0.47		0.02	1.08	0.07	1.65	1.65	**68.9**	47.5		0.5	15.7	5.2	66.5	70.5	68.9	21%
SCET1	Sugar cane (Brazil)	**2.09**	0.17	-0.01	1.93	*92.2%*	0.09	1.88	0.09		0.03	2.09	2.10	**24.8**	17.9	-1.4	6.7		1.6	22.7	26.9	24.8	72%
WFET1	F wood	**1.97**	0.28	0.01	1.68	*85.2%*	0.11		0.01	1.81	0.03	1.86	2.07	**22.8**	6.3		0.9	14.0	1.6	20.9	39.5	22.8	74%
WWET1	W wood	**1.95**	0.27	0.01	1.68	*85.7%*	0.08		0.04	1.81	0.03	1.86	2.06	**19.5**	0.9		2.9	14.0	1.6	19.3	19.6	19.5	78%
STET1	Wheat straw	**1.32**	0.10	0.01	1.21	*91.7%*	0.05		0.01	1.24	0.03	1.32	1.32	**9.2**	3.1		0.7	3.7	1.6	9.1	9.2	9.2	89%
ETBE																											
LREB1	ETBE: imported C4 and wheat ethanol	**0.72**	0.42	0.01	0.29	*39.7%*	0.11		0.01	0.58	0.02	0.71	0.73	**29.9**	16.8		0.3	11.5	1.2	29.2	30.8	77.5	11%

Note: "% saving" in this table is total GHG including combustion compared to conventional gasoline (COG1)

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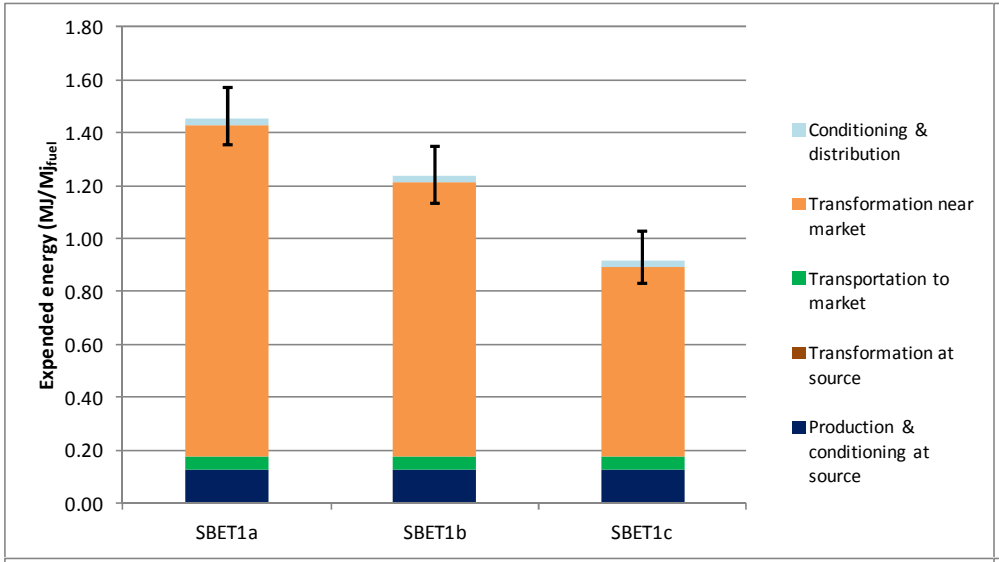

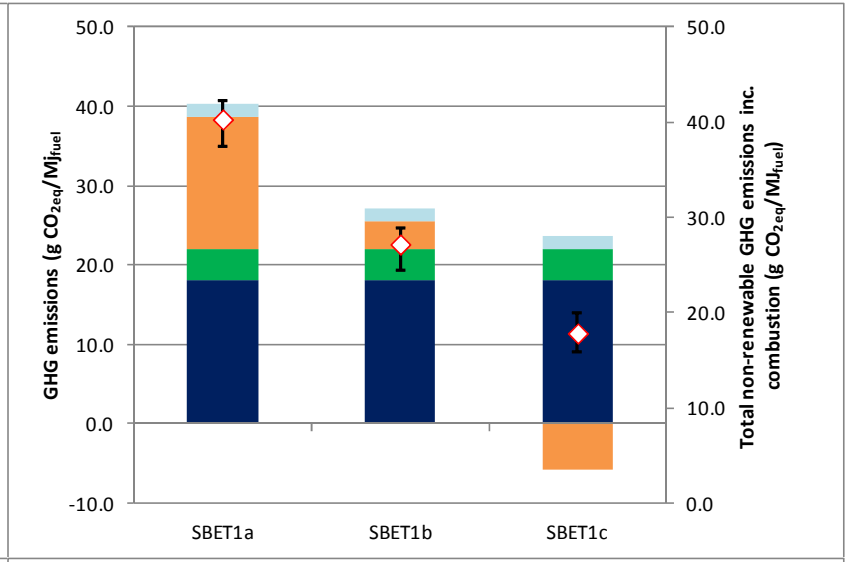

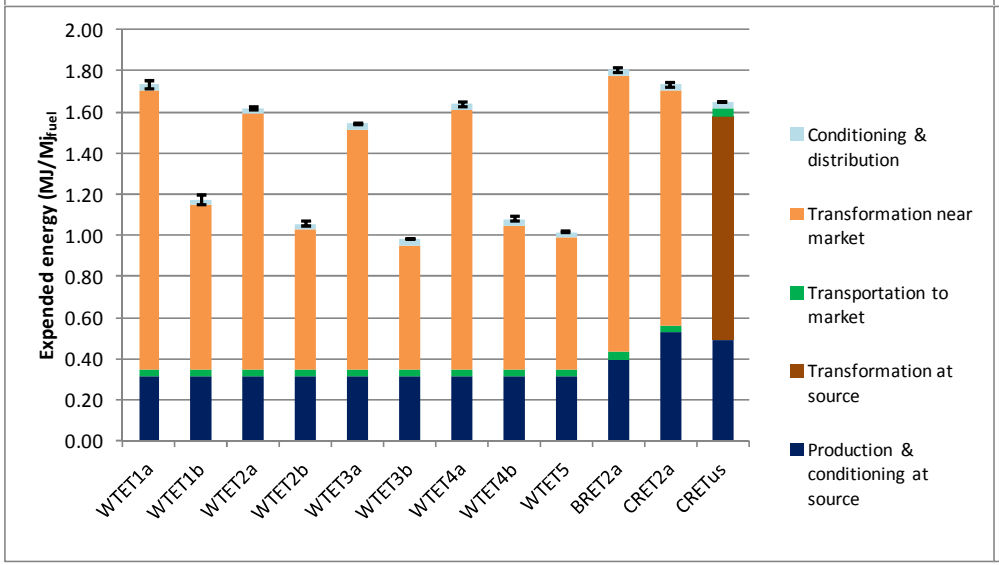

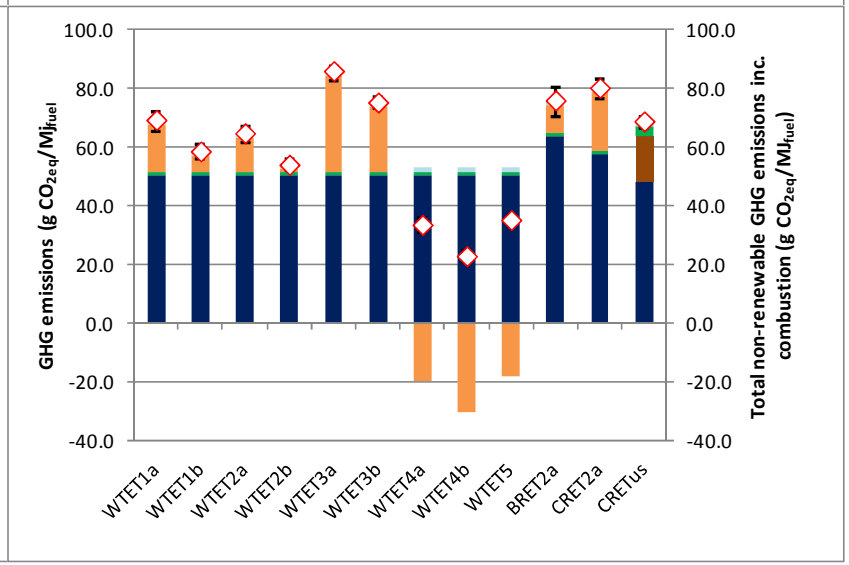

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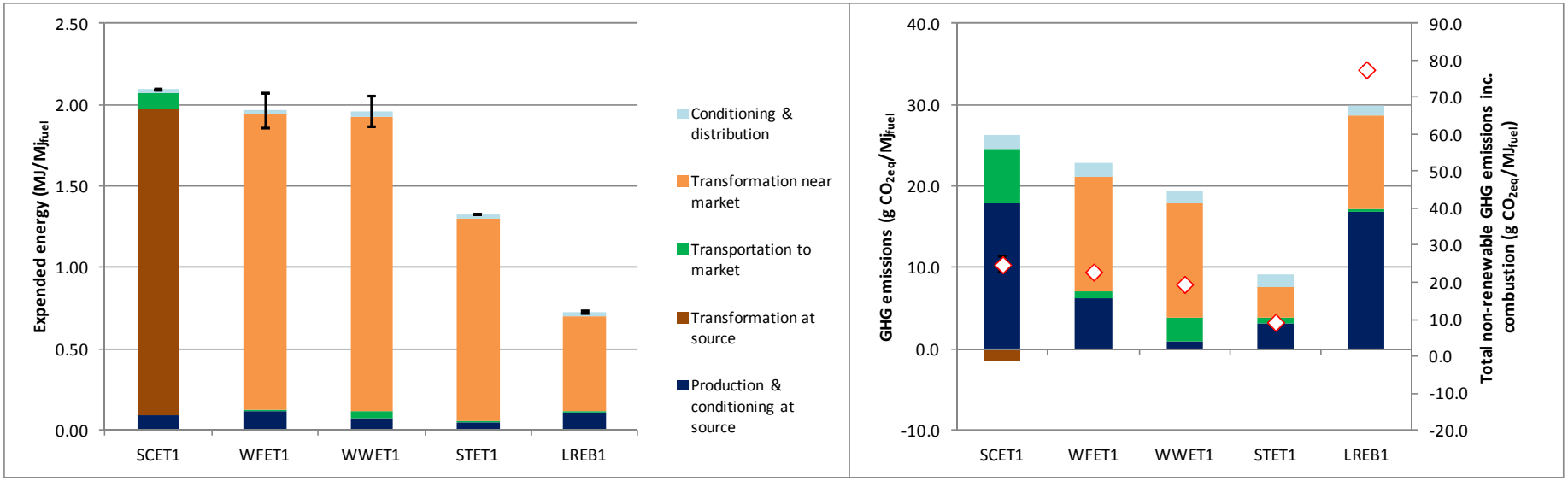

1.4 Biodiesel

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)								Total GHG inc. combustion	% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range			
Conventional fossil fuels																							
COD1	Diesel	**0.20**	0.20	0.01	0.00	*0.7%*	0.07		0.01	0.10	0.02	0.18	0.23	**15.4**	4.7		1.0	8.6	1.1	13.8	17.0	88.6	
Biodiesel																							COD1
ROFA1	RME: Meal as AF, glycerine as chem,	**1.12**	0.46	0.02	0.64	*57.2%*	0.35		0.02	0.73	0.02	1.12	1.13	**53.9**	57.6		0.6	-5.6	1.4	46.0	59.8	53.9	39%
ROFA2	RME: Meal and glycerine as AF	**1.18**	0.49	0.04	0.65	*55.0%*	0.35		0.02	0.78	0.02	1.17	1.18	**58.7**	57.6		0.6	-0.8	1.4	51.0	64.4	58.7	34%
ROFA3	RME: Meal as AF, glycerine to biogas	**1.13**	0.45	0.04	0.65	*57.1%*	0.35		0.02	0.74	0.02	1.13	1.14	**57.0**	57.6		0.6	-2.5	1.4	50.4	64.3	57.0	36%
ROFA4	RME: Meal and glycerine to biogas	**0.68**	0.16	-0.09	0.61	*90.0%*	0.35		0.02	0.28	0.02	0.62	0.73	**37.3**	57.6		0.6	-22.1	1.4	29.7	44.3	37.3	58%
ROFA5	RME: Meal as AF, Glycerine to hydrogen	**1.13**	0.44	0.04	0.65	*57.3%*	0.35		0.02	0.73	0.02	1.13	1.14	**56.7**	57.6		0.6	-2.8	1.4	50.1	63.9	56.7	36%
ROFE3	REE: Meal as AF, glycerine to biogas	**1.25**	0.42	0.04	0.79	*63.1%*	0.34		0.02	0.87	0.02	1.24	1.26	**56.6**	55.4		0.5	-0.7	1.3	47.3	60.2	56.6	36%
SOFA3	RME: Meal as AF, glycerine to biogas	**1.08**	0.43	0.04	0.61	*56.3%*	0.32		0.02	0.72	0.02	1.00	1.19	**45.9**	43.8		0.5	0.2	1.4	41.6	49.5	45.9	48%
SYFA3a	SYME: No till, oil import, meal as AF, glycerine to biogas	**2.53**	0.40	0.07	2.07	*81.8%*	0.18	2.13	0.04	0.16	0.02	2.52	2.54	**55.1**	57.4	-14.2	3.3	7.3	1.4	3.8	68.7	55.1	38%
SYFA3b	SYME: No till, beans import, meal as AF, glycerine to biogas	**2.69**	0.57	0.05	2.07	*76.8%*	0.19		0.32	2.16	0.02	2.68	2.70	**59.2**	58.1		23.0	-23.3	1.4	47.7	67.2	59.2	33%
SYFA3c	SYME: Conv. culture, oil import, meal as AF, glycerine to biogas	**2.60**	0.46	0.07	2.07	*79.6%*	0.24	2.13	0.04	0.16	0.02	2.59	2.61	**60.7**	63.0	-14.2	3.3	7.3	1.4	5.0	74.6	60.7	31%
POFA3a	POME: Meal as AF, no CH4 rec., heat credit, glycerine to biogas	**1.18**	0.17	0.03	0.97	*82.5%*	0.16	0.79	0.06	0.15	0.02	1.17	1.18	**50.8**	27.1	11.0	4.3	7.0	1.4	50.3	51.4	50.8	43%
POFA3b	POME: Meal as AF, CH4 rec., heat credit, glycerine to biogas	**1.18**	0.17	0.03	0.97	*82.6%*	0.15	0.79	0.06	0.15	0.02	1.17	1.18	**31.2**	27.0	-8.5	4.3	7.0	1.4	30.6	31.7	31.2	65%
POFA3c	POME: Meal as AF, no CH4 rec., no heat credit, glycerine to biogas	**1.33**	0.33	0.03	0.97	*72.7%*	0.15	0.95	0.06	0.15	0.02	1.33	1.34	**62.6**	27.0	22.8	4.3	7.0	1.4	62.0	63.1	62.6	29%
WOFA3a	FAME: waste cooking oil	**0.28**	0.21	0.01	0.05	*18.4%*				0.25	0.02	0.27	0.28	**13.8**				12.4	1.4	13.6	13.9	13.8	84%
TOFA3a	FAME: tallow oil	**0.48**	0.40	0.04	0.04	*7.6%*		0.30	0.01	0.15	0.02	0.48	0.48	**26.3**		17.5	0.4	7.0	1.4	26.2	26.5	26.3	70%
HVO																							COD1
ROHY1a	HRO (NExBTL), meal as AF	**1.12**	0.45	0.02	0.64	*57.4%*	0.35		0.02	0.72	0.02	1.11	1.12	**56.6**	57.5		0.6	-2.7	1.3	48.9	63.3	56.6	36%
ROHY1b	HRO (UOP), meal as AF	**0.99**	0.50	0.03	0.46	*46.3%*	0.31		0.02	0.64	0.02	0.99	1.00	**57.1**	51.1		0.5	4.2	1.3	50.7	63.5	57.1	36%
ROHY4	HRO (NExBTL), meal to biogas	**0.66**	0.16	-0.11	0.60	*91.4%*	0.35		0.02	0.26	0.02	0.61	0.73	**36.9**	57.5		0.6	-22.4	1.3	30.4	43.4	36.9	58%
SOHY1a	HSO (NExBTL), meal as AF	**1.04**	0.43	0.02	0.59	*56.3%*	0.31		0.02	0.68	0.02	0.95	1.13	**44.8**	43.2		0.5	-0.3	1.3	40.9	48.3	44.8	49%
SYHY1a	HSO (NExBTL), oil imported	**2.51**	0.41	0.04	2.05	*82.0%*	0.18	2.13	0.04	0.14	0.02	2.49	2.52	**55.1**	57.2	-14.1	3.3	7.5	1.3	8.0	68.5	55.1	38%
POY1a	HPO (NExBTL), no CH4 rec.	**1.13**	0.15	0.02	0.96	*85.3%*	0.15	0.79	0.06	0.11	0.02	1.13	1.13	**48.6**	27.0	11.0	4.3	5.1	1.3	48.1	49.2	48.6	45%
WOHY1a	HWO (NExBTL), waste cooking oil	**0.16**	0.13	0.00	0.02	*15.6%*				0.14	0.02	0.15	0.17	**8.1**				6.83	1.3	13.0	13.9	8.1	91%
TOHY1a	HTO (NExBTL), tallow oil	**0.44**	0.38	0.03	0.03	*7.0%*	0.00	0.30	0.01	0.11	0.02	0.44	0.44	**24.5**	0.2	17.3	0.4	5.3	1.3	29.7	30.0	24.5	72%

Note: "% saving" in this table is total GHG including combustion compared to conventional diesel (COD1)

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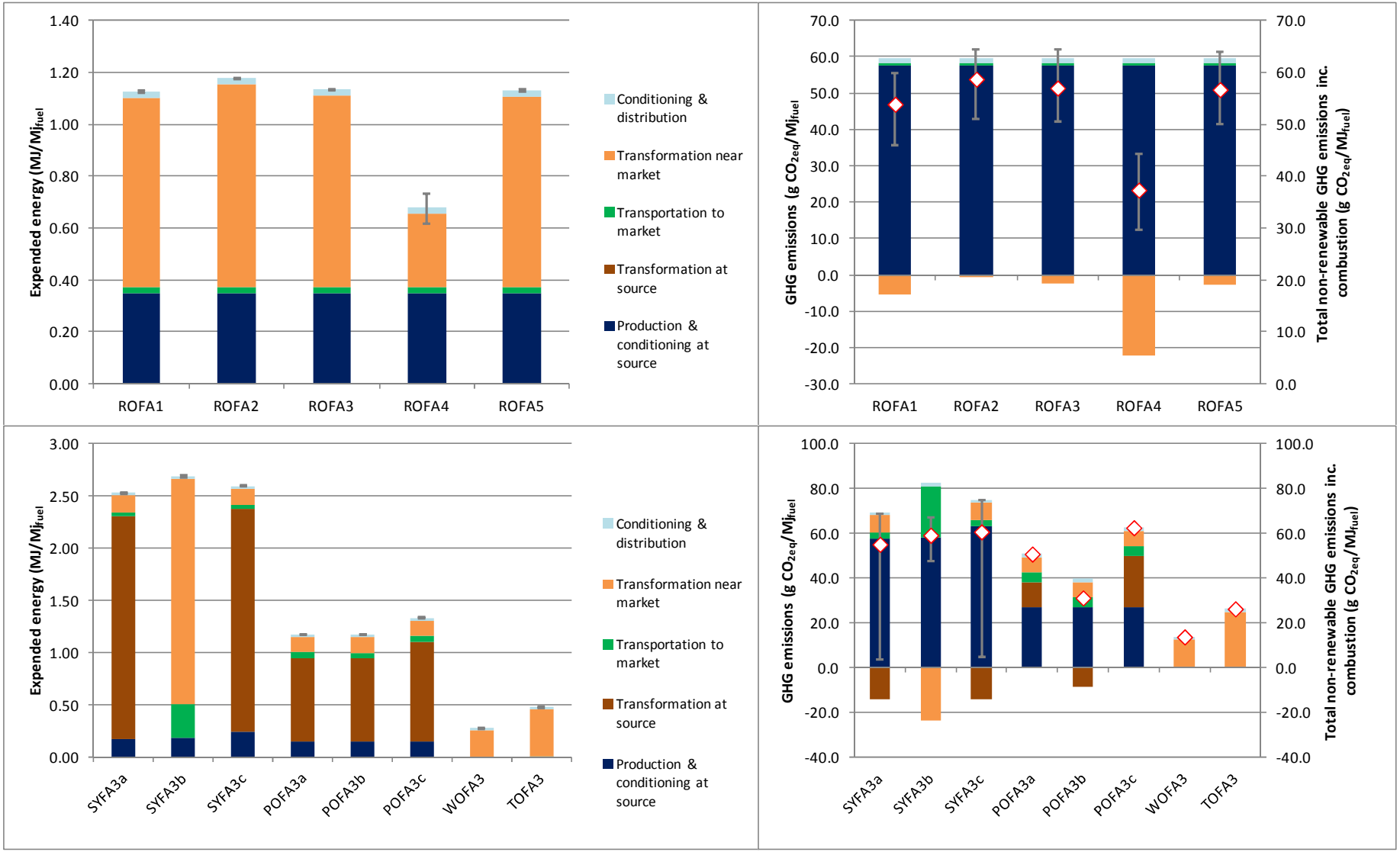

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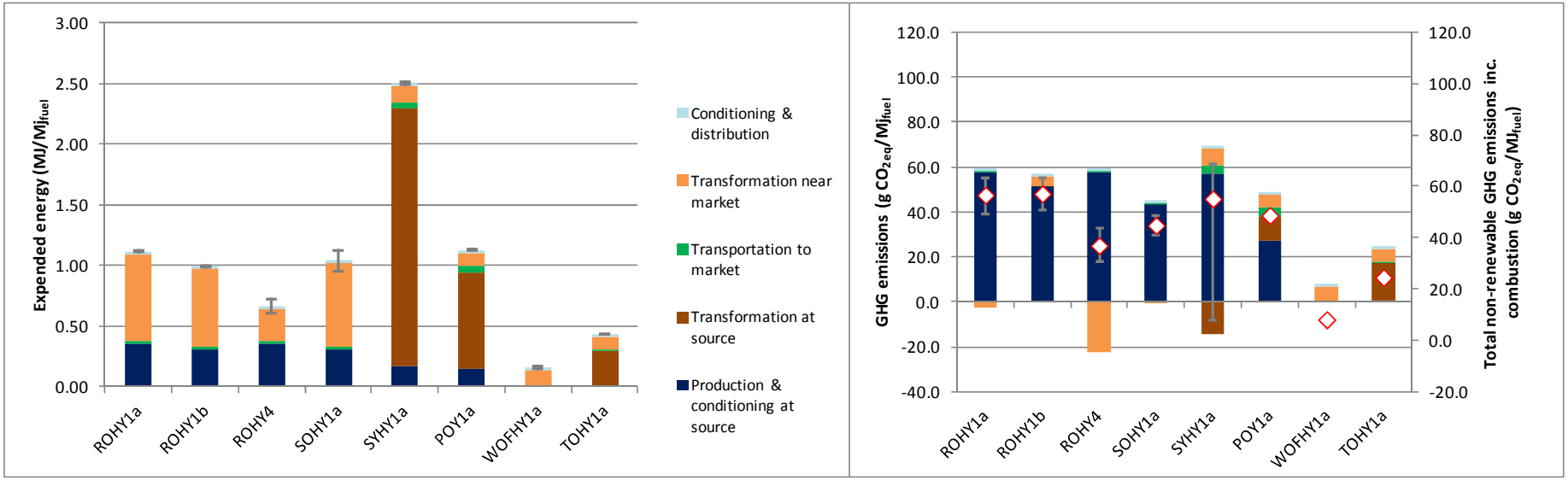

1.5 Synfuels

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	
Conventional fossil fuels																							
COD1	Diesel	**0.20**	0.20	0.01	0.00	*0.7%*	0.07		0.01	0.10	0.02	0.18	0.23	**15.4**	4.7		1.0	8.6	1.1	13.8	17.0	88.6	
Synfuels																							
GRSD1	Syndiesel: Rem GTL, diesel pool	**0.63**	0.62	0.01	0.00	*0.3%*	0.04	0.54	0.04		0.02	0.58	0.69	**23.4**	5.74	13.90	2.69		1.10	20.2	26.7	94.3	-6%
GRSD1C	Syndiesel: Rem GTL+CCS, diesel pool	**0.71**	0.70	0.01	0.00	*0.3%*	0.04	0.61	0.04		0.02	0.67	0.77	**13.4**	6.02	3.58	2.69		1.10	11.1	16.9	84.2	5%
KOSD1	Syndiesel: CTL, diesel pool	**0.97**	0.94	0.03	0.00	*0.4%*	0.16			0.78	0.02	0.88	1.05	**130.1**	28.49			100.39	1.19	121.2	138.7	200.9	-127%
KOSD1C	Syndiesel: CTL, CCS, diesel pool	**1.05**	1.02	0.03	0.00	*0.3%*	0.17			0.86	0.02	0.97	1.12	**40.0**	29.73			9.08	1.19	31.3	47.3	110.8	-25%
WFSD1	Syndiesel: F wood, diesel pool	**1.20**	0.06	0.01	1.13	*94.2%*	0.09		0.01	1.08	0.02	1.08	1.30	**7.0**	5.01		0.68	0.06	1.25	5.3	19.6	7.0	92%
WWSD2	Syndiesel: W Wood via black liquor, diesel pool	**0.91**	0.03	0.01	0.88	*95.9%*	0.05		0.01	0.83	0.02	0.86	0.97	**2.5**	0.66		0.60	0.00	1.24	2.5	2.5	2.5	97%
RESD1	Syndiesel: Renewable electricity, diesel pool	**1.60**	0.02	0.01	1.58	*98.7%*	0.00		0.10	1.47	0.02	1.52	1.67	**1.3**	0.00		0.00	0.00	1.25	1.2	1.3	1.3	99%
GPME1b	MeOH: NG 4000 km, EU prod., rail/road	**0.70**	0.69	0.01	0.00	*0.3%*	0.04		0.16	0.47	0.03	0.61	0.77	**32.2**	6.07		12.60	11.86	1.64	27.1	35.9	101.3	
GRME1	MeOH: Rem prod., sea/ rail/road	**0.61**	0.60	0.01	0.00	*0.4%*	0.04	0.46	0.08		0.03	0.59	0.64	**24.9**	5.46	11.49	5.94		2.02	23.9	26.7	94.0	
KOME1	MeOH: Coal EU-mix, EU prod., rail/road	**0.94**	-0.99	0.06	0.01	*1.4%*	0.15			0.77	0.02	0.86	1.05	**124.6**	26.78			96.30	1.51	115.4	135.8	193.7	
WFME1	MeOH: F Wood, road	**1.07**	0.06	0.00	1.01	*94.0%*	0.09		0.01	0.96	0.02	0.95	1.21	**6.6**	4.73		0.64	0.00	1.19	5.1	18.8	6.6	
WWME2	MeOH: W Wood via black liquor, road	**0.59**	0.03	0.00	0.56	*94.4%*	0.05		0.01	0.52	0.02	0.55	0.64	**2.2**	0.54		0.50	0.00	1.19	2.2	2.3	2.2	
GPDE1b	DME: NG 4000 km, EU prod., rail/road	**0.64**	0.63	0.01	0.00	*0.3%*	0.04		0.16	0.42	0.03	0.54	0.69	**30.4**	5.85		12.16	10.83	1.54	24.8	33.6	97.7	-10%
GRDE1	DME: Rem prod., sea/ rail/road	**0.53**	0.52	0.01	0.00	*0.4%*	0.03	0.41	0.06		0.03	0.52	0.57	**22.0**	5.27	10.57	4.33		1.80	21.0	23.8	89.3	-1%
GRDE1C	DME: Rem prod. with CCS, Sea, Rail/Road	**0.54**	0.53	0.01	0.00	*0.4%*	0.03	0.42	0.06		0.03	0.53	0.57	**12.0**	5.30	0.55	4.33		1.80	11.0	13.6	79.3	11%
KODE1	DME: Coal EU-mix, EU prod., rail/road	**0.95**	0.88	0.06	0.01	*1.3%*	0.15			0.77	0.03	0.85	1.04	**126.7**	26.78			98.11	1.78	117.3	136.1	194.0	-119%
WFDE1	DME: F Wood, road	**1.07**	0.06	0.00	1.01	*94.1%*	0.09		0.01	0.96	0.02	0.93	1.20	**6.5**	4.73		0.64	0.00	1.13	5.1	18.9	6.5	93%
WWDE2	DME: W Wood via black liquor, road	**0.56**	0.03	0.00	0.52	*94.2%*	0.04		0.01	0.49	0.02	0.51	0.60	**2.1**	0.53		0.49	0.00	1.13	2.1	2.2	2.1	98%

Note: "% saving" in this table is total GHG including combustion compared to conventional diesel (COD1)

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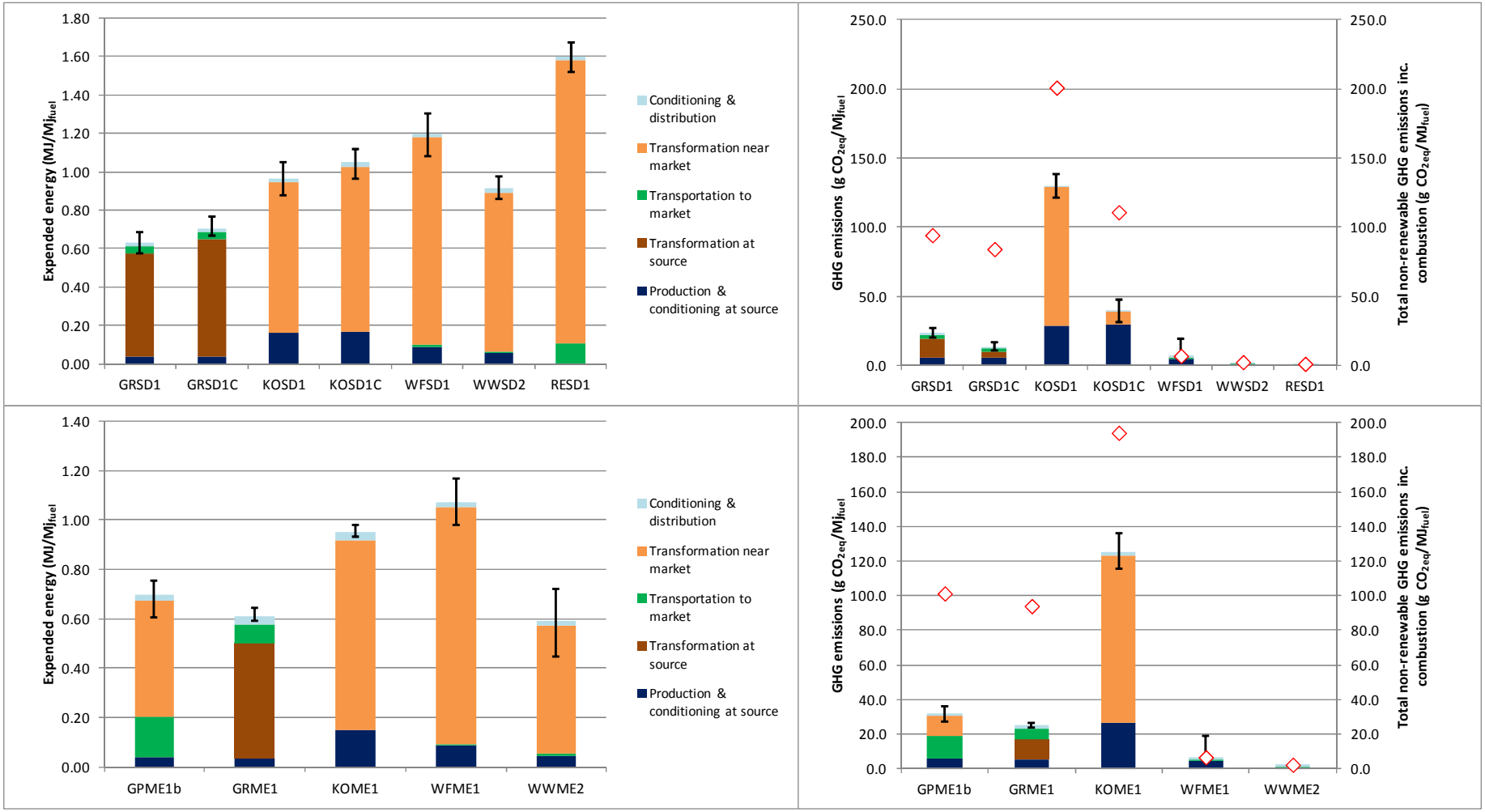
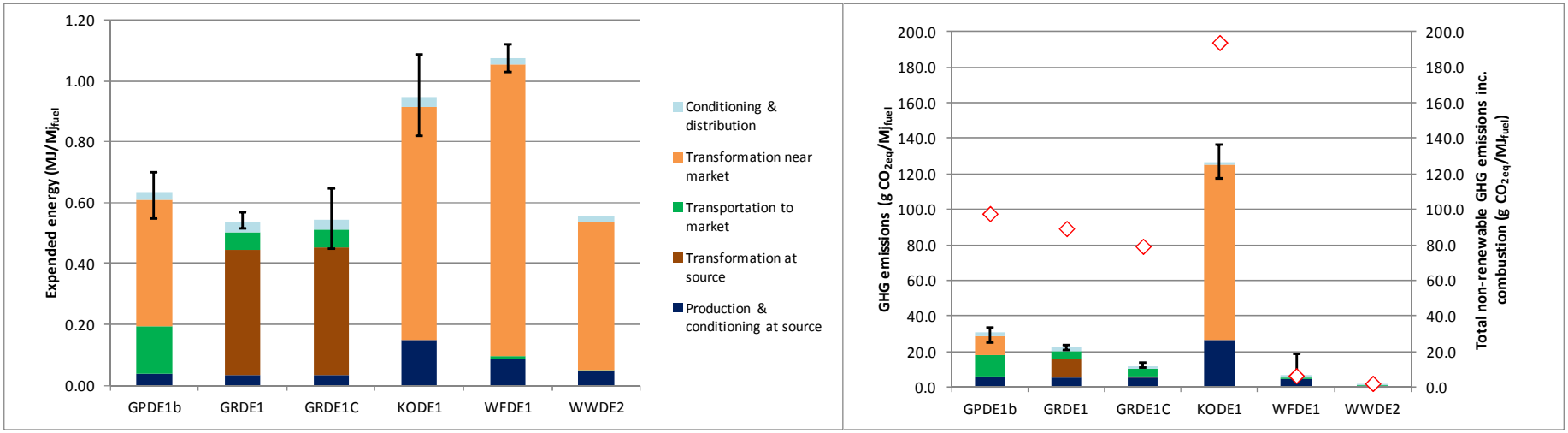


WTT APPENDIX 2



1.6 Electricity

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	% saving
Electricity																							
EMEL1	EU-mix high	**1.95**	0.57	1.09	0.30	*15.6%*				1.94	0.02	1.95	1.95	**136.0**				136.0	0.0	136.0	136.0	136.0	
EMEL2	EU-mix medium	**2.07**	0.62	1.13	0.32	*15.3%*				2.01	0.05	2.07	2.07	**141.1**				141.1	0.0	141.1	141.1	141.1	
EMEL3	EU-mix low	**2.26**	0.73	1.20	0.34	*14.8%*				2.14	0.12	2.26	2.26	**150.1**				150.1	0.0	150.1	150.1	150.1	
FOEL1	HFO	**1.94**	1.94	0.00	0.00	*0.0%*			0.24	1.58	0.12	1.94	1.94	**237.8**				237.8	0.0	237.8	237.8	237.8	
KOEL1	EU-mix Coal conv.	**1.81**	1.78	0.03	0.00	*0.1%*	0.23			1.46	0.12	1.44	2.02	**292.4**	41.2			251.2	0.0	255.0	314.2	292.4	
KOEL2	EU-mix Coal IGCC	**1.54**	1.52	0.03	0.00	*0.1%*	0.21			1.21	0.12	1.43	1.67	**262.4**	37.3			225.1	0.0	250.5	275.0	262.4	
KOEL2C	EU-mix Coal IGCC+CCS	**1.98**	1.94	0.03	0.00	*0.1%*	0.24			1.61	0.12	1.85	2.10	**71.0**	43.7			27.4	0.0	58.3	83.9	71.0	
GPEL1a	NG 7000 km, CCGT	**1.35**	1.35	0.00	0.00	*0.0%*	0.06		0.37	0.81	0.12	1.12	1.47	**145.0**	8.6		28.6	107.8	0.0	131.7	152.1	145.0	
GPEL1b	NG 4000 km, CCGT	**1.19**	1.19	0.00	0.00	*0.0%*	0.05		0.21	0.81	0.12	1.12	1.29	**132.4**	8.0		16.6	107.8	0.0	124.9	137.9	132.4	
GPEL1bC	NG 4000 km, CCGT+CCS	**1.71**	1.71	0.00	0.00	*0.0%*	0.06		0.26	1.26	0.12	1.12	1.86	**44.7**	9.9		20.5	14.3	0.0	32.8	53.6	44.7	
GREL1	LNG, CCGT	**1.39**	1.39	0.00	0.00	*0.0%*	0.05	0.18	0.22	0.81	0.12	1.34	1.47	**141.6**	7.9	12.2	14.1	107.4	0.0	139.0	146.0	141.6	
OWEL1a	Biogas ex municipal waste, local	**3.40**	-0.10	0.00	3.50	*102.8%*				3.34	0.06	3.03	3.73	**13.6**				13.6	0.0	13.0	14.3	13.6	
OWEL1b	Biogas ex municipal waste, large power plant	**2.71**	0.27	0.23	2.21	*81.4%*				2.59	0.12	2.45	3.02	**23.8**				23.8	0.0	17.7	30.0	23.8	
OWEL21a	Biogas ex wet manure, local (closed storage)	**5.69**	0.04	0.00	5.65	*99.2%*			0.04	5.58	0.06	5.54	5.90	**-175.5**	-199.4		3.3	20.6	0.0	-181.4	-170.6	-175.5	
OWEL21b	Biogas ex wet manure, local (open storage)	**4.66**	0.21	0.12	4.33	*92.9%*			0.04	4.51	0.12	4.55	4.77	**-139.6**	-159.0		2.7	16.7	0.0	-142.6	-136.6	-139.6	
OWEL22a	Biogas ex wet manure, large power plant (closed storage)	**6.04**	0.05	0.00	6.00	*99.2%*			0.05	5.93	0.06	5.84	6.25	**-116.0**	-209.9		3.5	90.4	0.0	-120.0	-111.9	-116.0	
OWEL22b	Biogas ex wet manure, large power plant (open storage)	**4.97**	0.22	0.12	4.63	*93.2%*			0.04	4.81	0.12	4.86	5.10	**-63.1**	-168.0		2.8	102.0	0.0	-65.1	-61.3	-63.1	
WFEL1	F Wood, 200 MW gasif	**1.44**	0.05	0.00	1.38	*96.3%*	0.10		0.01	1.20	0.12	1.36	1.55	**7.9**	5.6		0.8	1.6	0.0	6.2	23.7	7.9	
WFEL2	F Wood, 10 MW gasif	**2.32**	0.07	0.00	2.24	*96.8%*	0.14		0.01	2.04	0.12	2.20	2.43	**10.8**	7.6		1.0	2.1	0.0	8.4	29.9	10.8	
WFEL3	F Wood, Conv power	**2.67**	0.08	0.00	2.59	*97.0%*	0.15		0.02	2.38	0.12	2.50	2.85	**14.0**	8.5		1.1	4.4	0.0	11.1	37.4	14.0	
WFEL4	F Wood, co-firing coal plant	**1.70**	0.06	0.00	1.64	*96.5%*	0.11		0.01	1.46	0.12	1.36	1.95	**11.0**	6.2		0.8	3.9	0.0	8.7	28.6	11.0	
WWEL1	W Wood, 200 MW gasif	**1.43**	0.05	0.00	1.38	*96.6%*	0.07		0.04	1.20	0.12	1.34	1.54	**5.3**	0.8		2.9	1.6	0.0	5.0	5.6	5.3	
WWEL2	W Wood, 10 MW gasif	**2.27**	0.03	0.00	2.24	*98.7%*	0.09		0.01	2.04	0.12	2.14	2.39	**4.3**	1.1		1.0	2.1	0.0	4.2	4.4	4.3	
WWEL3	W Wood, conv.	**2.62**	0.03	0.00	2.59	*98.8%*	0.10		0.02	2.38	0.12	2.43	2.79	**6.8**	1.3		1.1	4.4	0.0	6.7	6.9	6.8	
WWEL4	W Wood, co-firing coal plant	**1.69**	0.05	0.00	1.64	*96.8%*	0.08		0.04	1.46	0.12	1.39	1.95	**8.1**	0.9		3.3	3.9	0.0	7.6	8.5	8.1	
WWEL5	Wood via black liquor	**0.29**	0.01	0.00	0.28	*96.0%*	0.04		0.01	0.12	0.12	0.25	0.33	**0.9**	0.4		0.4	0.0	0.0	0.8	0.9	0.9	
NUEL	Nuclear	**3.08**	0.06	3.01	0.01	*0.3%*	0.00		0.67	2.28	0.12	2.99	3.15	**5.0**	0.1		4.6	0.3	0.0	4.8	5.2	5.0	
WDEL	Wind offshore	**0.12**	0.00	0.00	0.12	*100.0%*				0.00	0.12	0.12	0.12	**0.0**				0.0	0.0	0.0	0.0	0.0	

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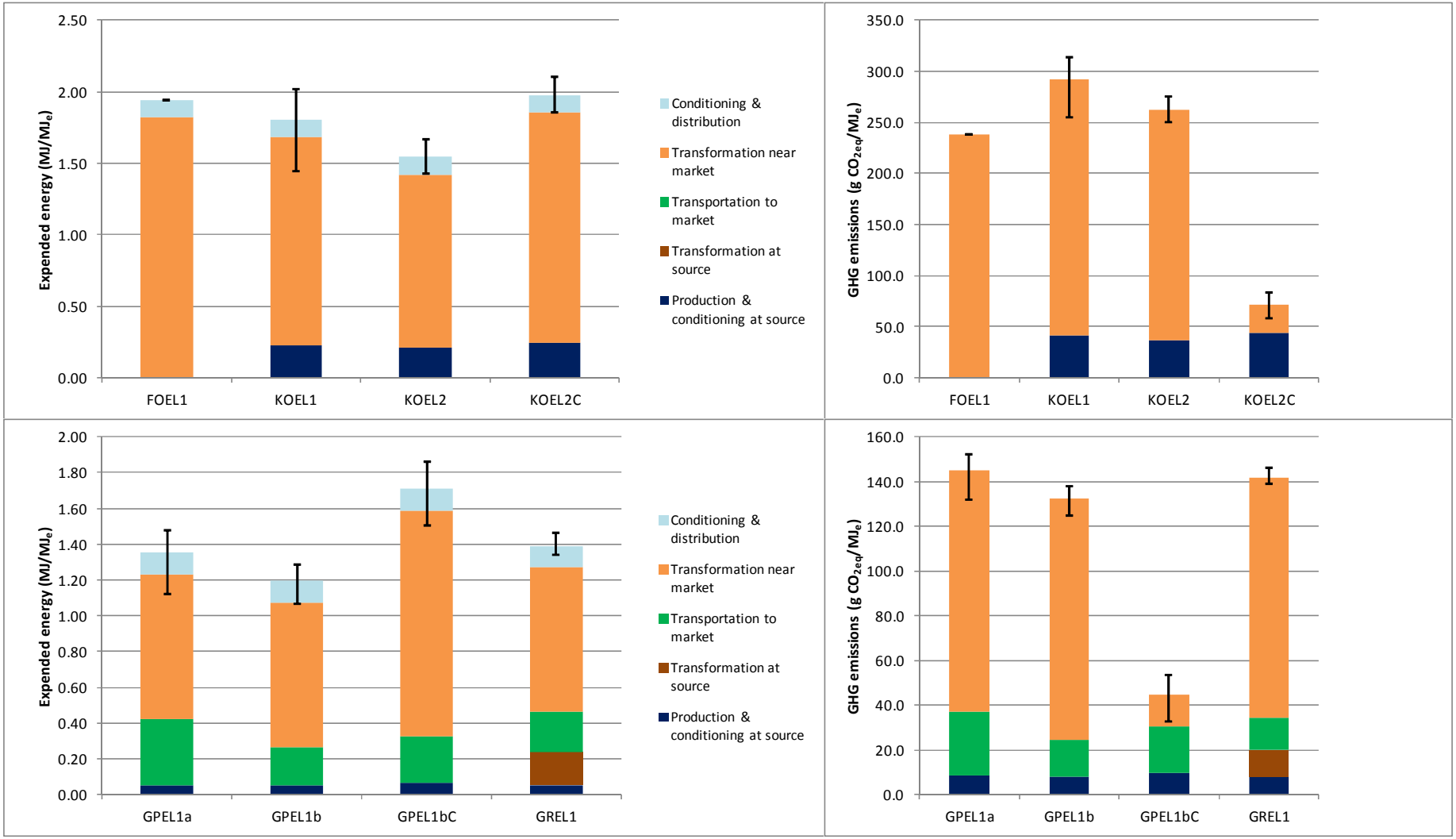

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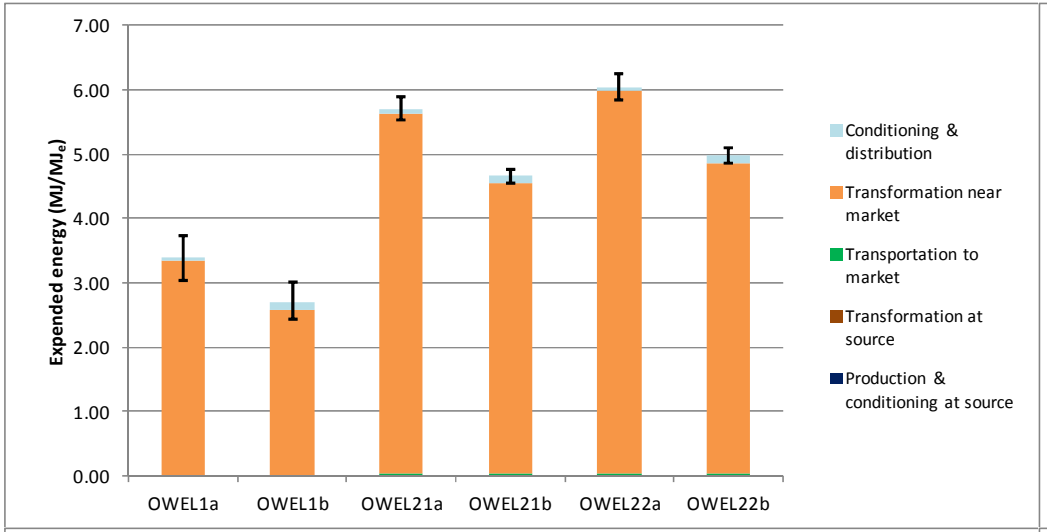

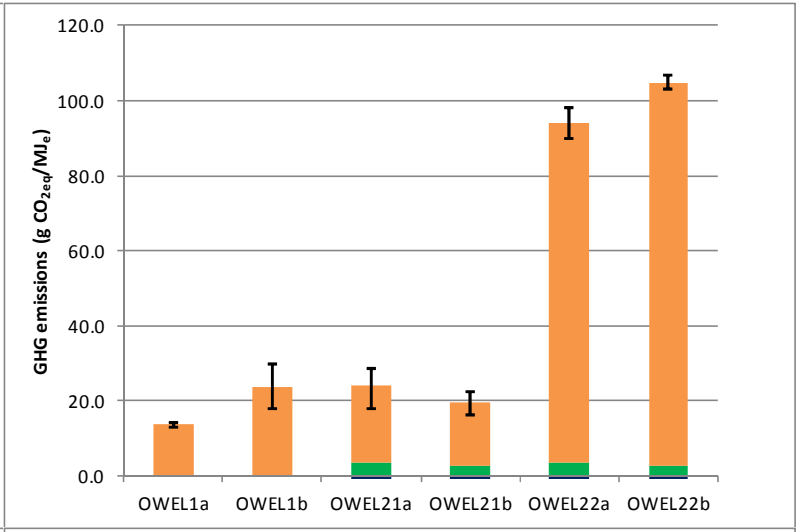

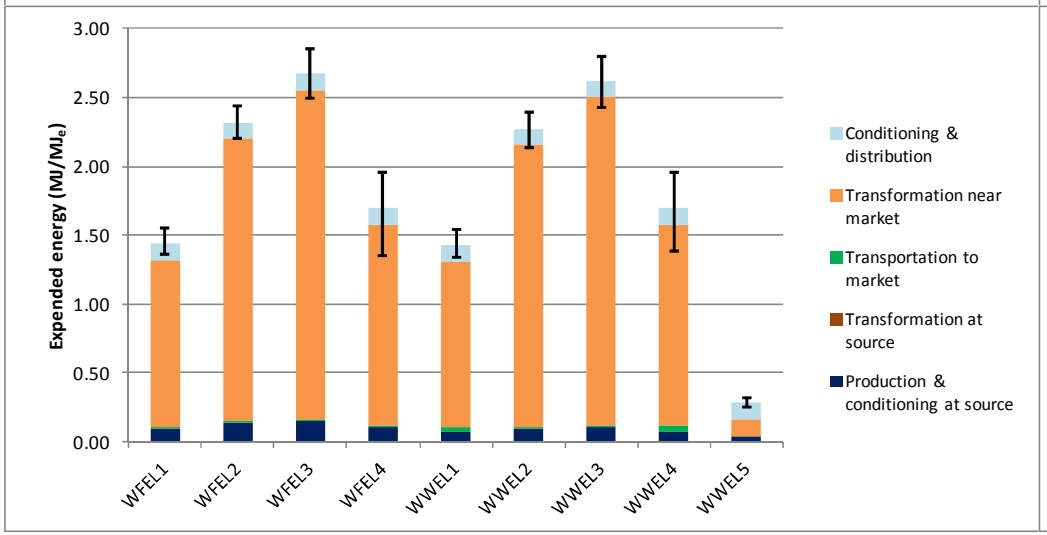

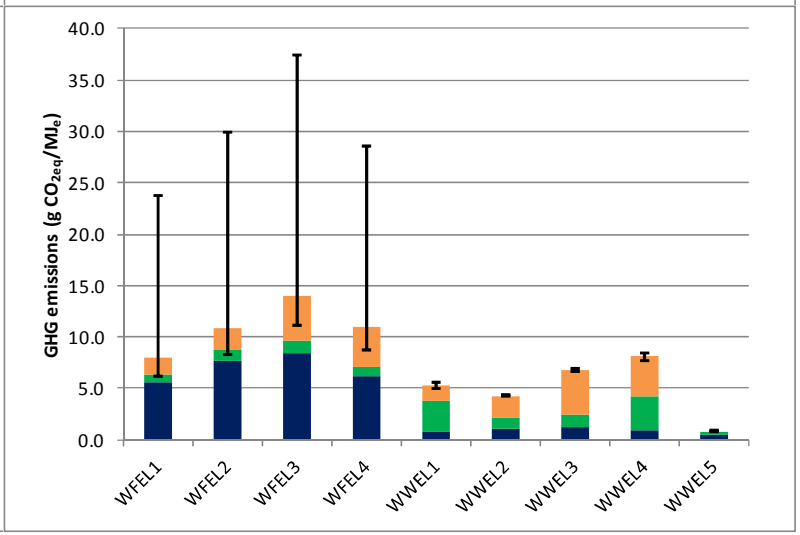

1.7 Heat and Power

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									Total GHG inc. combustion	% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range			
Heat																								
COHT1	Diesel, small scale	**0.39**	0.36	0.03	0.01	*1.8%*	0.08		0.14	0.18		0.36	0.42	**101.6**	5.2		11.3	85.1		99.4	103.9	101.6	
COHT2	Diesel, industrial	**0.41**	0.37	0.03	0.01	*2.2%*	0.08		0.14	0.19		0.38	0.44	**102.3**	5.2		11.3	85.8		100.0	104.7	102.3	
GPHT1a	NG (piped, 7000 km) small scale	**0.27**	0.25	0.02	0.01	*2.0%*	0.03		0.19	0.05		0.16	0.34	**76.8**	4.4		14.8	57.6		70.6	80.9	76.8	
GPHT1b	NG (piped 4000 km) industrial	**0.19**	0.16	0.02	0.01	*2.8%*	0.03		0.11	0.05		0.13	0.23	**70.3**	4.1		8.6	57.6		66.7	72.4	70.3	
GPHT2a	NG (piped, 4000 km) small scale	**0.42**	0.39	0.02	0.01	*1.6%*	0.03		0.21	0.18		0.29	0.48	**86.1**	4.9		16.5	64.7		78.3	89.3	86.1	
GPHT2b	NG (piped 7000 km) industrial	**0.33**	0.30	0.02	0.01	*2.0%*	0.03		0.12	0.18		0.26	0.36	**78.8**	4.6		9.6	64.7		74.6	80.8	78.8	
GRHT1	LNG, small scale	**0.29**	0.26	0.02	0.01	*1.9%*	0.03	0.10	0.12	0.05		0.28	0.31	**75.1**	4.1	6.3	7.3	57.3		74.5	76.3	75.1	
GRHT2	LNG, industrial	**0.44**	0.41	0.03	0.01	*1.6%*	0.03	0.11	0.13	0.18		0.43	0.46	**84.0**	4.6	7.0	8.1	64.3		83.3	85.2	84.0	
OWHT1a	Biogas (municipal waste, closed storage)	**0.97**	0.17	0.14	0.67	*68.5%*				0.97		0.81	1.12	**14.0**				14.0		11.0	17.2	14.0	
OWHT21a	Biogas (wet manure, closed storage)	**1.99**	0.14	0.08	1.77	*89.1%*			0.02	1.97		1.97	2.01	**-70.7**	-82.4		1.4	10.3		-71.7	-69.8	-70.7	
OWHT22a	Biogas (wet manure, open storage)	**2.15**	0.14	0.08	1.93	*89.7%*			0.02	2.13		2.13	2.17	**-46.1**	-87.1		1.5	39.6		-47.0	-45.1	-46.1	
WFHT1	Farmed wood, small scale	**0.36**	0.08	0.04	0.23	*64.1%*	0.05		0.01	0.30		0.32	0.40	**8.6**	2.9		0.4	5.3		7.7	16.4	8.6	
WWHT1	Waste wood, small scale	**0.34**	0.07	0.04	0.24	*70.2%*	0.04		0.01	0.30		0.30	0.39	**6.1**	0.4		0.4	5.3		6.1	6.1	6.1	
WFHT2	Farmed wood, industrial	**0.30**	0.06	0.02	0.21	*71.2%*	0.05		0.01	0.24		0.26	0.34	**6.5**	2.8		0.4	3.2		5.6	13.6	6.5	
WWHT2	Waste wood, industrial	**0.28**	0.05	0.02	0.21	*75.4%*	0.04		0.01	0.24		0.25	0.32	**4.1**	0.4		0.4	3.2		4.0	4.1	4.1	
CHP																								
GPEH1a	Elec: Piped gas 7000km, GT-CHP	**0.47**	0.47	0.00	0.00	*0.0%*	0.07		0.50	-0.23	0.12	0.16	0.69	**91.0**	11.6		38.7	40.7	0.0	73.2	104.0	91.0	
GPEH1b	Elec: Piped gas 4000km, GT-CHP	**0.37**	0.37	0.00	0.00	*0.0%*	0.07		0.29	-0.11	0.12	0.18	0.53	**83.1**	10.8		22.5	49.8	0.0	72.1	92.3	83.1	
GREH1b	Elec: LNG, GT-CHP	**0.49**	0.49	0.00	0.00	*0.0%*	0.07	0.25	0.30	-0.25	0.12	0.45	0.54	**89.1**	10.8	16.5	19.0	42.8	0.0	86.6	91.9	89.1	
GPHE1b	Elec: Waste wood, CHP	**-0.30**	-0.30	0.00	0.00	*0.0%*	0.06		0.26	-0.74	0.11	-0.45	-0.12	**42.0**	9.8		20.3	11.9	0.0	32.7	52.4	42.0	
WFEH1	Elec: Farmed wood, CHP	**0.59**	0.03	0.00	0.55	*94.0%*	0.22		0.02	0.23	0.12	0.29	0.85	**4.8**	12.0		1.6	-8.9	0.0	-7.7	30.8	4.8	
WWEH1	Heat: Piped gas 4000km, CHP	**0.57**	0.01	0.00	0.55	*97.5%*	0.15		0.02	0.28	0.12	0.32	0.85	**1.7**	1.8		1.6	-1.8	0.0	1.5	1.9	1.7	
WFHE1	Heat: Waste wood, CHP	**-0.38**	0.01	0.00	-0.40	*103.6%*	0.09		0.01	-0.59	0.11	-0.51	-0.25	**1.3**	4.8		0.6	-4.2	0.0	-4.9	10.8	1.3	
WWHE1	Heat: Farmed wood, CHP	**-0.39**	0.01	0.00	-0.40	*101.4%*	0.06		0.01	-0.57	0.11	-0.51	-0.27	**0.1**	0.7		0.6	-1.3	0.0	0.0	0.1	0.1	

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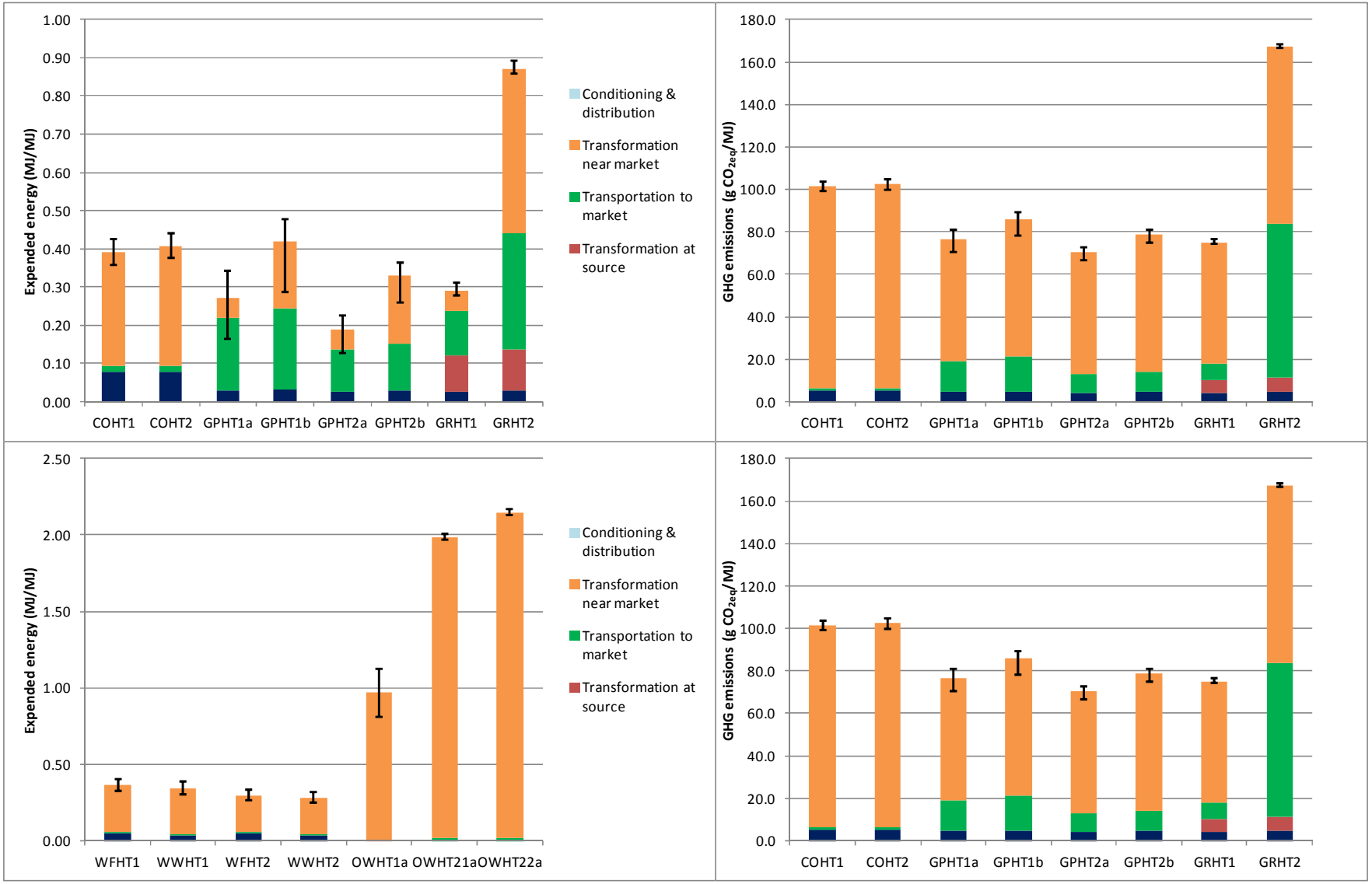

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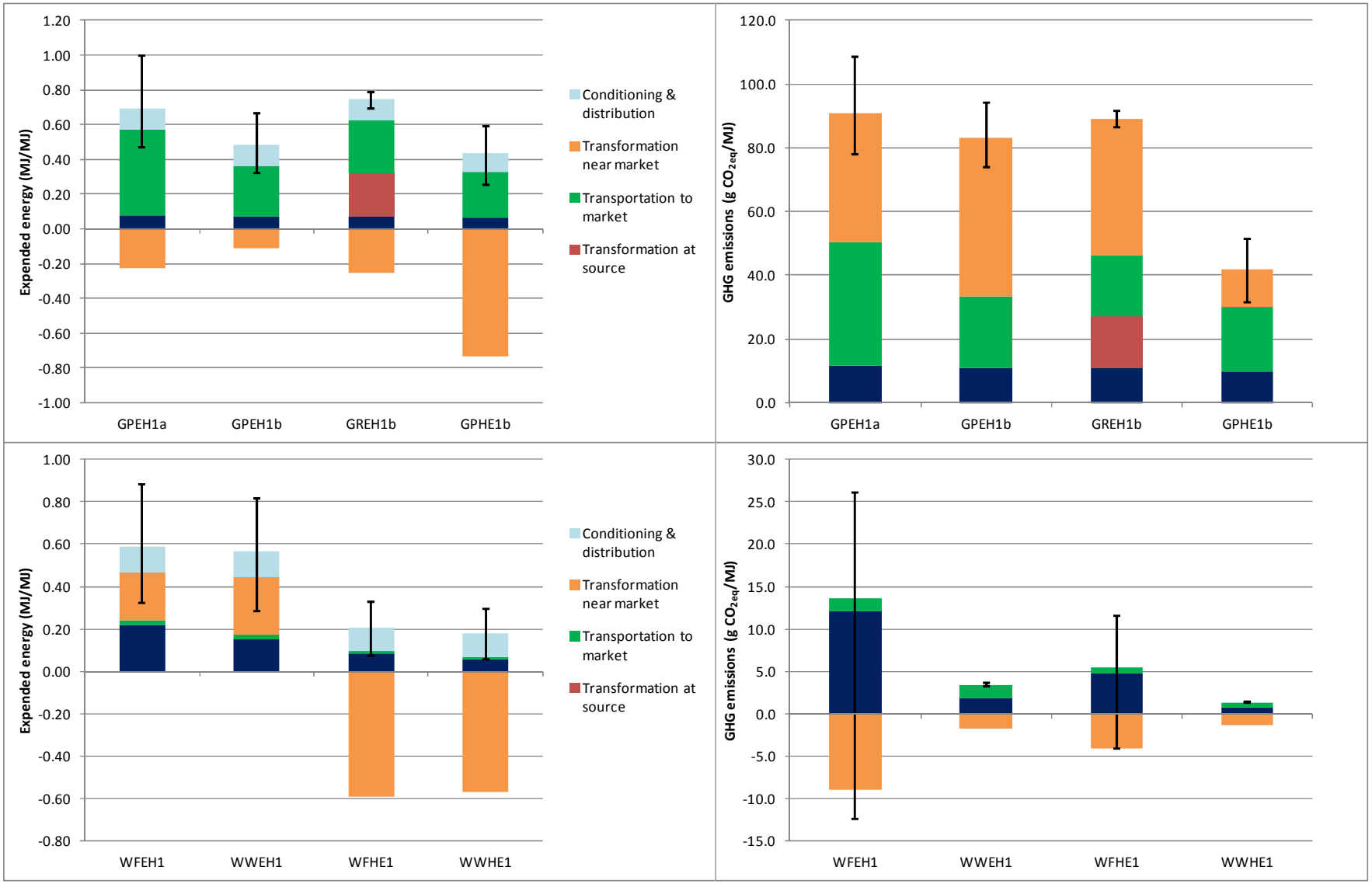
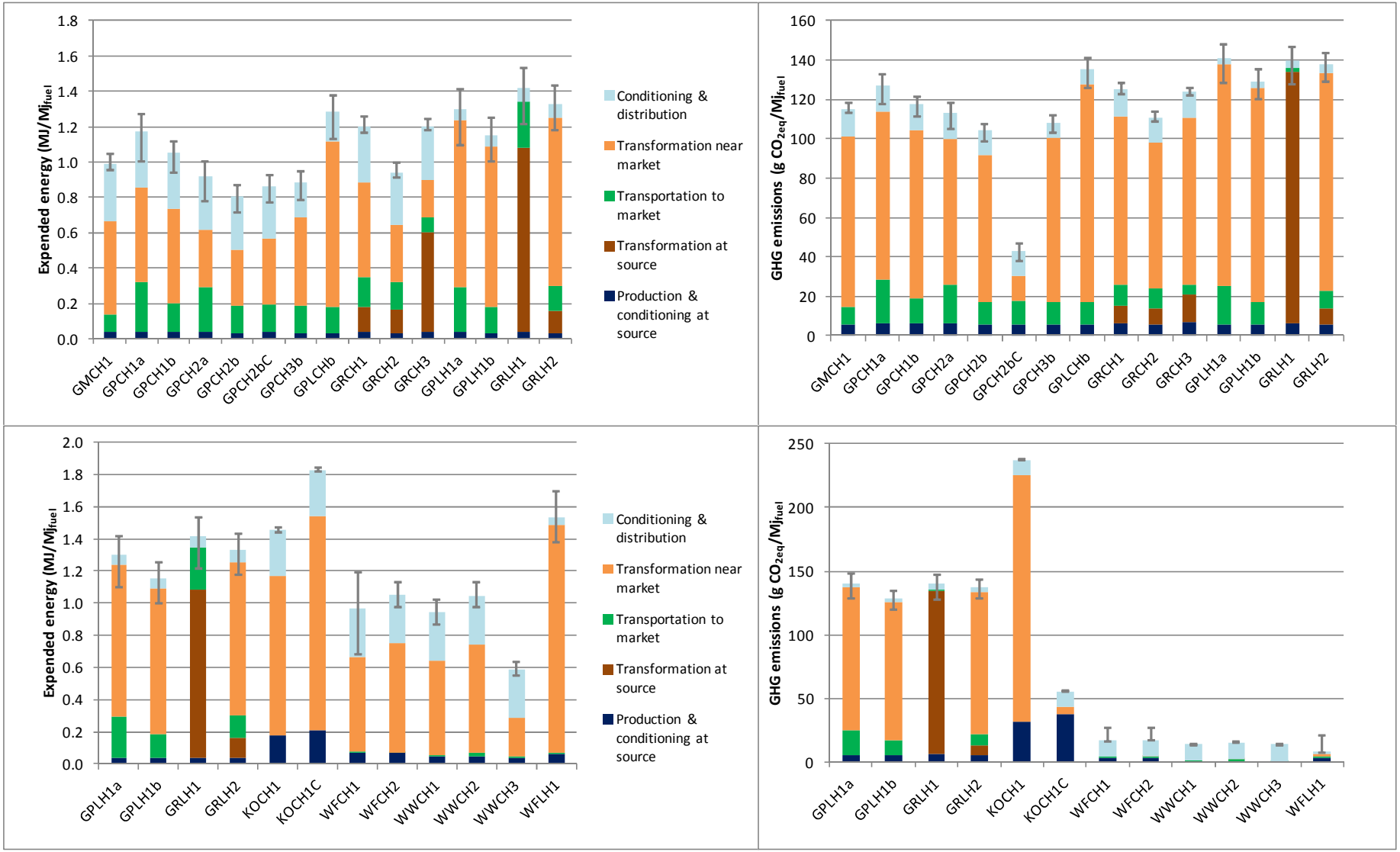


1.8 Hydrogen (thermal)

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	
Hydrogen (thermal)																							
GMCH1	C-H2: EU-mix, O/S Ref	**0.99**	0.81	0.14	0.04	*4.0%*	0.04		0.10	0.53	0.32	0.95	1.04	**115.2**	5.9		8.4	87.1	13.8	113.1	118.4	115.2	
GPCH1a	C-H2: NG 7000 km, O/S Ref	**1.17**	0.99	0.14	0.04	*3.3%*	0.04		0.28	0.53	0.32	1.01	1.27	**127.3**	6.5		21.8	85.2	13.8	117.7	132.9	127.3	
GPCH1b	C-H2: NG 4000 km, O/S Ref	**1.05**	0.87	0.14	0.04	*3.7%*	0.04		0.16	0.53	0.32	0.94	1.12	**117.7**	6.1		12.7	85.2	13.8	111.2	121.3	117.7	
GPCH2a	C-H2: NG 7000 km, Cen ref, Pipe	**0.92**	0.78	0.10	0.03	*3.2%*	0.04		0.26	0.32	0.30	0.78	1.01	**113.1**	6.0		19.9	74.3	13.0	105.1	118.1	113.1	
GPCH2b	C-H2: NG 4000 km, Cen Ref, Pipe	**0.81**	0.68	0.10	0.03	*3.6%*	0.04		0.15	0.32	0.30	0.71	0.87	**104.4**	5.6		11.6	74.3	13.0	98.8	107.7	104.4	
GPCH2bC	C-H2: NG 4000 km, Cen Ref, Pipe, CCS	**0.87**	0.73	0.10	0.03	*3.3%*	0.04		0.15	0.37	0.30	0.77	0.92	**43.2**	5.8		12.0	12.5	13.0	37.6	46.5	43.2	
GPCH3b	C-H2: NG 4000 km, Cen Ref, Road	**0.88**	0.72	0.13	0.04	*4.0%*	0.04		0.15	0.49	0.21	0.79	0.95	**108.1**	5.6		11.6	82.0	9.0	102.7	111.8	108.1	
GPLCHb	C-H2: NG 4000 km, Cen Ref, Liq, Road, Vap/comp.	**1.28**	1.20	0.06	0.02	*1.4%*	0.04		0.15	0.91	0.19	1.13	1.38	**135.0**	5.5		11.4	108.8	9.3	125.8	140.6	135.0	
GRCH1	C-H2: LNG, O/S Ref	**1.20**	1.02	0.14	0.04	*3.3%*	0.04	0.12	0.19	0.53	0.32	1.16	1.26	**124.8**	6.1	8.3	11.7	85.0	13.8	122.6	128.0	124.8	
GRCH2	C-H2: LNG, Cen Ref, Pipe	**0.94**	0.81	0.10	0.03	*3.1%*	0.04	0.11	0.17	0.32	0.30	0.91	0.99	**110.8**	5.5	7.6	10.7	74.1	13.0	108.9	113.7	110.8	
GRCH3	C-H2: Rem NG, methanol, O/S Ref	**1.20**	1.05	0.12	0.03	*2.7%*	0.04	0.56	0.08	0.22	0.30	1.18	1.24	**123.5**	6.6	13.9	5.4	84.6	13.0	122.3	125.7	123.5	
KOCH1	C-H2: Coal EU-mix, cen Ref, Pipe	**1.45**	1.30	0.12	0.03	*2.0%*	0.18			0.99	0.29	1.44	1.47	**237.3**	32.1			193.0	12.3	236.7	237.9	237.3	
KOCH1C	C-H2: Coal EU-mix, cen Ref, Pipe, CCS	**1.83**	1.67	0.12	0.03	*1.6%*	0.21			1.33	0.29	1.82	1.84	**55.6**	37.5			5.8	12.3	55.1	56.2	55.6	
WFCH1	C-H2: F Wood, O/S gasif	**0.97**	0.19	0.10	0.68	*70.0%*	0.02	0.05	0.01	0.59	0.30	0.68	1.19	**17.4**	3.3	0.6	0.5	0.0	13.0	16.0	27.3	17.4	
WFCH2	C-H2: F Wood, Cen gasif, pipe	**1.05**	0.19	0.10	0.76	*72.3%*	0.02	0.04	0.01	0.68	0.30	0.98	1.13	**17.6**	3.1	0.5	0.5	0.5	13.0	16.8	27.3	17.6	
WWCH1	C-H2: W Wood, O/S gasif	**0.94**	0.16	0.10	0.68	*71.7%*		0.05	0.01	0.59	0.30	0.63	1.16	**14.1**		0.6	0.5	0.0	13.0	13.4	14.7	14.1	
WWCH2	C-H2: W Wood, Cen gasif, Pipe	**1.05**	0.18	0.10	0.76	*72.5%*		0.04	0.02	0.68	0.30	0.97	1.13	**15.7**		0.5	1.9	0.3	13.0	15.0	16.4	15.7	
WWCH3	C-H2: W Wood, Black liquor	**0.59**	0.16	0.10	0.33	*55.3%*		0.04	0.01	0.25	0.30	0.55	0.63	**13.8**		0.5	0.4	0.0	13.0	13.2	14.6	13.8	
GPLH1a	Cc-H2:NG 7000 km, Cen Ref, Liq, Road	**1.30**	1.28	0.01	0.00	*0.3%*	0.04		0.25	0.95	0.06	1.09	1.41	**140.8**	5.9		19.6	112.2	3.1	128.6	147.7	140.8	
GPLH1b	Cc-H2: NG 4000 km, Cen Ref, Liq, Road	**1.15**	1.13	0.01	0.00	*0.3%*	0.04		0.15	0.91	0.06	1.00	1.25	**128.8**	5.5		11.4	108.8	3.1	120.0	134.9	128.8	
GRLH1	Cc-H2: Rem Ref, Liq, Sea, Road	**1.42**	1.39	0.02	0.01	*0.4%*	0.04	1.04	0.30		0.03	1.30	1.54	**140.0**	6.1	128.2	4.2		1.5	133.3	147.3	140.0	
GRLH2	Cc-H2: LNG, Cen Ref, Liq, Road	**1.33**	1.31	0.01	0.00	*0.3%*	0.03	0.11	0.11	1.00	0.07	1.21	1.46	**137.4**	5.4	7.4	7.3	113.1	4.2	130.6	145.3	137.4	
WFLH1	Cc-H2: F Wood, Cen gasif, Liq, Road	**1.53**	0.08	0.01	1.44	*93.8%*	0.02	0.04	0.01	1.41	0.05	1.38	1.69	**8.8**	3.0	0.5	0.5	2.5	2.3	7.9	21.1	8.8	
WWLH1	Cc-H2: W Wood, Cen gasif, Liq, Road	**1.53**	0.08	0.01	1.44	*94.1%*		0.04	0.02	1.41	0.05	1.37	1.66	**6.2**		0.5	1.9	1.5	2.3	5.9	6.4	6.2	

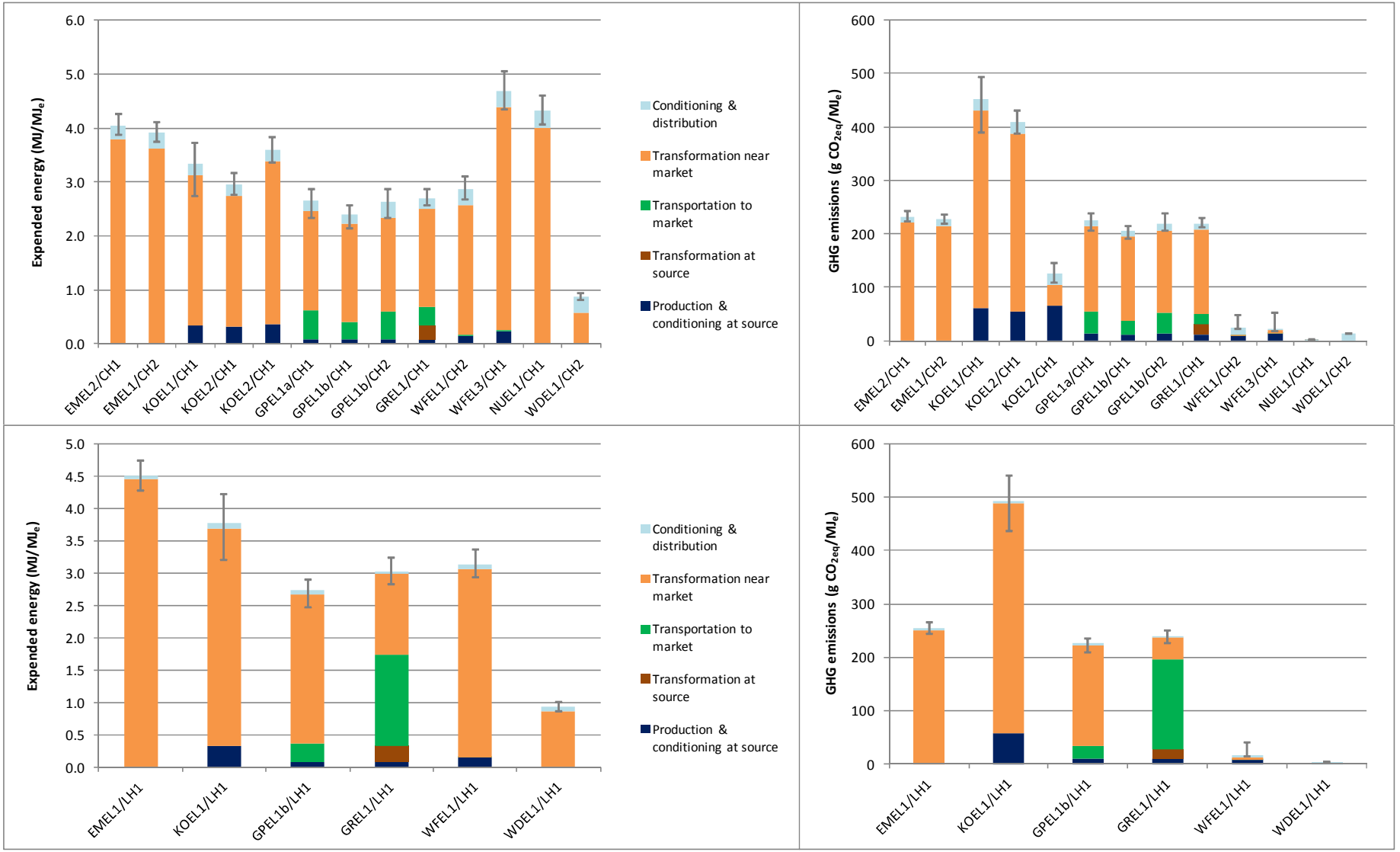
WTT APPENDIX 2



1.9 Hydrogen (electrolysis)

Pathway		Energy expended (MJ/MJ final fuel)												WTT GHG emitted (g CO_2eq/MJ final fuel)									% saving
Code	Description	**Total**	Fossil	Nuclear	Renewable	*Fract renew*	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		**Total**	Production & conditioning at source	Transformation at source	Transportation to market	Transformation near market	Conditioning & distribution	Range		Total GHG inc. combustion	
Hydrogen (electrolysis)																							
GPEL1a/CH1	C-H2: NG 7000 km, CCGT, O/S Ely	**2.64**	3.64	0.00	-1.00	*-37.8%*	0.08		0.54	1.82	0.19	2.33	2.87	**224.6**	12.6		42.2	159.0	10.75	205.7	238.4	224.6	
GPEL1b/CH1	C-H2: NG 4000 km, CCGT, O/S Ely	**2.40**	3.40	0.00	-1.00	*-41.7%*	0.08		0.32	1.82	0.18	2.14	2.57	**205.2**	11.8		24.5	159.0	9.82	190.1	215.4	205.2	
GPEL1b/CH2	C-H2: NG 4000 km, CCGT, Cen Ely, Pipe	**2.40**	3.27	0.10	-0.97	*-40.5%*	0.07		0.30	1.72	0.30	2.16	2.55	**201.2**	11.4		23.6	153.2	12.97	186.7	209.9	201.2	
GREL1/CH1	C-H2: LNG, O/S Ely	**2.70**	3.70	0.00	-1.00	*-37.0%*	0.08	0.27	0.33	1.82	0.20	2.56	2.87	**219.4**	11.7	18.0	20.7	158.4	10.50	211.2	229.1	219.4	
WFEL1/CH2	C-H2: F Wood, 200 MW gasif, CCGT, Cen ely, Pipe	**2.88**	0.23	0.10	2.54	*88.4%*	0.15		0.02	2.41	0.30	2.68	3.10	**24.7**	8.3		1.1	2.3	12.97	22.1	47.0	24.7	
WFEL3/CH1	C-H2: F Wood, Conv power, O/S Ely	**4.69**	0.12	0.00	4.56	*97.3%*	0.23		0.02	4.15	0.29	4.35	5.04	**21.7**	12.5		1.7	6.5	1.04	18.1	52.6	21.7	
EMEL2/CH1	C-H2: Elec EU-mix, O/S Ely	**3.92**	2.61	1.81	-0.49	*-12.6%*				3.62	0.30	3.75	4.11	**226.3**				213.3	12.97	218.5	235.4	226.3	
EMEL1/CH2	C-H2: Elec EU-mix, Cen ely, Pipe	**4.05**	2.68	1.86	-0.48	*-11.8%*				3.79	0.26	3.87	4.26	**232.5**				221.4	11.14	224.0	242.1	232.5	
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen ely, Liq, Road	**4.51**	2.93	2.02	-0.43	*-9.6%*				4.45	0.06	4.27	4.74	**254.4**				251.2	3.15	243.1	264.7	254.4	
KOEL1/CH1	C-H2: Elec coal EU-mix conv., O/S Ely	**3.35**	4.30	0.04	-1.00	*-29.8%*	0.34			2.78	0.23	2.74	3.73	**452.9**	60.7			370.5	21.69	390.2	492.8	452.9	
KOEL2/CH1	C-H2: Elec coal EU-mix IGCC, O/S Ely	**2.96**	3.92	0.04	-1.00	*-33.7%*	0.31			2.42	0.23	2.74	3.73	**408.7**	55.0			331.9	21.69	388.0	430.2	408.7	
KOEL2C/CH1	C-H2: Elec coal EU-mix IGCC + CCS, O/S Ely	**3.60**	4.55	0.05	-1.00	*-27.7%*	0.36			3.01	0.23	3.35	3.82	**126.5**	64.4			40.4	21.69	108.0	146.2	126.5	
NUEL1/CH1	C-H2: Elec nuclear, O/S Ely	**5.32**	0.00	0.00	-1.00	*-18.8%*	0.00			5.00	0.32	5.06	5.61	**8.0**	0.1			7.6	0.38	7.6	8.4	8.0	
WDEL1/CH2	C-H2: Wind, Cen Ely, Pipe	**0.87**	0.15	0.10	0.62	*71.1%*				0.57	0.30	0.81	0.94	**13.0**				0.0	12.97	12.3	13.6	13.0	
GPEL1b/LH1	Cc-H2: NG 4000 km, CCGT, Cen Ely, Liq, Road	**2.74**	3.73	0.01	-1.00	*-36.3%*	0.07		0.30	2.30	0.07	2.47	2.90	**225.9**	11.2		23.3	187.2	4.24	280.4	305.9	225.9	
GREL1/LH1	Cc-H2: LNG, Ely	**3.03**	4.01	0.02	-1.00	*-32.9%*	0.07	0.26	0.28	2.34	0.07	2.84	3.24	**238.9**	11.0	16.9	18.1	188.7	4.24	298.2	322.2	238.9	
WFEL1/LH1	Cc-H2: F Wood, 200 MW gasif, CCGT, Cen Ely. Liq, Road	**3.13**	0.12	0.01	2.99	*95.7%*	0.14		0.01	2.92	0.06	2.93	3.37	**15.9**	7.9		0.5	4.4	3.15	85.3	111.7	15.9	
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen Ely, Liq, Road	**4.51**	2.93	2.02	-0.43	*-9.6%*				4.45	0.06	4.27	4.74	**254.4**				251.2	3.15	313.9	335.5	254.4	
KOEL1/LH1	Cc-H2: Elec coal EU-mix, Cen Ely, Liq, Road	**3.77**	4.70	0.06	-0.99	*-26.3%*	0.32			3.37	0.07	3.20	4.23	**493.5**	57.6			431.7	4.24	506.3	611.7	493.5	
WDEL1/LH1	Cc-H2: Wind, Cen Ely, Liq, Road	**0.94**	0.05	0.01	0.88	*93.0%*				0.87	0.07	0.87	1.01	**4.2**				0.0	4.24	75.0	75.1	4.2	

WTT APPENDIX 2



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Title: WELL-TO-TANK Appendix 2 - Version 4.a. Summary of energy and GHG balance of individual pathways.

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Abstract

The Well-to-Tank study describes the process of producing, transporting, manufacturing and distributing a number of fuels suitable for road transport powertrains. It covers all steps from extracting, capturing or growing the primary energy carrier to refuelling the vehicles with the finished fuel.
This Appendix 2 summarises the results for individual pathways.
This Version 4.a replaces Version 4.0 [Report EUR 26028 EN] published in 2013

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