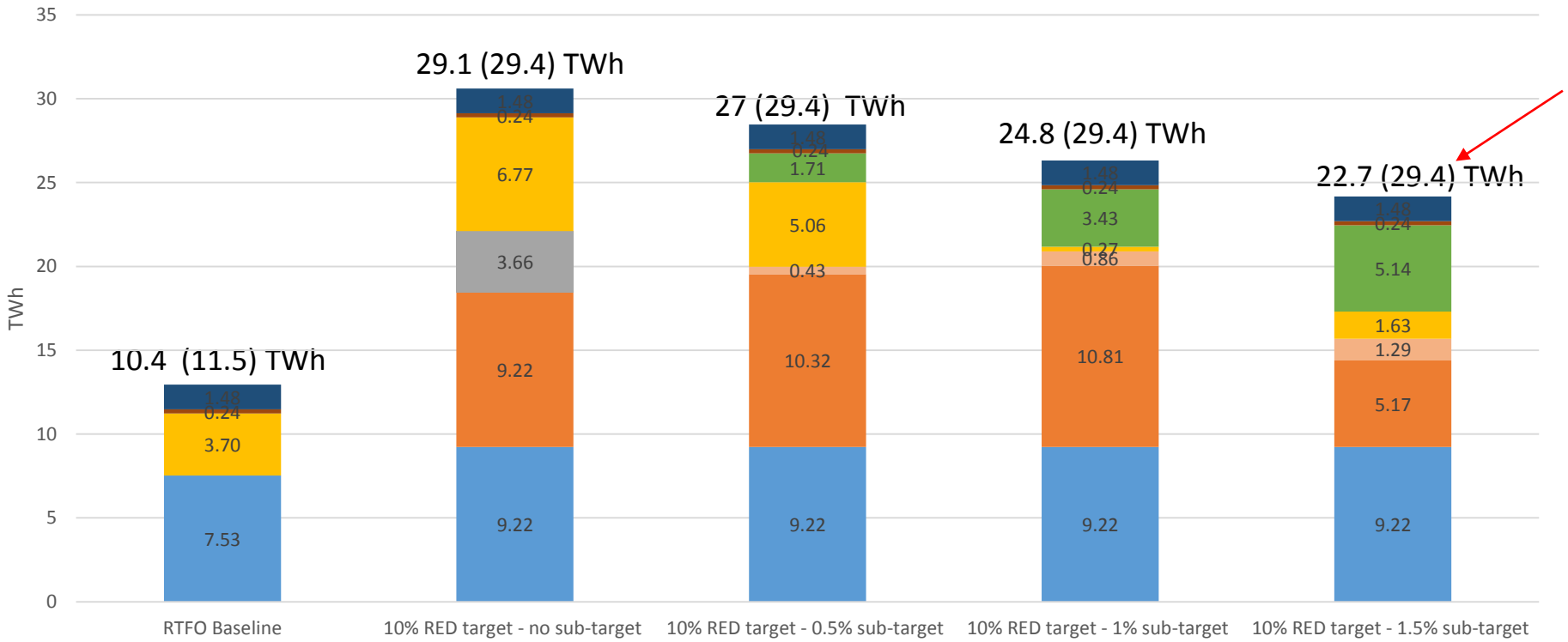
PART 1: 2020 SCENARIOS

(changes/new data marked up in red)

1a) CENTRAL WASTE SCENARIO

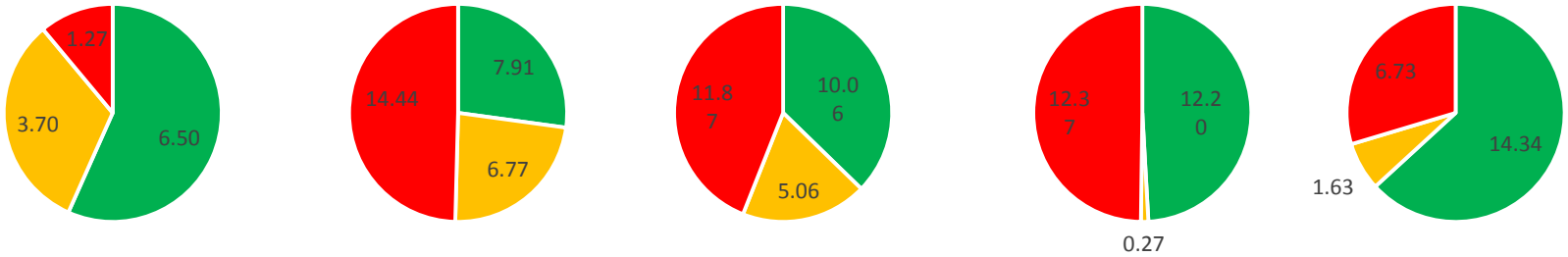


Value in brackets shows TWh Assuming Council agreement text double counting advanced biofuels to the cross-sector RED target.

- electricity
- Biomethane
- High blend crop ethanol
- Advanced ethanol
- Low blend crop ethanol
- Advanced biodiesel
- High blend crop biodiesel
- Low blend crop biodiesel
- Low blend waste biodiesel

2020 SUPPLY MIX:

SUSTAINABILITY:



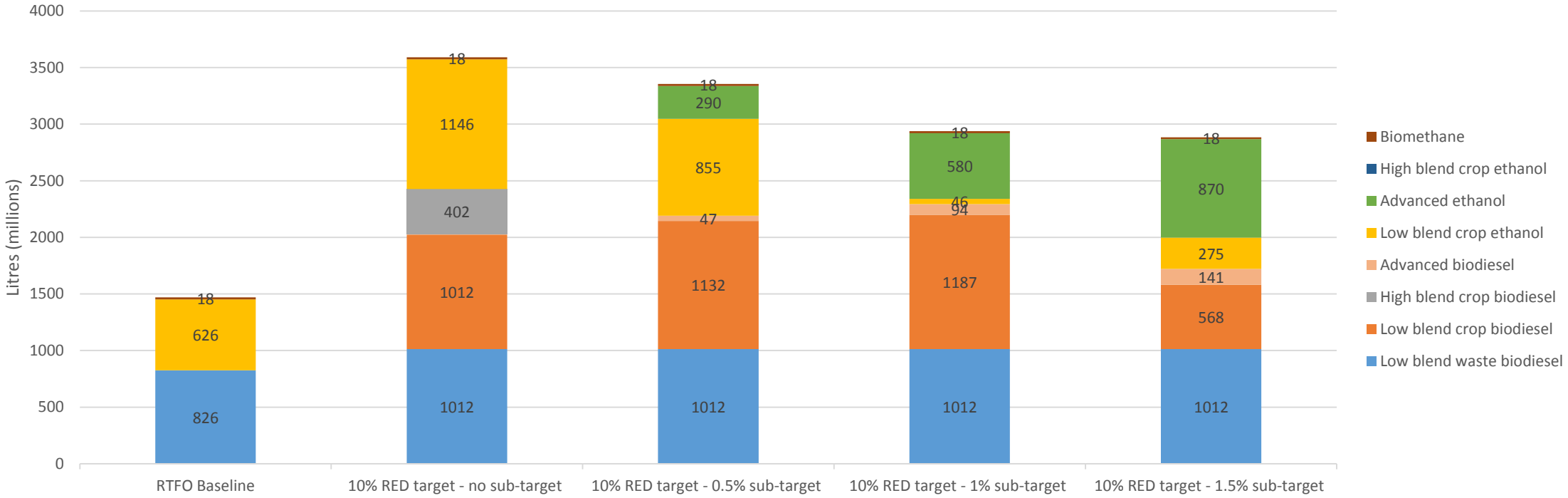
- UCO and advanced
- crop ethanol
- high indirect emissions (crop biodiesel and tallow)

2020 GHG SAVINGS:	2.3 MT	2.8 MT	3.1 MT	3.0 MT	3.9 MT
2020 CROP SHARE:	0.86%	4.59%	3.59%	2.59%	1.59%
2020 COSTS: (2014 price base)	£147m/year £13 (13)/MWh £64/tCO2	£373m/year £13 (13)/MWh £135/tCO2	£283m/year £11 (10)/MWh £90/tCO2	£265m/year £11 (9)/MWh £89/tCO2	£201m/year £9 (7)/MWh £52/tCO2
RTFO VOLUME TARGET REQUIRED:	4.75%	9.35%	9.50%	9.31%	9.78%

What the charts show – central waste scenario

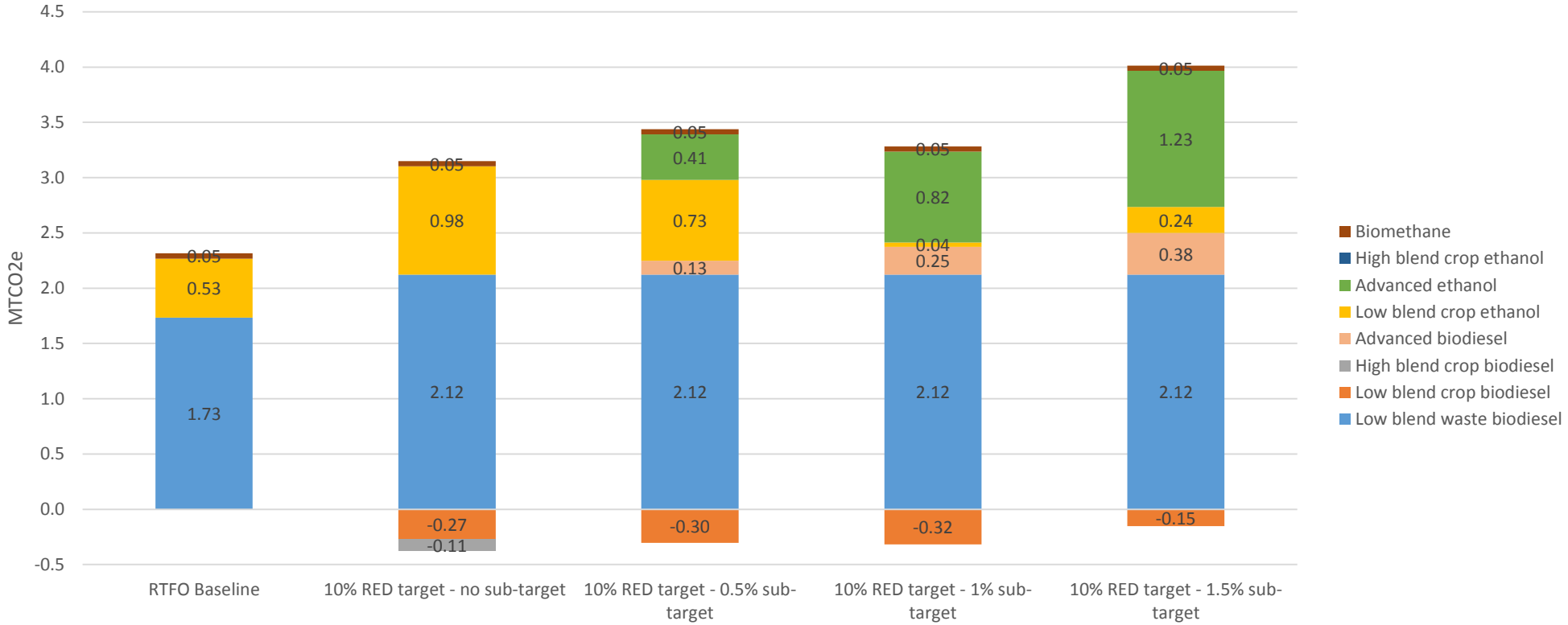
- The total volume of supply required to meet the sub-target is affected significantly by the amount of double-counted material supplied
- Overall GHG savings increase with more fuel, but savings are limited due to supply of crop biodiesel which is assumed to increase GHG emissions due to ILUC
- E10 is only supplied in scenarios one & two, where biodiesel is blended up to the B7 blend wall. This is due to the assumptions in the supply preferences (E5, then B7, then E10) and the volumes required
- The share of crop based fuels is less than 5% in all scenarios due to the supply assumptions around waste based fuels
- The overall costs are highest with the highest supply. This is because advanced fuels double count and are assumed to cost less than twice as much (relative to the displaced fossil fuel) as conventional fuels.

1a) CENTRAL WASTE SCENARIO (Volumetric)



% of total fuel by volume	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.70%	2.08%	2.08%	2.09%	2.08%
Low blend crop biodiesel	0.00%	2.08%	2.33%	2.45%	1.17%
High blend crop biodiesel	0.00%	0.83%	0.00%	0.00%	0.00%
Advanced biodiesel	0.00%	0.00%	0.10%	0.19%	0.29%
Total biodiesel	**1.70%**	**4.99%**	**4.51%**	**4.73%**	**3.54%**
Low blend crop ethanol	1.29%	2.35%	1.76%	0.10%	0.57%
Advanced ethanol	0.00%	0.00%	0.60%	1.20%	1.79%
High blend crop ethanol	0.00%	0.00%	0.00%	0.00%	0.00%
Total ethanol	**1.29%**	**2.35%**	**2.35%**	**1.29%**	**2.36%**
Biomethane	0.04%	0.04%	0.04%	0.04%	0.04%
Biofuel total	**3.03%**	**7.38%**	**6.90%**	**6.06%**	**5.93%**

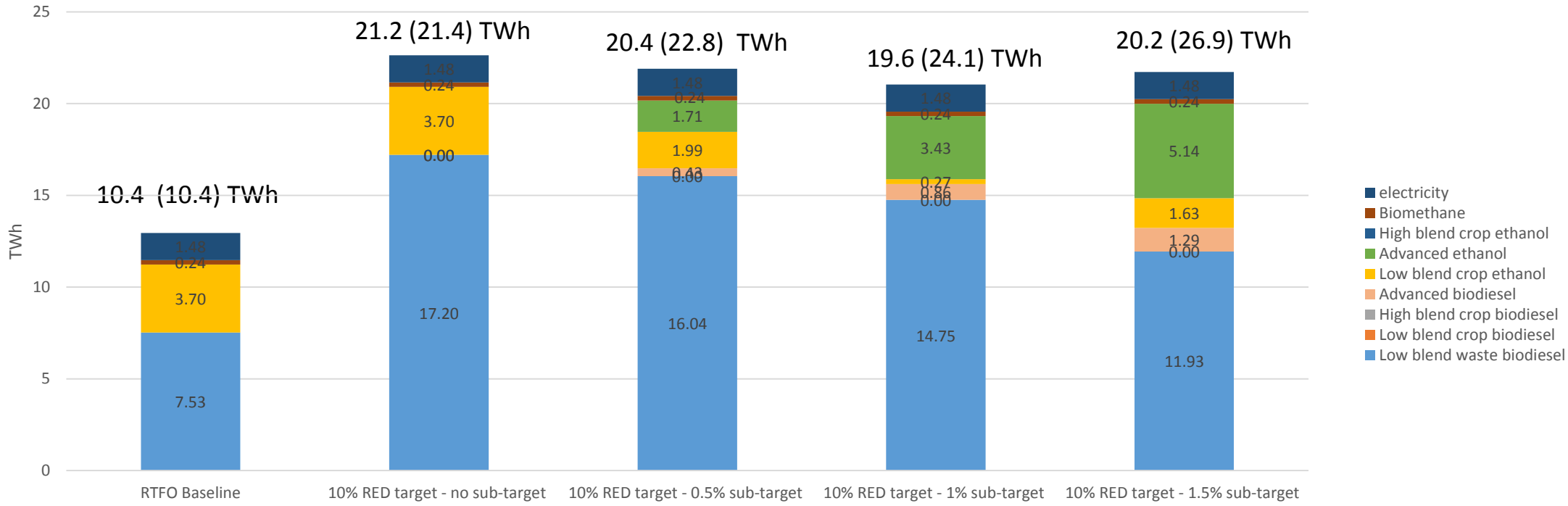
1a) CENTRAL WASTE SCENARIO (GHG Savings)



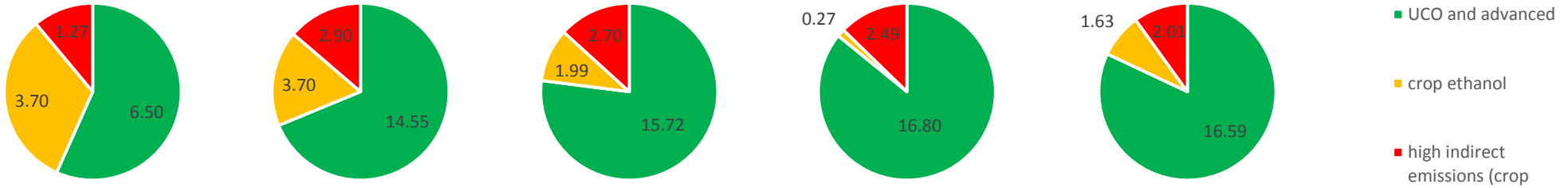
	GHG Savings (MTCO2e)				
	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.73	2.12	2.12	2.12	2.12
Low blend crop biodiesel	0.00	-0.27	-0.30	-0.32	-0.15
High blend crop biodiesel	0.00	-0.11	0.00	0.00	0.00
Advanced biodiesel	0.00	0.00	0.13	0.25	0.38
Low blend crop ethanol	0.53	0.98	0.73	0.04	0.24
Advanced ethanol	0.00	0.00	0.41	0.82	1.23
High blend crop ethanol	0.00	0.00	0.00	0.00	0.00
Biomethane	0.05	0.05	0.05	0.05	0.05
Total	**2.31**	**2.77**	**3.13**	**2.96**	**3.86**

1b) HIGH WASTE SCENARIO:

2020 SUPPLY MIX:

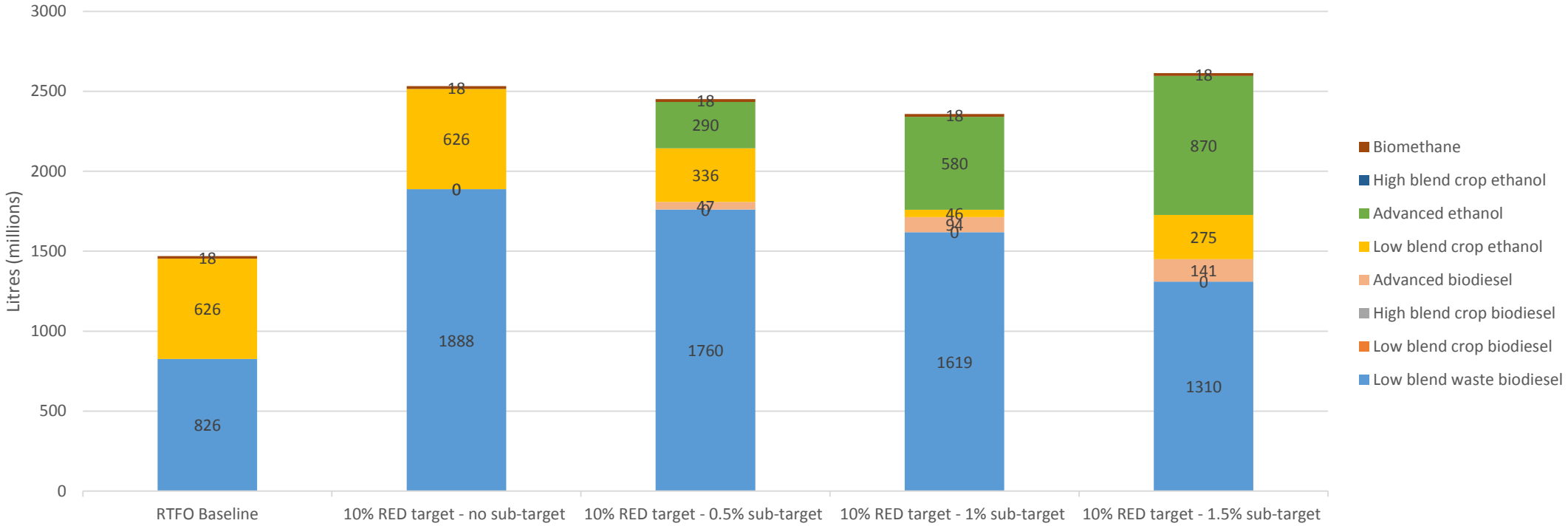


SUSTAINABILITY:



2020 GHG SAVINGS:	2.3 MT	4.5 MT	4.6 MT	4.6 MT	4.6 MT
2020 CROP SHARE:	0.86%	0.86%	0.46%	0.06%	0.38%
2020 COSTS: (2014 price base)	£147m/year £13 (13)/MWh £64/tCO2	£319m/year £15 (15)/MWh £70/tCO2	£284m/year £14 (13)/MWh £62/tCO2	£247m/year £13 (10)/MWh £54/tCO2	£270m/year £10 (7)/MWh £42/tCO2
RTFO VOLUME TARGET REQUIRED:	4.75%	8.87%	9.09%	9.26%	9.78%

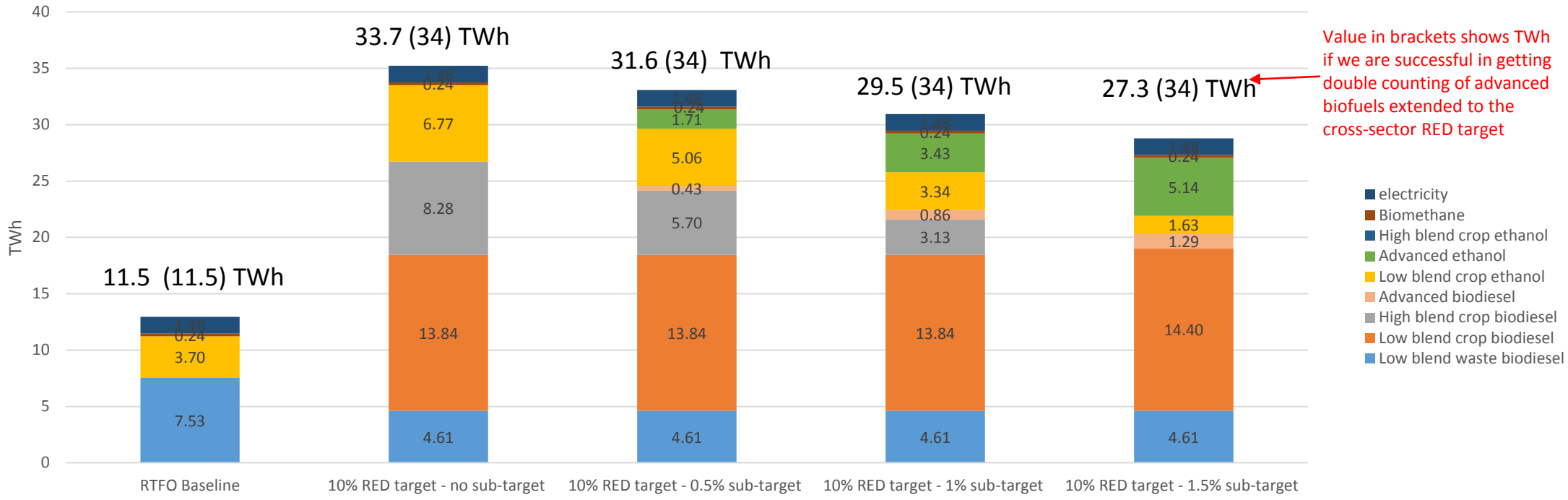
1b) HIGH WASTE SCENARIO (Volumetric):



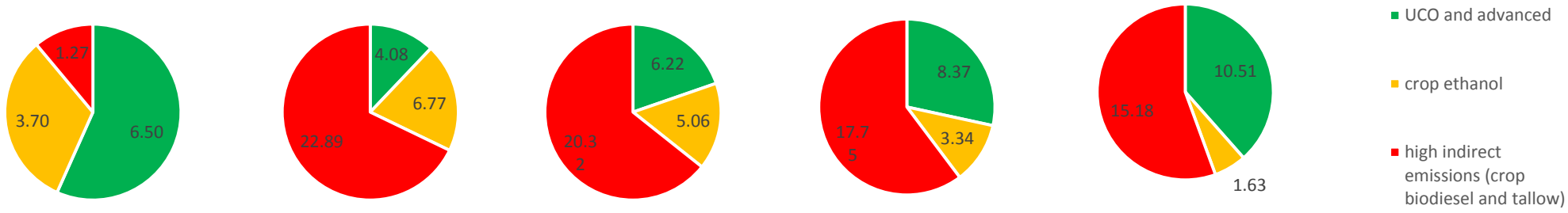
% of total fuel by volume	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.70%	3.90%	3.63%	3.34%	2.70%
Low blend crop biodiesel	0.00%	0.00%	0.00%	0.00%	0.00%
High blend crop biodiesel	0.00%	0.00%	0.00%	0.00%	0.00%
Advanced biodiesel	0.00%	0.00%	0.10%	0.19%	0.29%
Total biodiesel	**1.70%**	**3.90%**	**3.73%**	**3.54%**	**2.99%**
Low blend crop ethanol	1.29%	1.29%	0.69%	0.10%	0.57%
Advanced ethanol	0.00%	0.00%	0.60%	1.20%	1.79%
High blend crop ethanol	0.00%	0.00%	0.00%	0.00%	0.00%
Total ethanol	**1.29%**	**1.29%**	**1.29%**	**1.29%**	**2.36%**
Biomethane	0.04%	0.04%	0.04%	0.04%	0.04%
Biofuel total	**3.03%**	**5.23%**	**5.06%**	**4.87%**	**5.38%**

1c) LOW WASTE SCENARIO:

2020 SUPPLY MIX:

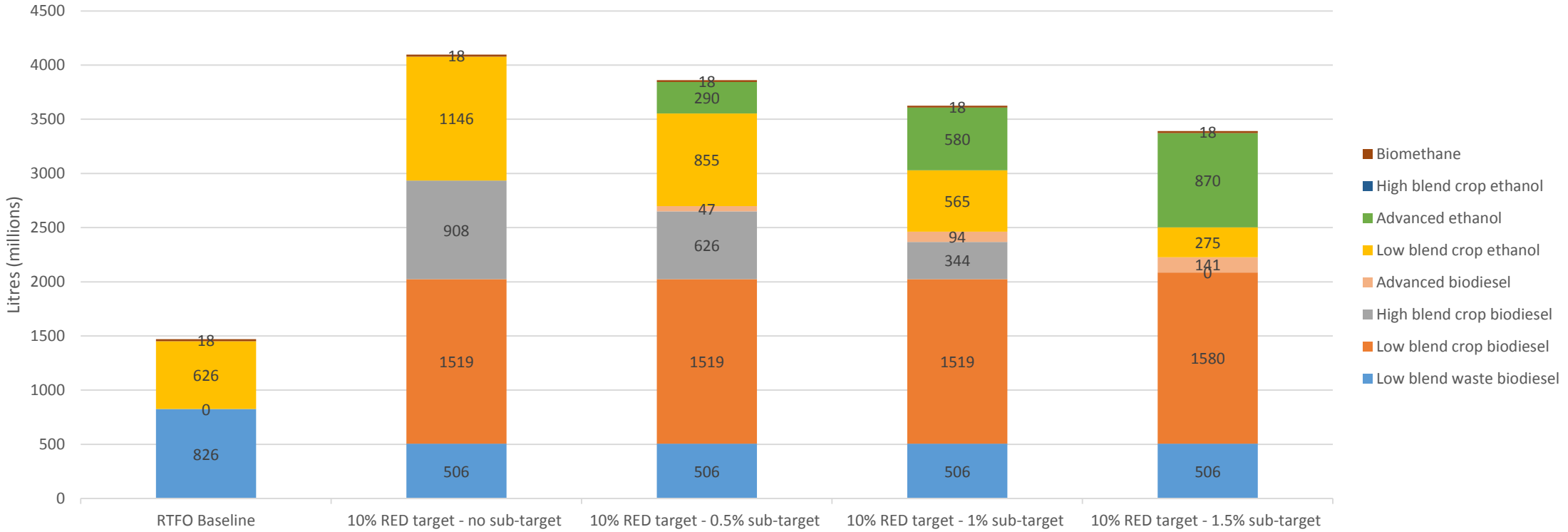


SUSTAINABILITY:



2020 GHG SAVINGS:	2.3 MT	1.4 MT	1.8 MT	2.2 MT	2.5 MT
2020 CROP SHARE:	0.86%	6.74%	5.74%	4.74%	3.74%
2020 COSTS: (2014 price base)	£147m/year £13 (13)/MWh £64/tCO2	£451m/year £13 (13)/MWh £314/tCO2	£376m/year £12 (11)/MWh £209/tCO2	£300m/year £10 (9)/MWh £139/tCO2	£217m/year £8 (6)/MWh £86/tCO2
RTFO VOLUME TARGET REQUIRED:	4.75%	9.44%	9.59%	9.73%	9.87%

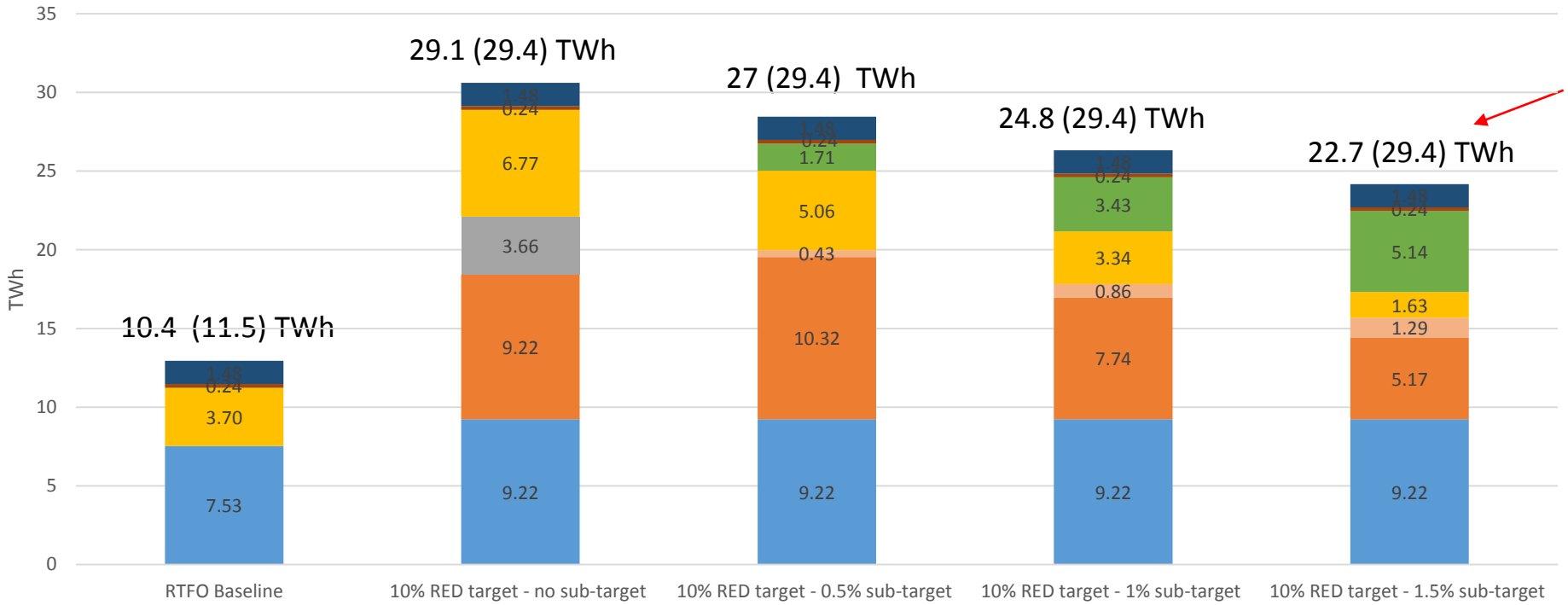
1c) LOW WASTE SCENARIO (Volumetric):



% of total fuel by volume	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.70%	1.04%	1.04%	1.04%	1.04%
Low blend crop biodiesel	0.00%	3.12%	3.12%	3.12%	3.25%
High blend crop biodiesel	0.00%	1.86%	1.29%	0.71%	0.00%
Advanced biodiesel	0.00%	0.00%	0.10%	0.19%	0.29%
Total biodiesel	**1.70%**	**6.02%**	**5.54%**	**5.06%**	**4.58%**
Low blend crop ethanol	1.29%	2.35%	1.76%	1.16%	0.57%
Advanced ethanol	0.00%	0.00%	0.60%	1.19%	1.79%
High blend crop ethanol	0.00%	0.00%	0.00%	0.00%	0.00%
Total ethanol	**1.29%**	**2.35%**	**2.35%**	**2.35%**	**2.35%**
Biomethane	0.04%	0.04%	0.04%	0.04%	0.04%
Biofuel total	**3.03%**	**8.41%**	**7.93%**	**7.45%**	**6.97%**

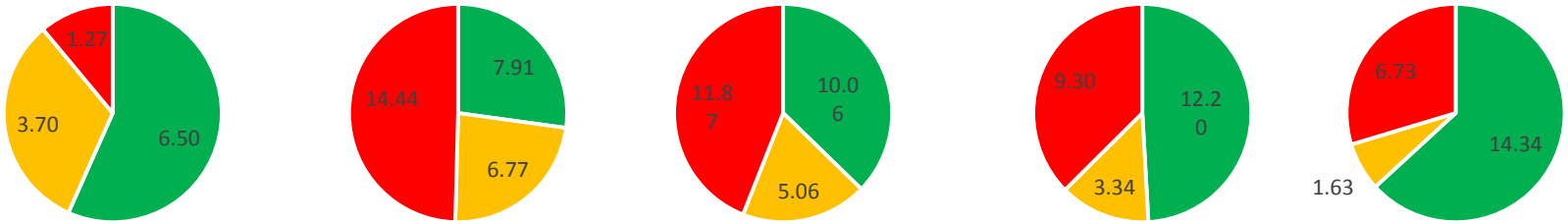
2b) MANAGED E10 SCENARIO:

2020 SUPPLY MIX:



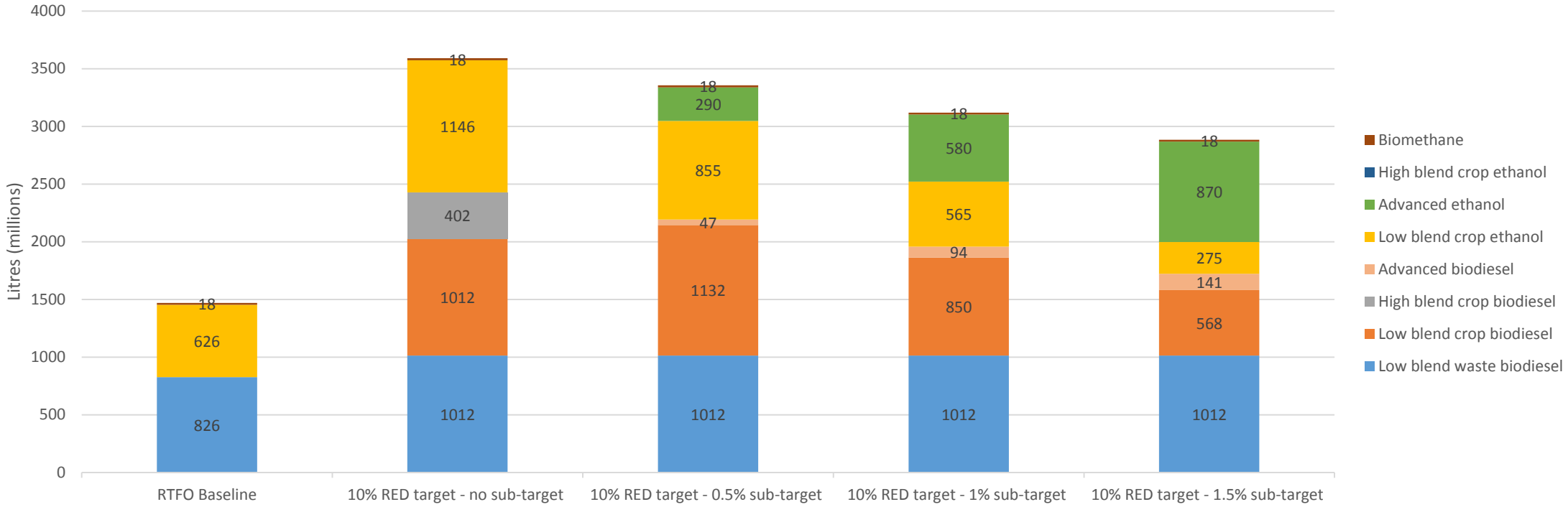
Value in brackets shows TWh Assuming Council agreement text double counting advanced biofuels to the cross-sector RED target.

SUSTAINABILITY:



2020 GHG SAVINGS:	2.3 MT	2.8 MT	3.1 MT	3.5 MT	3.9 MT
2020 CROP SHARE:	0.86%	4.59%	3.59%	2.59%	1.59%
2020 COSTS: (2014 price base)	£147m/year £13 (13)/MWh £64/tCO2	£373m/year £13 (13)/MWh £135/tCO2	£283m/year £11 (10)/MWh £90/tCO2	£242m/year £10 (8)/MWh £69/tCO2	£201m/year £9 (7)/MWh £52/tCO2
RTFO VOLUME TARGET REQUIRED:	4.75%	9.35%	9.50%	9.64%	9.78%

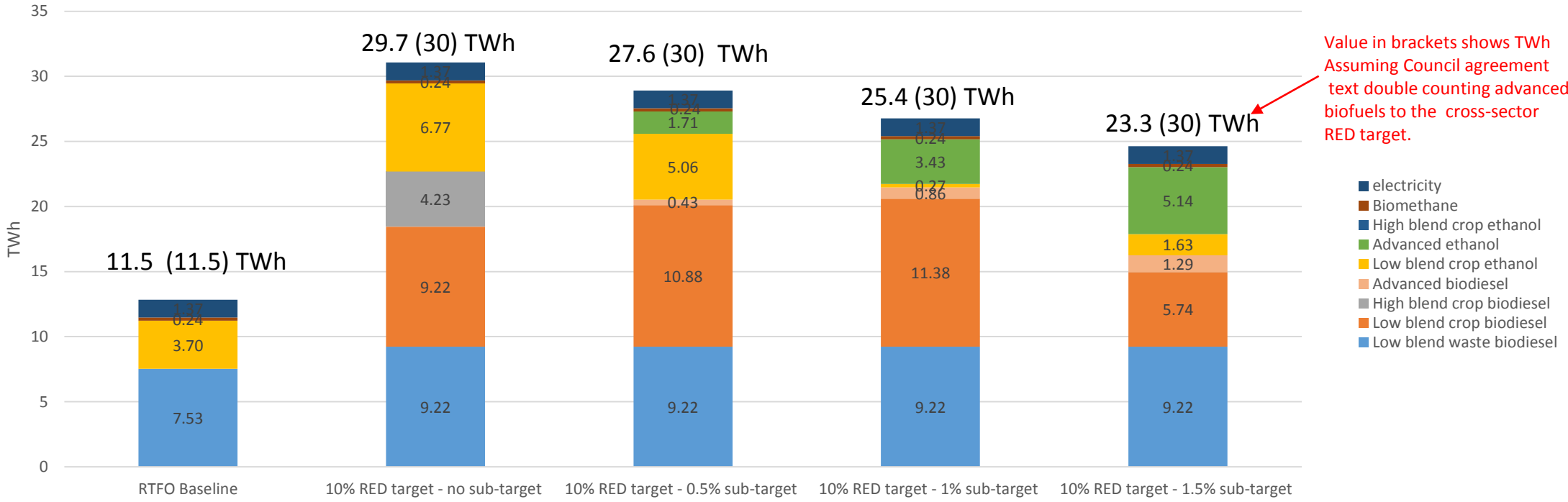
2b) MANAGED E10 SCENARIO: (Volumetric)



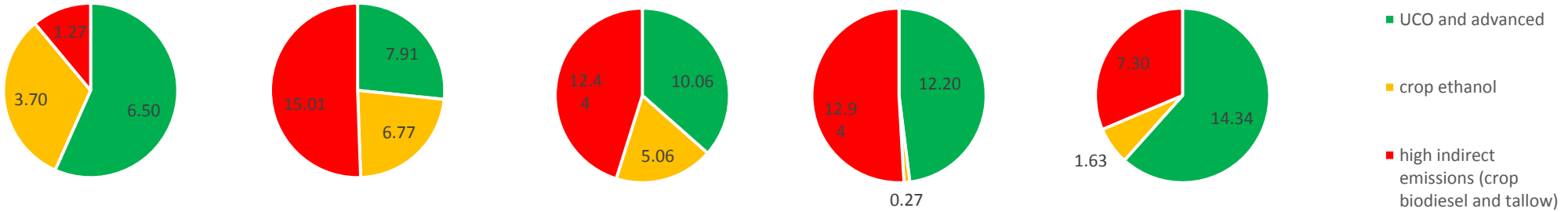
% of total fuel by volume	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.70%	2.08%	2.08%	2.08%	2.08%
Low blend crop biodiesel	0.00%	2.08%	2.33%	1.75%	1.17%
High blend crop biodiesel	0.00%	0.83%	0.00%	0.00%	0.00%
Advanced biodiesel	0.00%	0.00%	0.10%	0.19%	0.29%
Total biodiesel	**1.70%**	**4.99%**	**4.51%**	**4.02%**	**3.54%**
Low blend crop ethanol	1.29%	2.35%	1.76%	1.16%	0.57%
Advanced ethanol	0.00%	0.00%	0.60%	1.19%	1.79%
High blend crop ethanol	0.00%	0.00%	0.00%	0.00%	0.00%
Total ethanol	**1.29%**	**2.35%**	**2.35%**	**2.36%**	**2.36%**
Biomethane	0.04%	0.04%	0.04%	0.04%	0.04%
Biofuel total	**3.03%**	**7.38%**	**6.90%**	**6.42%**	**5.93%**

2i) LOW EV UPTAKE SCENARIO:

2020 SUPPLY MIX:

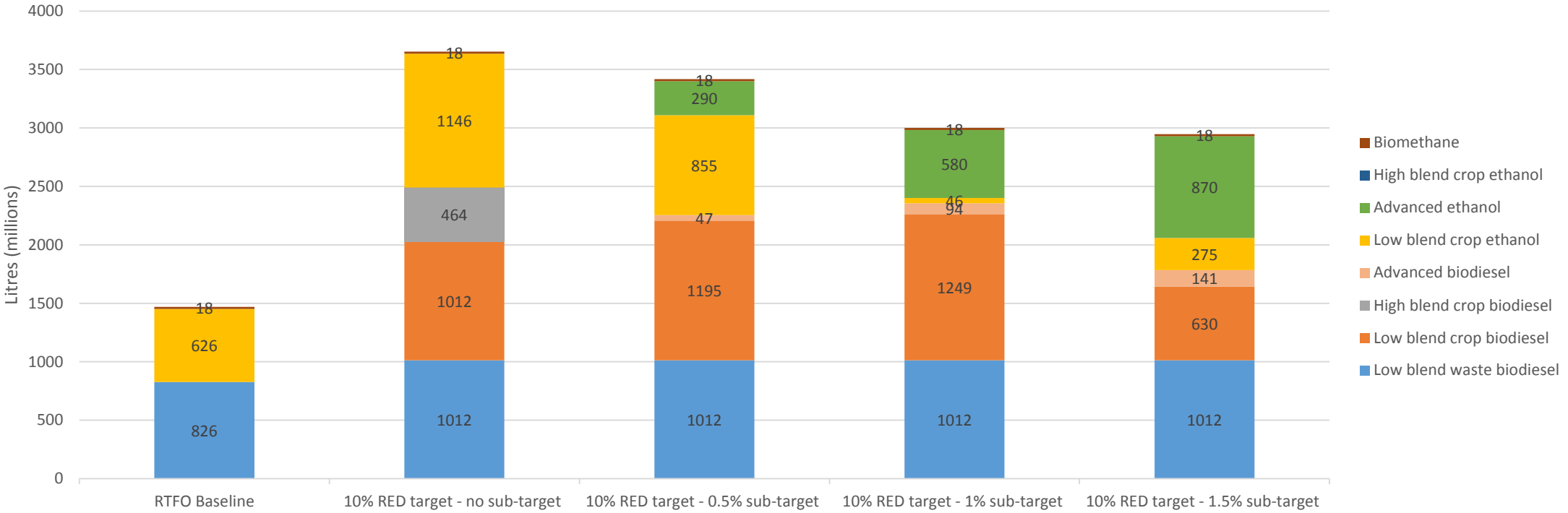


SUSTAINABILITY:



2020 GHG SAVINGS:	2.3 MT	2.8 MT	3.1 MT	2.9 MT	3.8 MT
2020 CROP SHARE:	0.86%	4.72%	3.72%	2.72%	1.72%
2020 COSTS: (2014 price base)	£147m/year £13 (13)/MWh £64/tCO2	£387m/year £13 (13)/MWh £134/tCO2	£290m/year £11 (10)/MWh £96/tCO2	£271m/year £11 (9)/MWh £100/tCO2	£207m/year £9 (7)/MWh £80/tCO2
RTFO VOLUME TARGET REQUIRED:	4.75%	9.48%	9.62%	9.43%	9.90%

2i) LOW EV UPTAKE SCENARIO (Volumetric):



% of total fuel by volume	RTFO Baseline	10% RED target - no sub-target	10% RED target - 0.5% sub-target	10% RED target - 1% sub-target	10% RED target - 1.5% sub-target
Low blend waste biodiesel	1.70%	2.08%	2.08%	2.09%	2.08%
Low blend crop biodiesel	0.00%	2.08%	2.45%	2.58%	1.30%
High blend crop biodiesel	0.00%	0.95%	0.00%	0.00%	0.00%
Advanced biodiesel	0.00%	0.00%	0.10%	0.19%	0.29%
Total biodiesel	**1.70%**	**5.11%**	**4.63%**	**4.86%**	**3.67%**
Low blend crop ethanol	1.29%	2.35%	1.76%	0.10%	0.57%
Advanced ethanol	0.00%	0.00%	0.60%	1.20%	1.79%
High blend crop ethanol	0.00%	0.00%	0.00%	0.00%	0.00%
Total ethanol	**1.29%**	**2.35%**	**2.35%**	**1.29%**	**2.36%**
Biomethane	0.04%	0.04%	0.04%	0.04%	0.04%
Biofuel total	**3.03%**	**7.50%**	**7.02%**	**6.19%**	**6.06%**

PART 2: DATA & ASSUMPTIONS

(changes/new data marked up in red)

2a) Target Accounting

The modelling assumes that 10% RED transport sub-target is met through combination of RTFO and an advanced biofuel sub-target set

The advanced biofuel sub-target has been modelled at 0, 0.5%, 1.0% and 1.5%. (to note: in this context 0.5% means 0.5% **not** 0.25% double counted)

Waste-derived biodiesel, advanced biofuels and (waste-derived) biomethane are assumed to be double counted towards the target

The renewable share of electricity used in road is assumed to be counted 5x towards the target and the renewable share of electricity in rail is assumed to be 2.5x counted

2a) RED Accounting

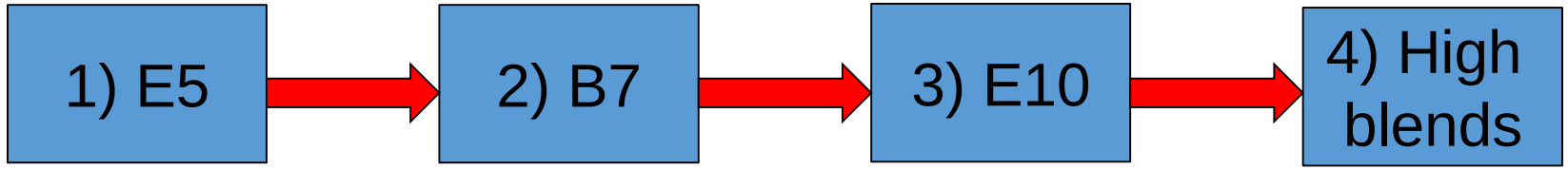
The **RED target denominator** takes account of liquid fuel and electricity used in road transport and rail. It does not include gaseous fuels.

The **RED target numerator** takes account of electricity, liquid and gaseous fuels used in road and rail transport.

The **FQD target numerator & denominator** take into account electricity, liquid and gaseous fuels used in road transport and NRMM.

ISSUE: What do we assume about biodiesel blending into LSGO (rail and non-rail NRMM)? At the moment we are assuming zero
ISSUE: What about aviation?

2b) Supply choices



Suppliers assumed to supply E5 (E4.6 effective); then B7 (B6.8 effective, waste is blended first due to double certificates); then E10 (E8.3 effective)

Under some scenarios, ethanol blending does not exceed the E5 ‘blend wall’ (either because of high volumes of waste biodiesel being supplied or high advanced biofuel sub-targets), so ‘managed E10 introduction’ scenarios have been modelled where E10 is introduced before B7 has been maximised.

The supply of advanced biofuels is assumed to require a sub-target (i.e. no advanced biofuel is supplied in absence of a sub-target)

Some fuels are not included in the modelling (e.g. methanol, ETBE, HVO, butanol)

2c) Waste biodiesel (UCO/tallow) assumptions

Waste biodiesel availability has a significant impact on modelled supply outcomes due to double certification (chart below shows 2020 supply mix with central and high waste assumptions – under the high waste scenario ethanol supply does not exceed the E5 ‘blend wall’)

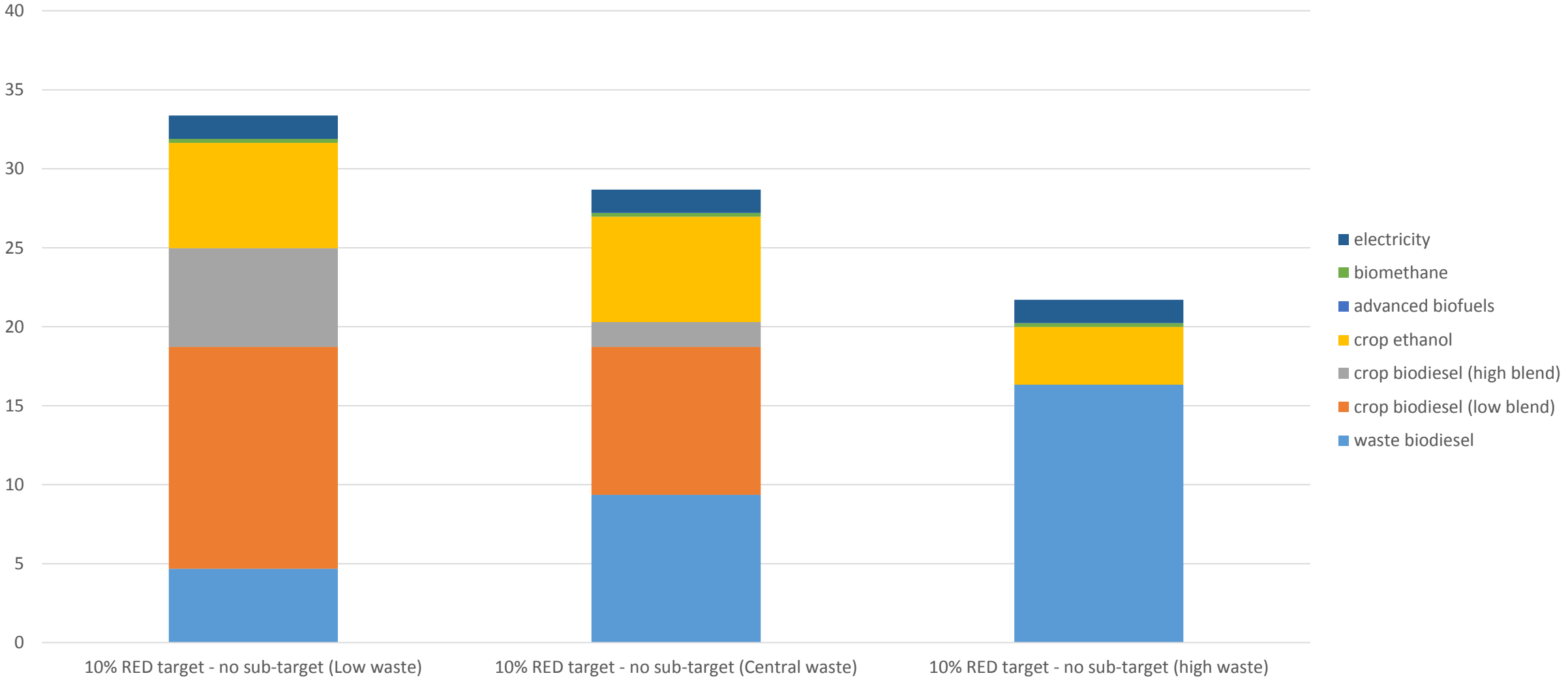
Central assumption is sufficient waste for B3.5 (~9.5 TWh, 1 billion litres) will be available

High Assumption is B7 (~19 TWh, 2 billion litres waste) will be available

Year 4 (highest to date) RTFO supply was 7.4TWh (810 million litres)

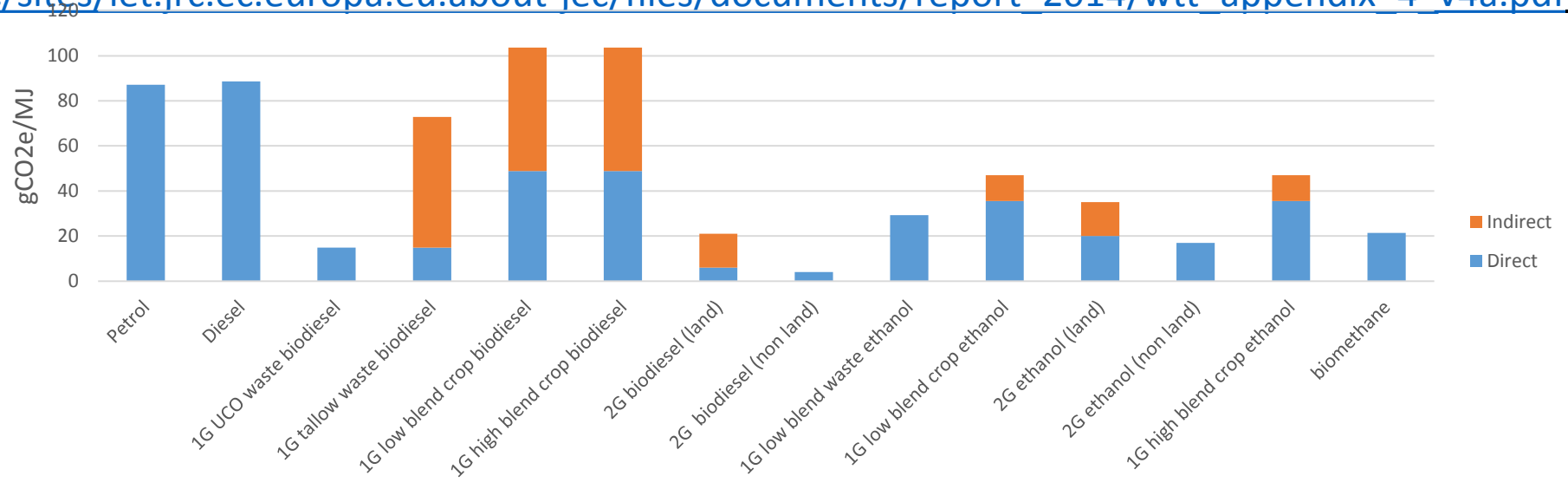
UCO/tallow assumed to be split 83.1% and 16.9% respectively (based upon observed supply volumes in years 5 & 6 of the RTFO)

2c) Waste biodiesel (UCO/tallow) assumptions



2d) GHG emissions (data in spreadsheet)

Direct emissions - RTFO stats for currently supplied biofuels (Source: historical RTFO data (from year 4b onwards), available at https://www.gov.uk/government/collections/biofuels-statistics) and RED annex V for advanced biofuels Source: Renewable Energy Directive, Annex V, Part E - available at: http://faolex.fao.org/docs/pdf/eur88009.pdf
Indirect emissions - EU ILUC impact assessment for 1G crop biofuel and land using advanced biofuels (Source: European Commission ILUC impact assessment (p.26/27), available at http://ec.europa.eu/energy/renewables/biofuels/doc/biofuels/swd_2012_0343_ia_en.pdf) and Ecometrica research for tallow (Source: Ecometrica research for the Renewable Fuels Agency (now DfT), Available at http://webarchive.nationalarchives.gov.uk/20110407094507/http:/www.renewablefuelsagency.gov.uk/sites/rfa/files/_documents/Appendix_7_-_Tallow_Case_Study_200912231729.pdf)
Fossil Emissions - JRC Well-to-Wheels study (Available at http://iet.jrc.ec.europa.eu/about-jec/sites/iet.jrc.ec.europa.eu.about-jec/files/documents/report_2014/wtt_appendix_4_v4a.pdf)



2d) GHG emissions - questions

FEEDBACK: some suggestion that the advanced biofuel direct emissions did not look correct?

QUESTION: Is there a better source than the RED for advanced biofuel emissions

2e) fossil fuel price projections (data in spreadsheet)

Petrol, diesel and gas prices based upon DECC energy price projections

Source: DECC energy price projections which are available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/212521/130718_decc-fossil-fuel-price-projections.pdf

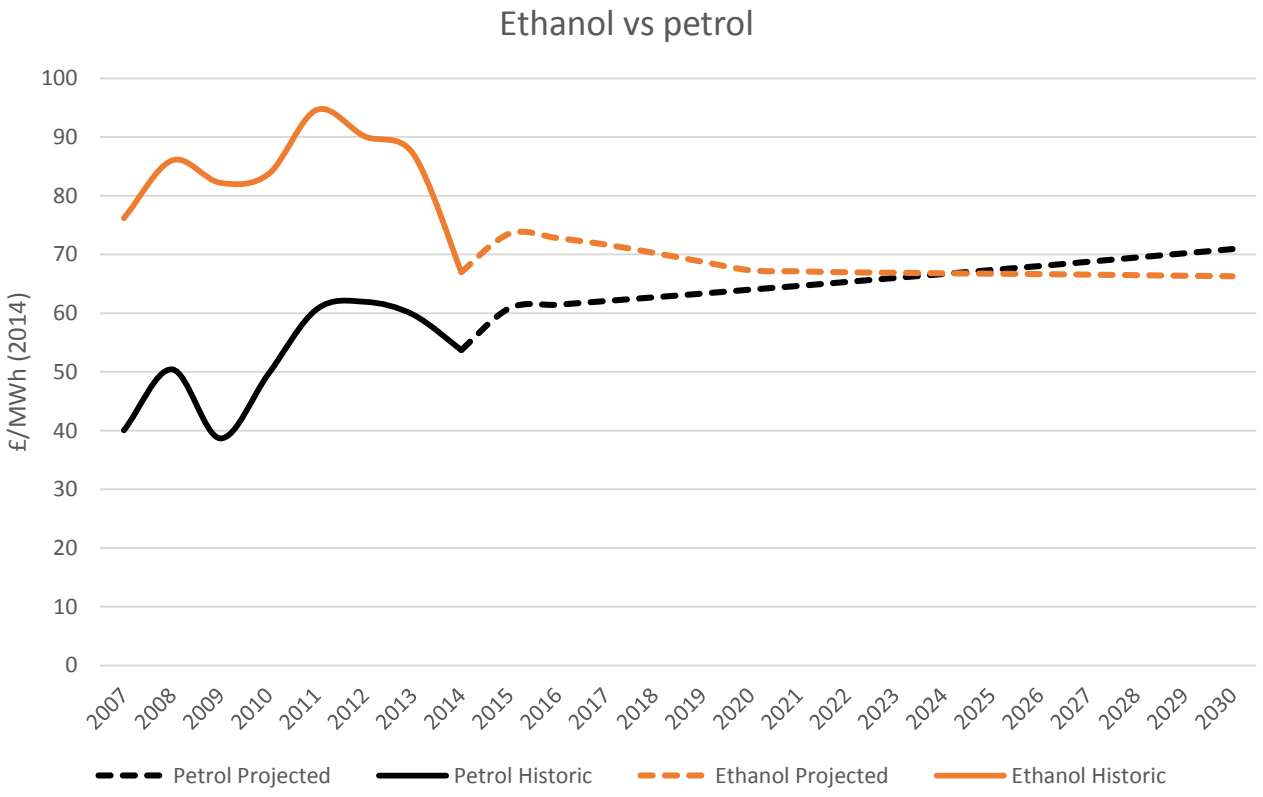
2f) biofuel price projections (data in spreadsheet)

1G biofuel price projections
Source (processing costs): Poyry study, not yet published. Source (crop price projections): OECD Aglink model (UCO/tallow price uplift based upon observed price premium in market), not yet published

Advanced biofuel price projections
Source (processing costs): NNFCC advanced biofuel research, available at: http://www.nnfcc.co.uk/tools/advanced-biofuels-the-potential-for-a-uk-industry-nnfcc-11-011

Biomethane price projections
Source (processing costs): AEA-Ricardo research, not yet published

2f) biofuel price projections (data in spreadsheet)



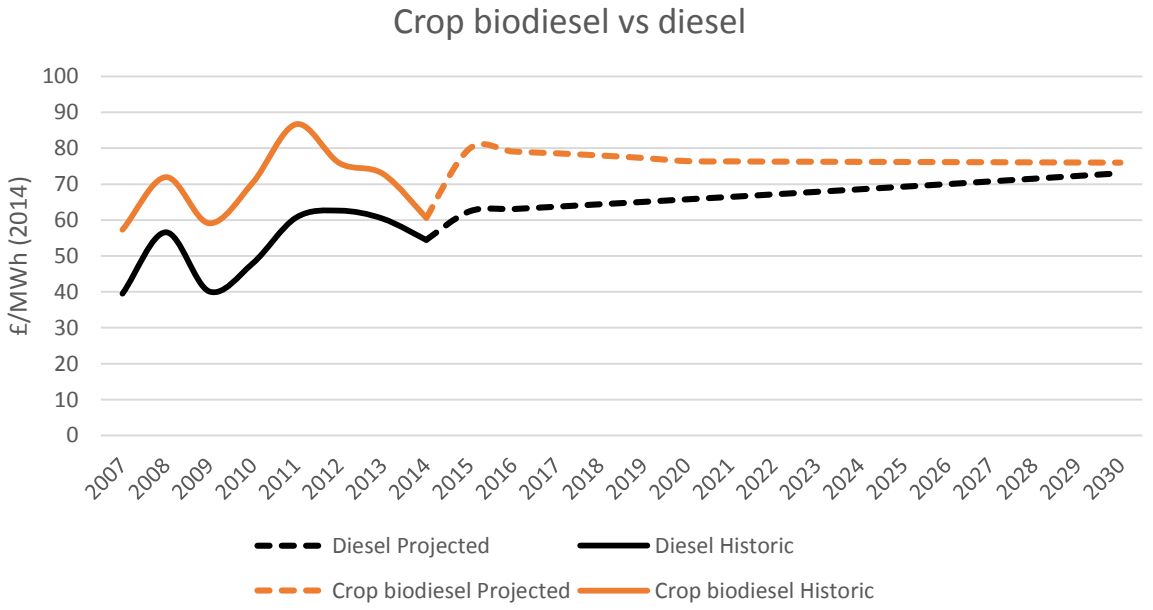
Fossil fuel and biofuel price projections are based upon oil (DECC) and crop price (OECD Aglink model) projections.

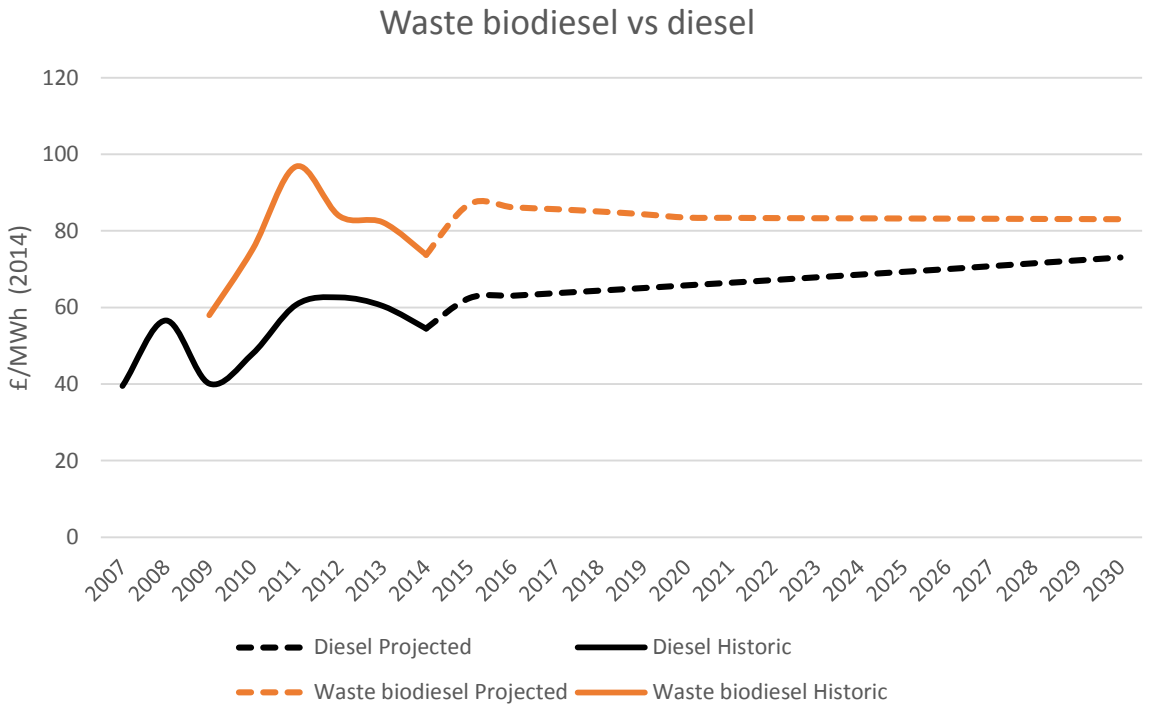
When comparing historical prices and projected prices, there is a big fall in the spread between ethanol and petrol (and therefore ethanol becomes a lot cheaper to subsidise under the RTFO)

Is this realistic?

Are there any alternative projections which could be used?

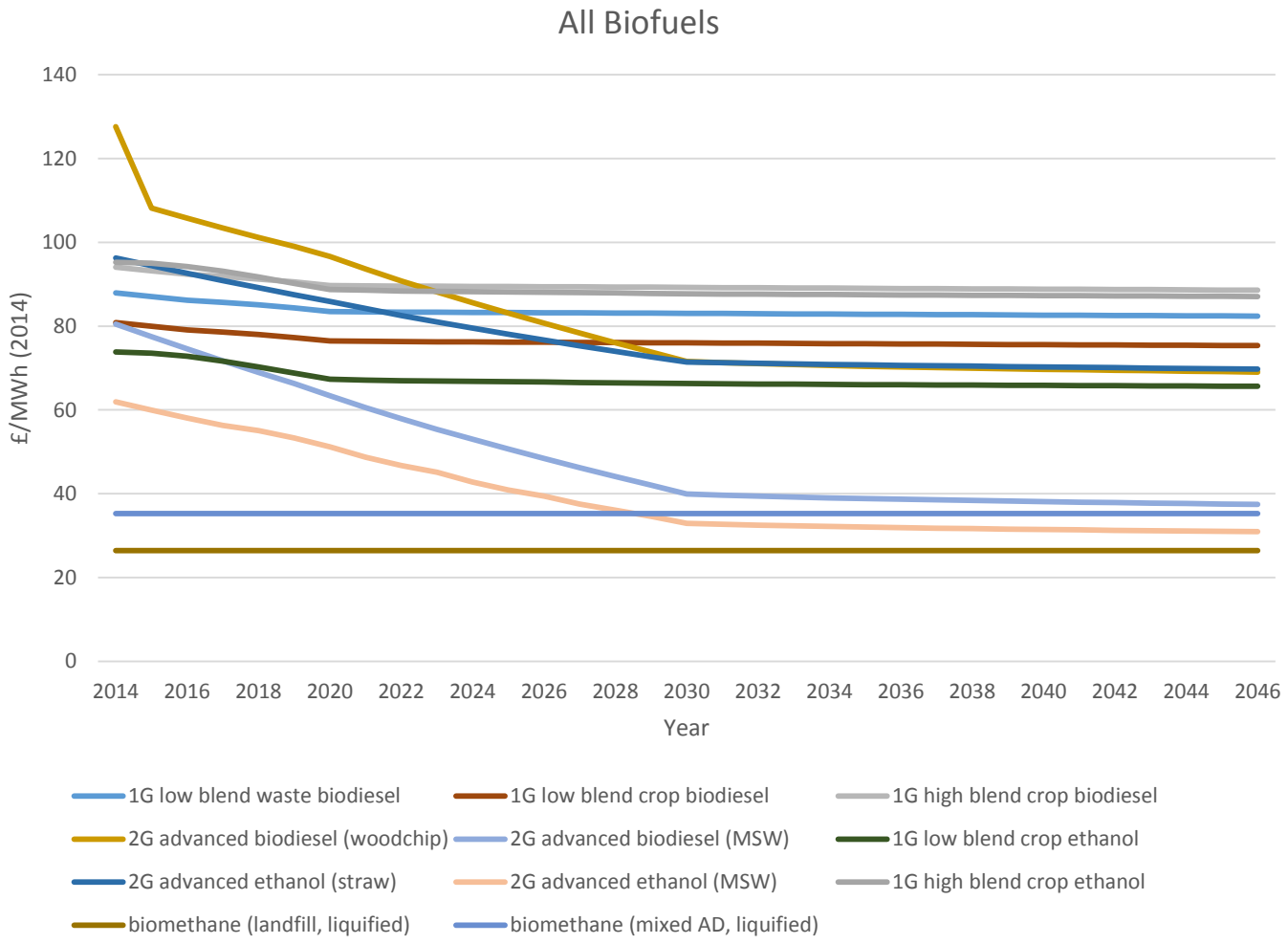
2f) biofuel price projections (data in spreadsheet)





There is less divergence between the historical and projected diesel/biodiesel spread….

2f) biofuel price projections (data in spreadsheet)



Advanced biofuel production costs are based upon NNFCC cost estimates for 2020 when technologies are assumed to be at a relatively mature stage of development.

Costs are projected to fall markedly over the period to 2030 due to a steeply declining discount rate (18% in 2014 falling to 10% in 2030). Due to large capex component, this has a significant impact on levelised cost calculation.

Are these assumptions realistic?

We assume 1G price is set by crop prices and therefore production costs. Is this assumption appropriate for advanced fuels?

2g) Energy Demand Projections (data in spreadsheet)

Projections of electricity, liquid and gaseous fuels used in road and rail transport have been taken from DECC Energy & Emissions Projections (annex F). These projections can be found in the data spreadsheet which accompanies this presentation and are also available online at:

https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2014

Dieselisation assumptions have also been taken from DECC Energy & Emissions Projections. These are not published online but can be found in the data spreadsheet which accompanies this presentation.

Projections of **non-rail NRMM** fuel demand have been estimated by rolling forward LSGO supply volume reported under year 6 of the RTFO net of projected rail demand for liquid fuels. These projections can be found in the data spreadsheet which accompanies this presentation.

2i) Electricity Contribution

2020 rail electricity demand	4.2 TWh
2020 road electricity demand	0.8TWh

2j) Fuel substitution

The following fuel substitution is assumed to take place:

Bioethanol --> petrol
biodiesel --> diesel
biomethane --> natural gas