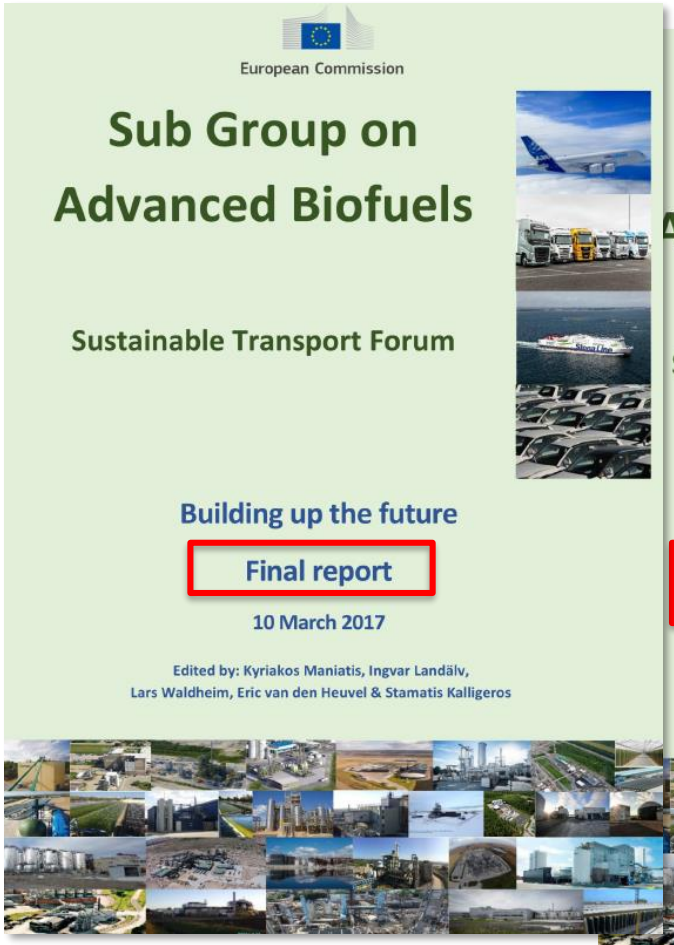
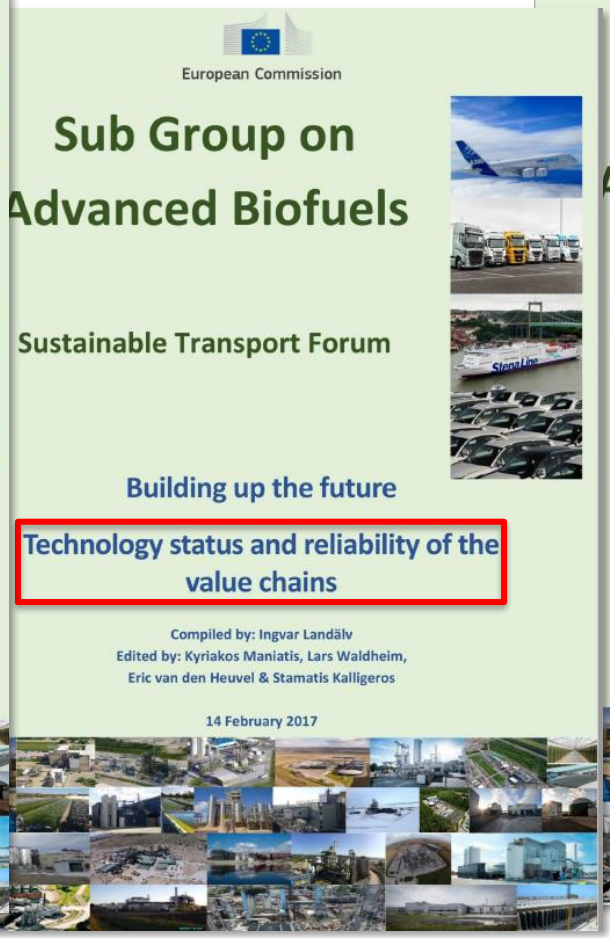
Biofuels potential, production costs and GHG reduction capability – Results from SGAB work 2016

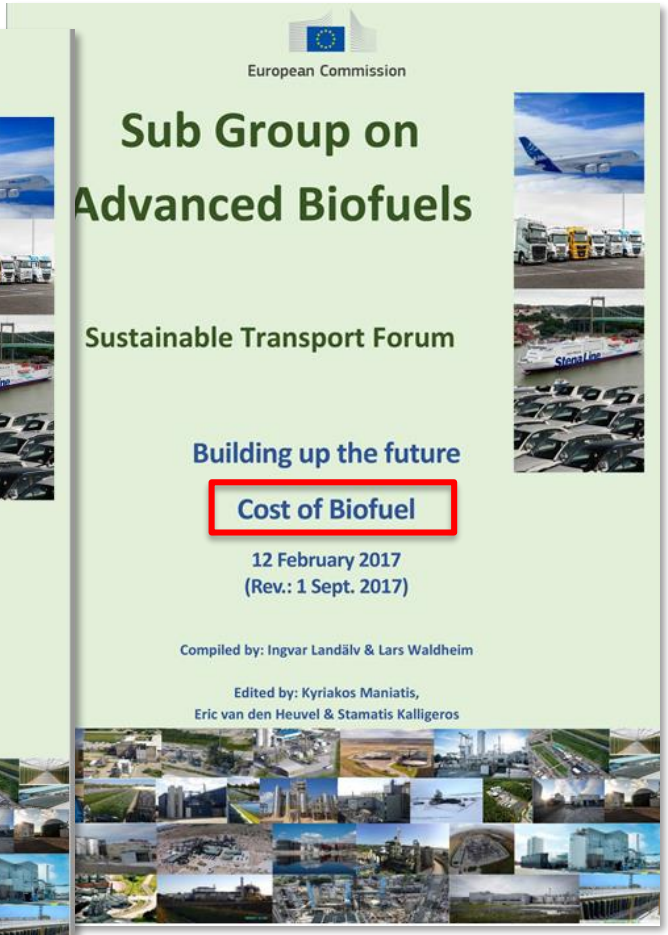
Ingvar Landälv
Vice Chair of SGAB and member of SC for ETIP Bioenergy

ETIP Bioenergy
European Technology and Innovation Platform

8th STAKEHOLDER PLENARY MEETING
11-12 APRIL 2018 - BRUSSELS







Agenda

- **Background:**
  - Infrastructure Directive 2014/94/EU **==>**
  - STF, Sustainable Transport Forum 2015 **==>**
  - SGAB, Subgroup Advanced Biofuels 2015/16
- **SGAB:** Participants and timeline

<u>SGAB results</u>

- **Feedstock Potential**
- **GHG reduction**
- **Cost of Production:** Based on Technology Status Report and with strong engagement of stakeholders

Presentation by V. Bulc:
Note the emphasis on “Decarbonisation”

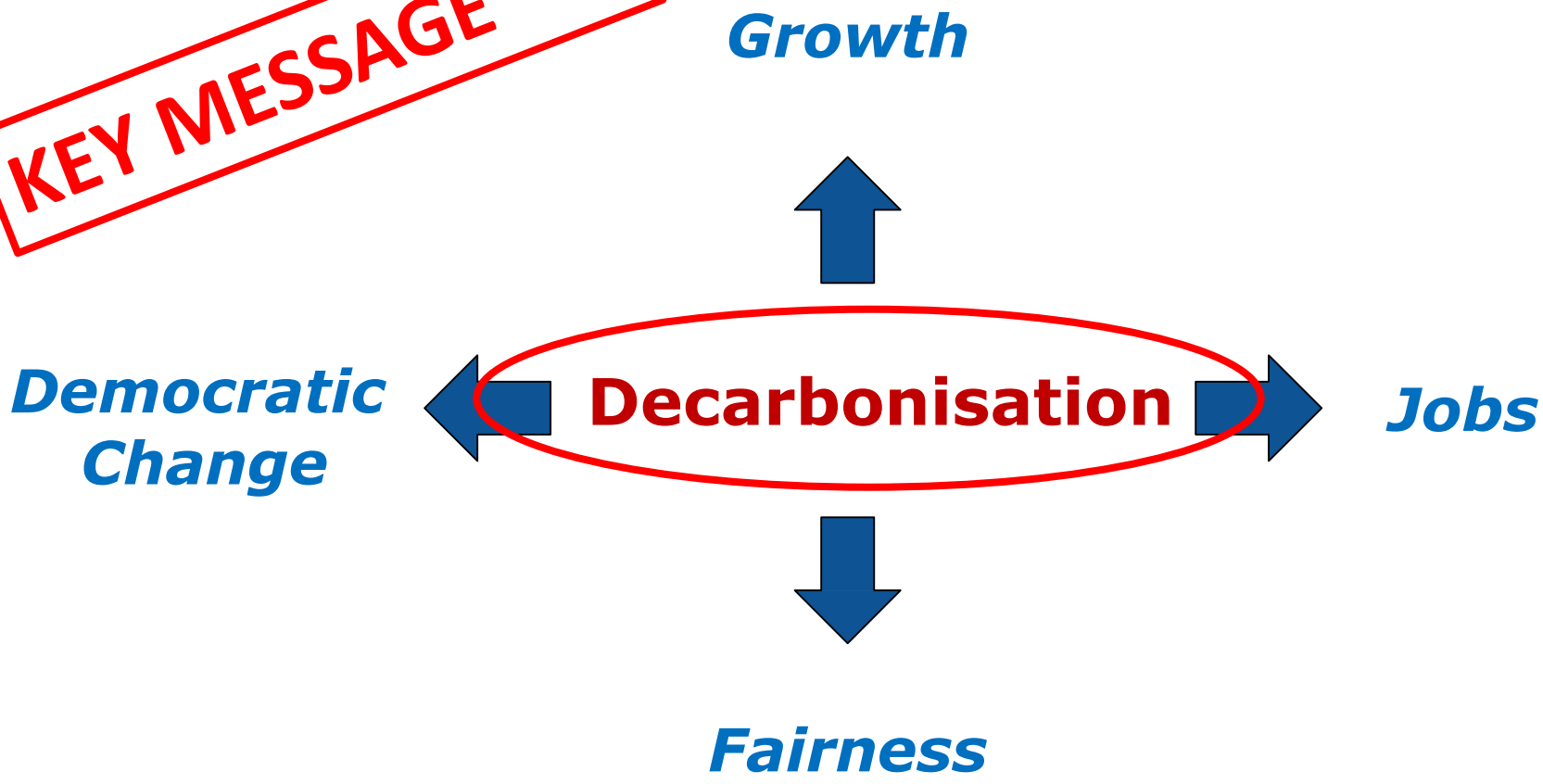
Sustainable Transport Forum 1st Meeting

Opening address

Transport Commissioner Violeta Bulc

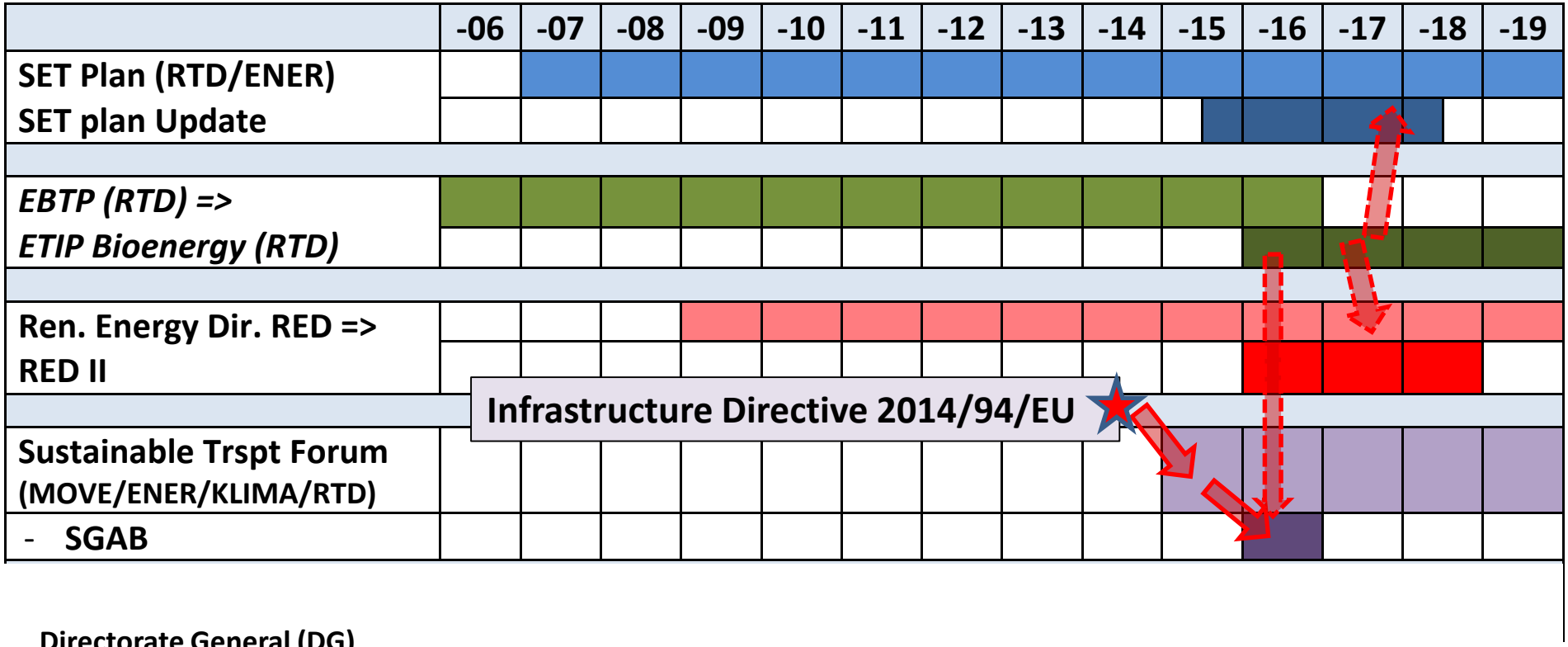
Bruxelles 29 June 2015

KEY MESSAGE



Important ETIP Bioenergy interactions including SGAB

(Also: Directive 2014/94/EU => STF => SGAB)



Directorate General (DG)

RTD: Research & Innovation
MOVE: Mobility and Transport
ENER: Energy
CLIMA: Climate Action

Members of SGAB

1	Aho	Mika	ST1
2	Bauen	Ausilio	E4Tech
3	Brown	Adam	IEA
4	Cavigliasso	Piero	Mossi & Ghisolfi
5	Dekker	Eelco	Methanol Institute
6	Gameson	Tom	ABENGOA
7	Gaupmann	Gloria	Clariant
8	Girio	Francisco	LNEG
9	Greening	Paul	ACEA
10	Hamje	Heather	Concawe
11	Harrison	Pete	EU Climate Foundation
12	Holmgren	Jennifer	Lanzatech
13	Hudson	Leigh	British Airways
14	Hull	Angelica	Swedish Biofuels
15	Janhunen	Marko	UPM
16	Judd	Robert	GERG
17	Klintbom	Patrik	VOLVO
18	Labrie	Marie-Helene	ENERKEM

19	Landälv	Ingvar	Lulea University of Technology
20	Lastikka	Ilmari	NESTE oil
21	Malins	Chris	The International Council on Clean Transportation
22	Marchand	Philippe	Total
23	Mirabella	Walter	European Fuel Oxygenates Association
24	Murfin	Andrew	Shell
25	Schapers	Eline	SkyNRG
26	Sipila	Kai	VTT
27	Stefenson	Per	Stena Lines
28	Stępień	Adam	Copa-Cogeca
29	Strömberg	Jonas	SCANIA
30	van Campen	Jeroen	DuPont
31	Venendaal	René	BTG
32	Vink	Tim	Honeywell/UOP
33	Wellinger	Arthur	EBA
34	Zschocke	Alexander	Lufthansa

SGAB Core Team

Chair: Kyriakos Maniatis, DG ENER

Co-Chair: Ingvar Landälv, Luleå Univ.

Rapporteurs:
Lars Waldheim
Eric van den Heuvel
Stamatis Kalligeros

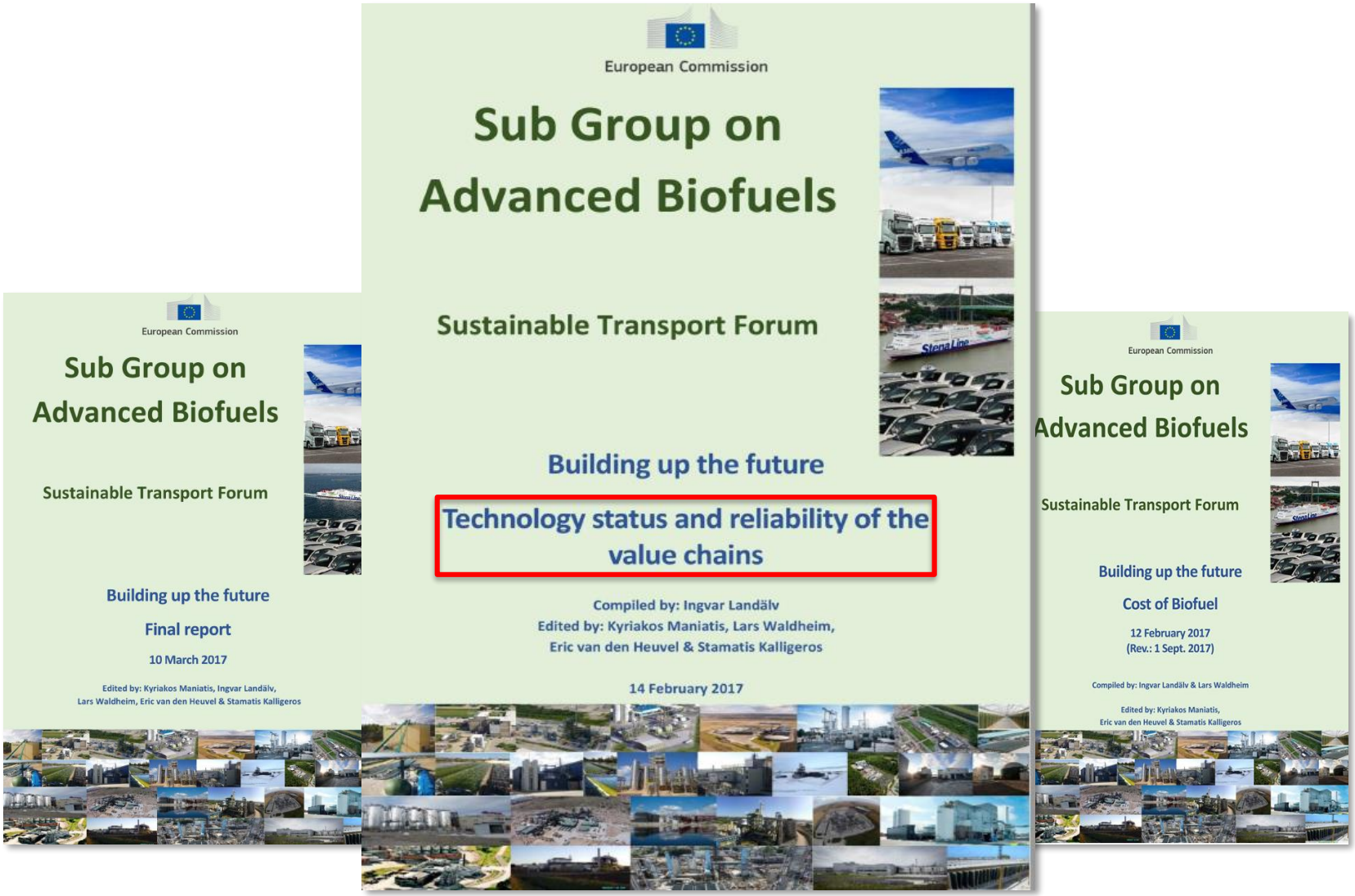
Members of SGAB representing …

Interest Group	Numbers
Technology providers	12
Oil companies	3
Airlines	2
Industry associates	7
Heavy duty transports	2
Maritime transport	1
Consultants	4
IEA	1
Think tanks	2
TOTAL	34

Observers of SGAB

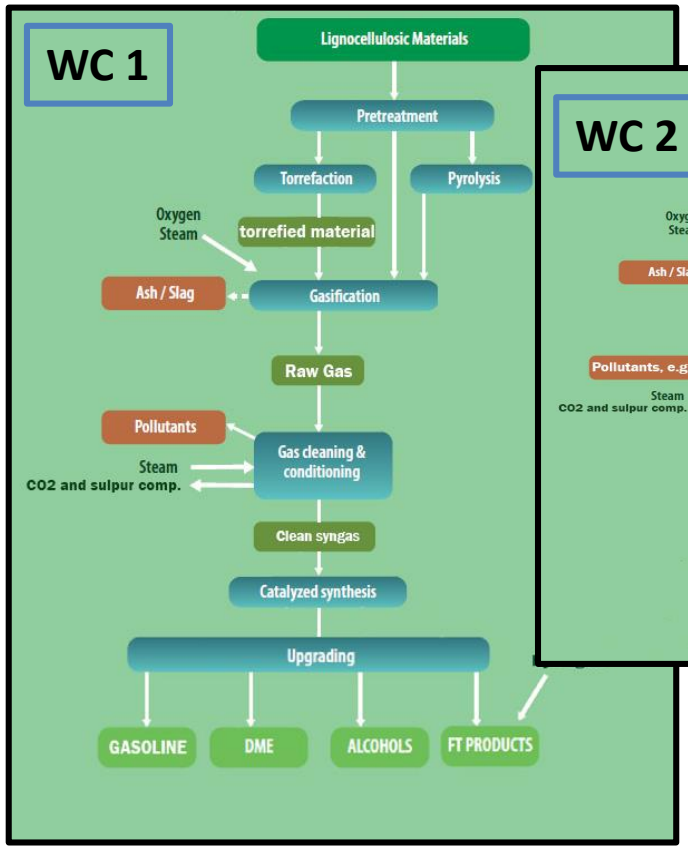
1	Bach	Heinz		Austria
2	Bernodusson	Jón	The Icelandic Transport Authority	Iceland
3	Buffet	Laura	Transport & Environment	NGO
4	Cluyts	Ivo	Ministry of Environment	Belgium
5	Desplechin	Emmanuel	ePure	European Association
6	Florea	Leonard	Regulatory Authority for Energy	Romania
7	Garofalo	Raffaello	EBB	European Association
8	Gruson	Jean-François	IFP Energies nouvelles	France
9	Hameau	Thierry	SNCF	France
10	Leahy	Patrick	Department of Transport	UK
11	Neeft	John	Netherlands Enetrprise Agency	The Netherlands
12	Nicolau	Alexandra	General Directorate for Energy & Geology	Portugal
13	Pezzaglia	Marco	Consultant, Italian Ministry of Economic Development	Italy
14	Pinheiro	Sérgio Manso	General Directorate for Energy & Geology	Portugal
15	Stausbøll	Yvonne	UPEI	Association
16	Weber	Thomas	Federal Ministry for the Environment	Germany

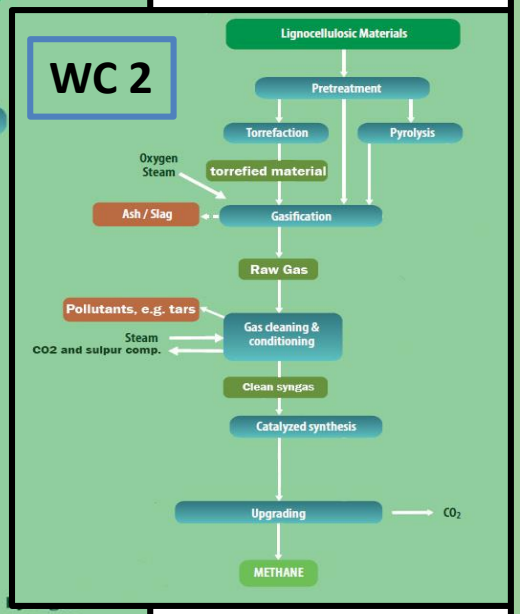
Report: “Technology Status and reliability of the Value Chains”

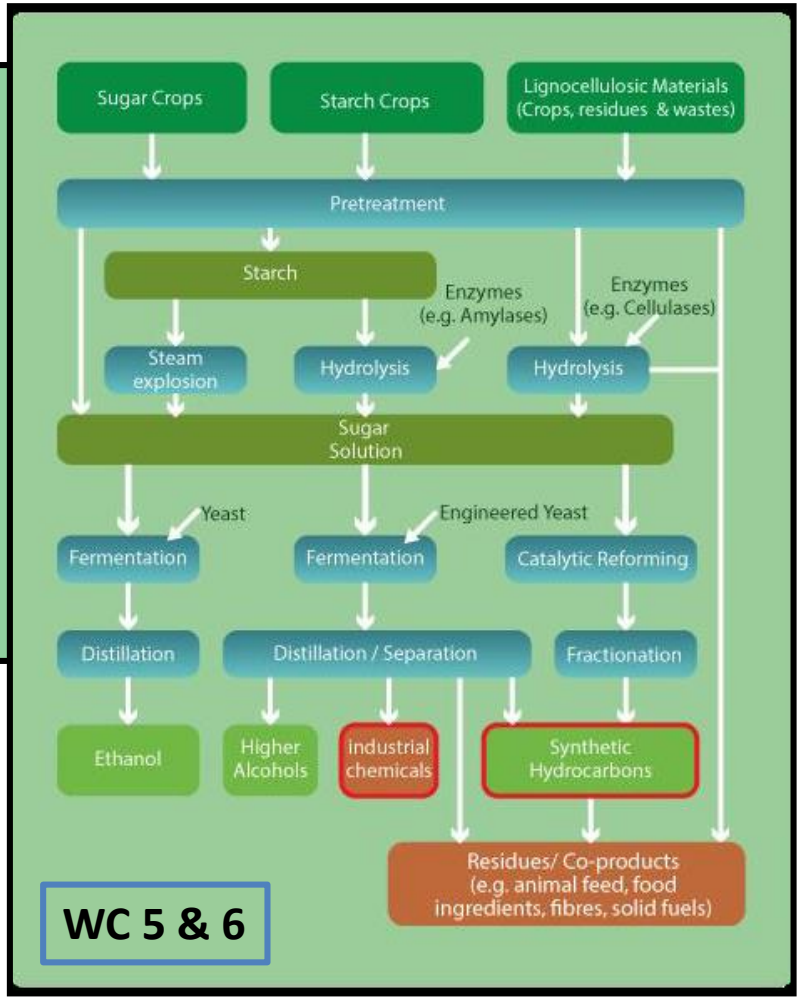


Examples: Block diagram for VC 1, 2, 5 and 6

(see: http://www.etipbioenergy.eu/value-chains/conversion-technologies/advanced-technologies)



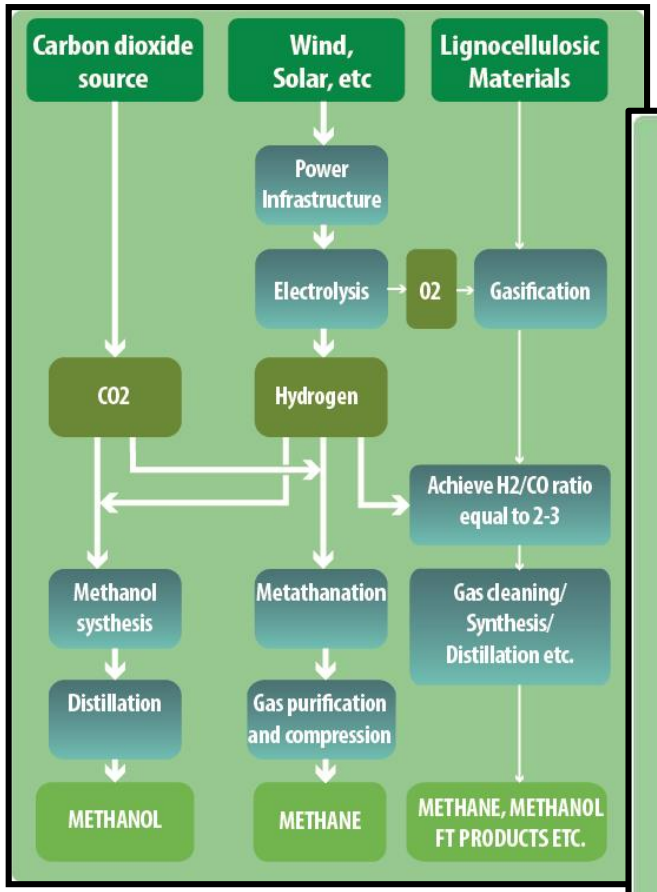




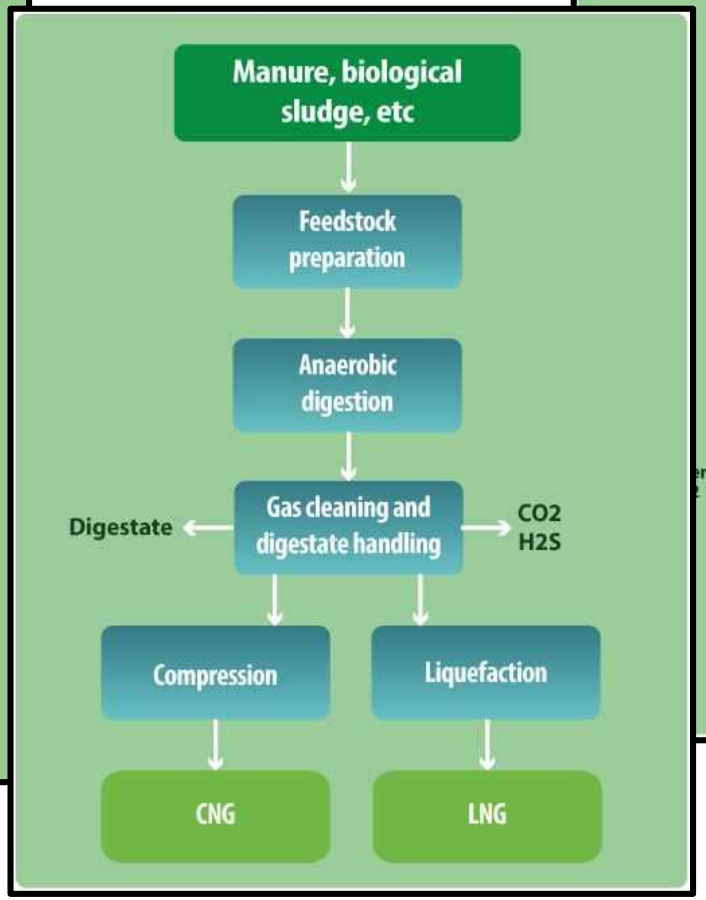
Examples of other Conversion Pathways

(not covered by ETIP Bioenergy's 7 Value Chains)

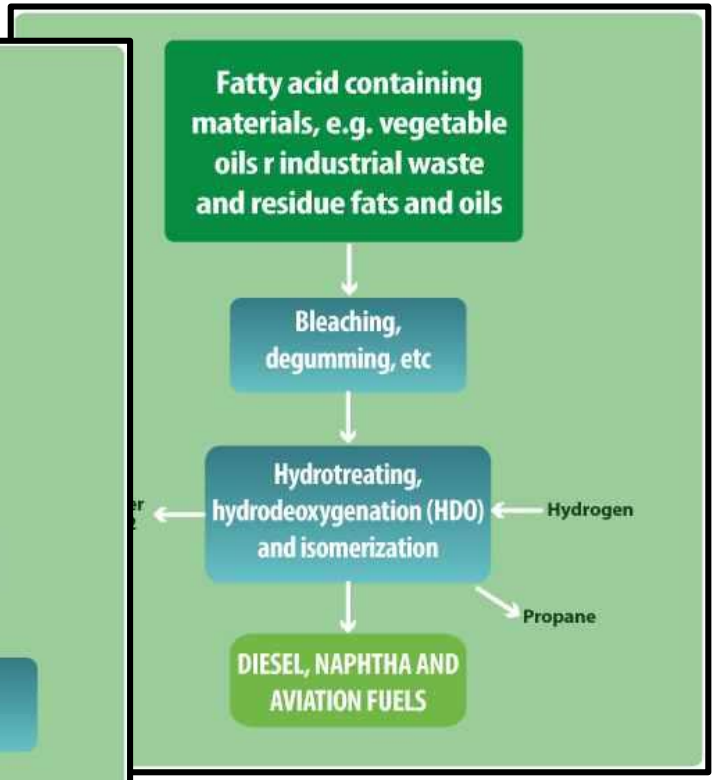
ELECTROFUELS



BIO-METHANE VIA FERMENTATION



HYDROTREATED VEGETABLE OILS (HVO)

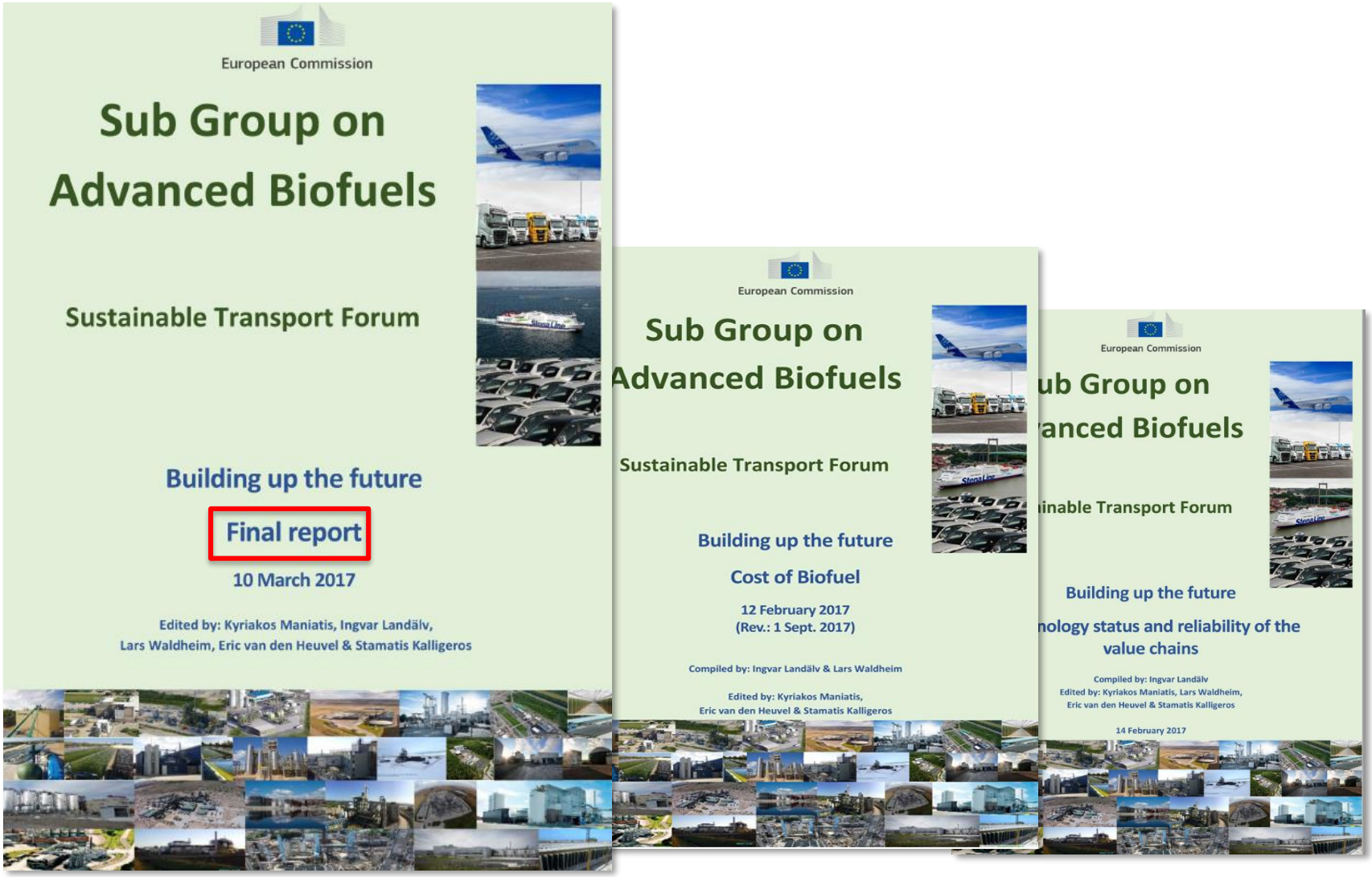


Information asked for:

A short description with name, location and background and list of key technologies utilized in the plant. The information provider was asked also to classify the plant as a Pilot plant (P), a Demonstration plant (D) or a Commercial plant (C). Finally, the following additional points were also addressed:

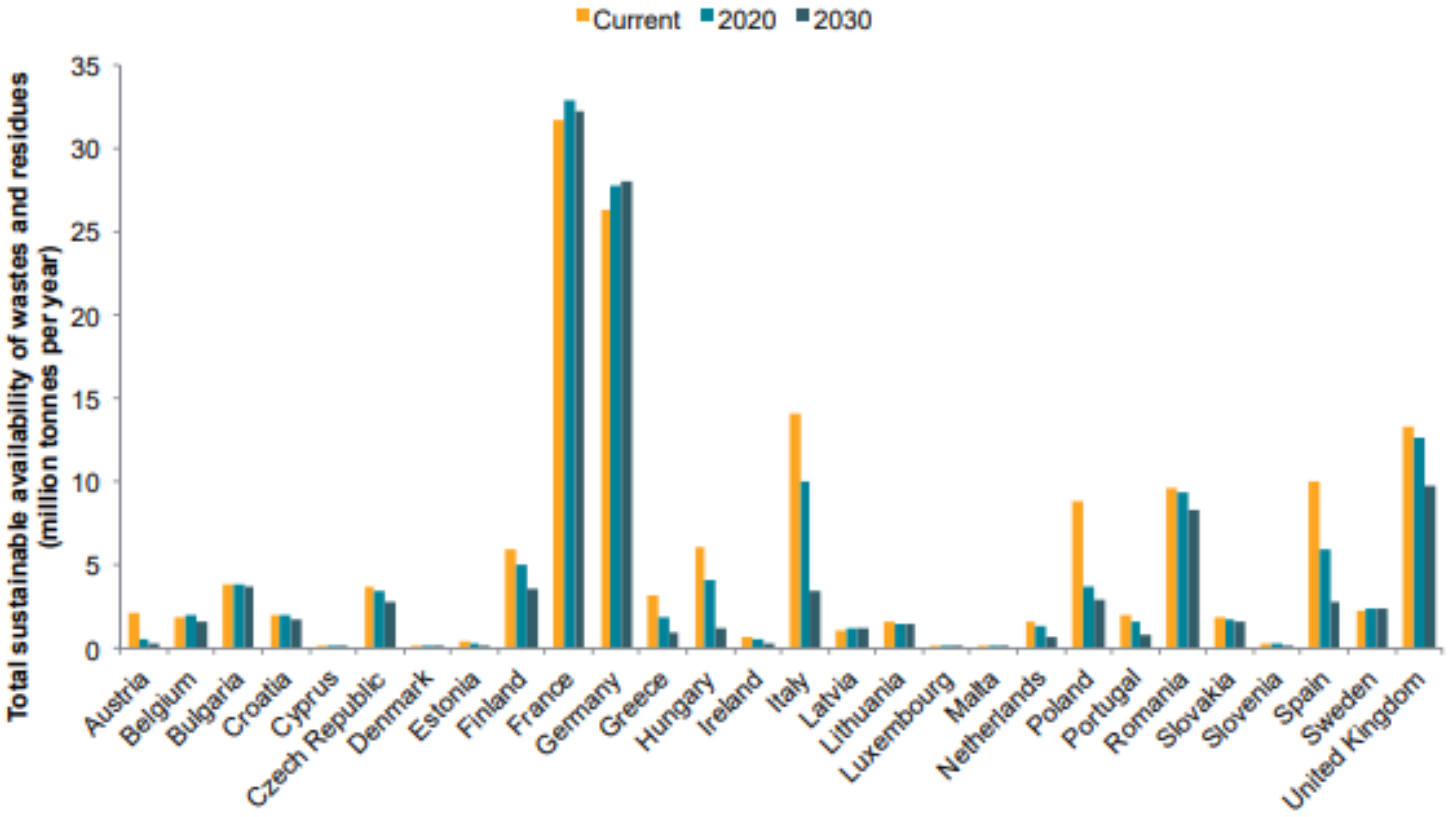
1. **Start-up year** – plus current status
2. **Plant size expressed as feedstock consumption** e.g. as ton dry biomass/day or MW Lower Heating Value (LHV) including other important feeds/utilities such as electric power.
3. **Plant product capacity** expressed as ton/day, m^3/day, Nm^3/h of product or similar – status including important by-products
4. **Efficiency number**, e.g. tons of product per ton of dry biomass or MW_{out}/MW_{in}. should be able to be calculated from item 2 and 3 - status
5. **Number of hours of operation** since start-up (comment length of continuous operation or similar) – reliability description
6. **Next step** (e.g. first full sized plant planned for start-up in year 20xx) – status
7. **Comment potential technology barriers** or potential show-stoppers

Report: “Final Report”



About Feedstock potential

220 million tons of dry waste and reidue per year available 2020 according to BIOFRONTIERS 2016 report

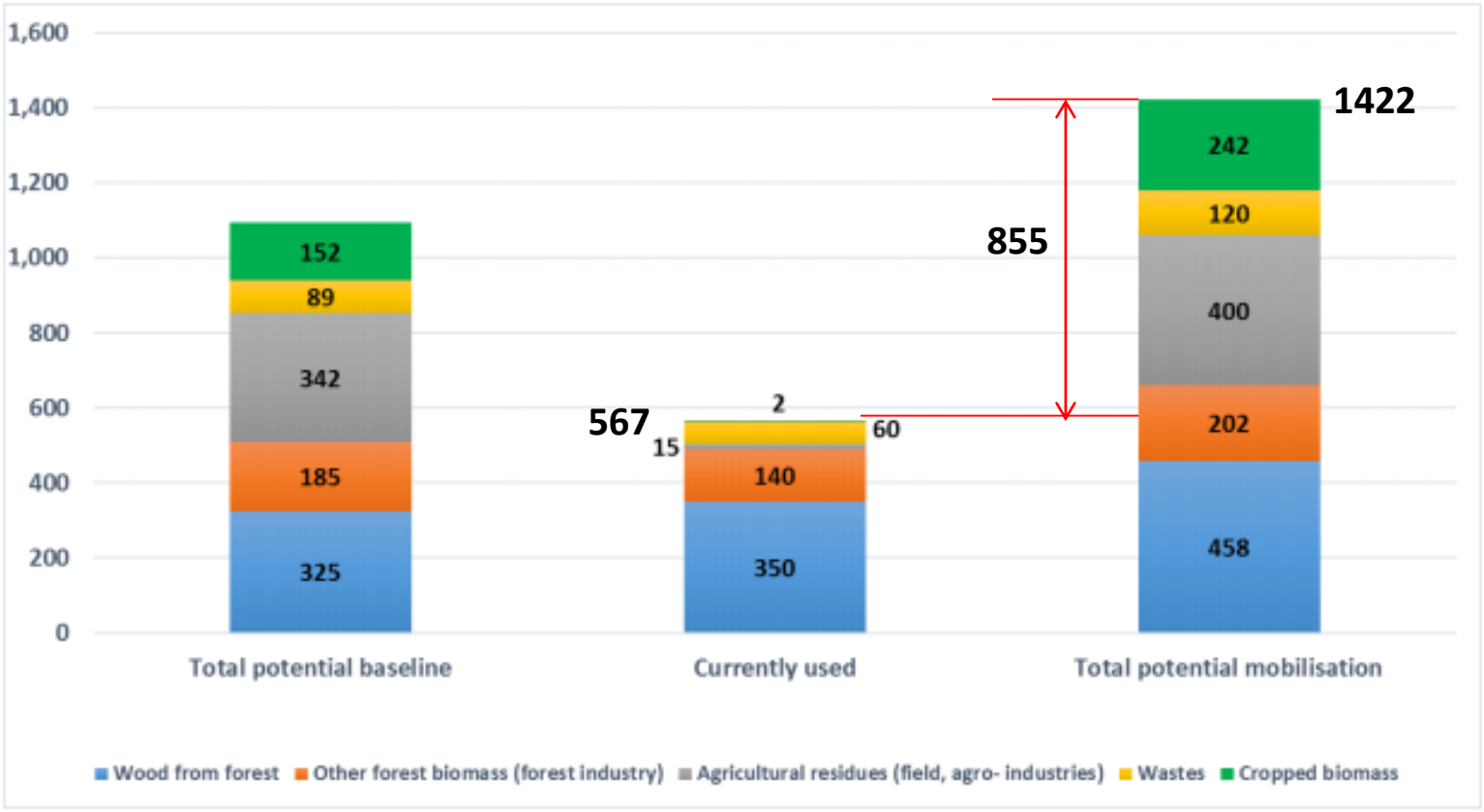


Source: Figure 1 in BIOFRONTIERS, Responsible innovation for tomorrow's liquid fuels, 2016

855 million tons of dry biomass per year available 2030 according to *the S2Biom project**

(NOTE: 2SBiom report not referred to in SGAB report)

* Other reports with similar potentail referred to in SGAB report



Source: Figure 2 in *Vision for 1 billion dry tons lignocellulosic biomass as a contribution to bio-based economy by 2030 in Europe.* Nov 2016

Biofuels production potential comparing BIOFRONTIERS and S2Biom for different coversion effciencies

- 80 million tons of biomass per year set aside for heat and power in both cases
- Transport energy used in EU approximately 360 million Toe

Variable	Unit	BIOFRONTIERS 2016	S2Biom 2016
Biomass	Million dry tons/year	140	775
Conv. Efficiency **0.35**	Million toe/year	20	113
Conv. Efficiency **0.50**	Million toe/year	29	161
Conv. Efficiency **0.60**	Million toe/year	35	194

Some thought and considerations with respect to feedstock potential for advanced biofuels

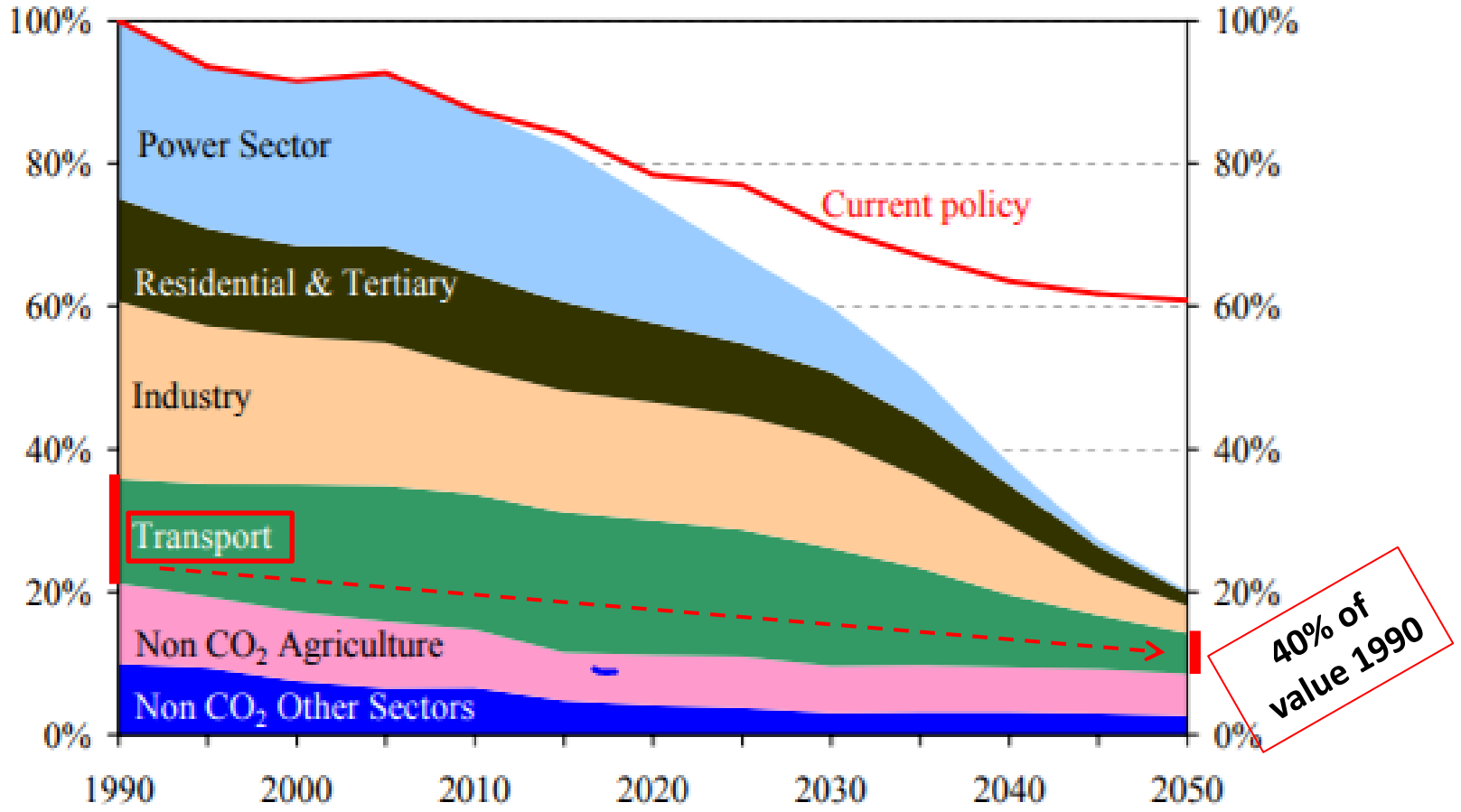
- There is plentiful of sustainable feedstock available, enough to replace in the order of 15-50% of currently used fossil fuels in the transport sector and still have resources available for other sectors.
- It is of limited value to keep asking "How much is available?". While reviewing the matter over and over the interests and initiatives among developers vanish.
- Transition into a bio-based system will take considerable time. Construction and operation of plants will lead to new innovative schemes and process combinations which will lead to smarter use of feedstock.
- Nothing hinders to have checkpoints "periodically" to evaluate if original predictions were correct, and if necessary introduce a change in course.

A parallel food for though: Should society wait to start along the electromobility pathway because 100% market penetration cannot be reached with today's battery solutions?

About GHG reduction

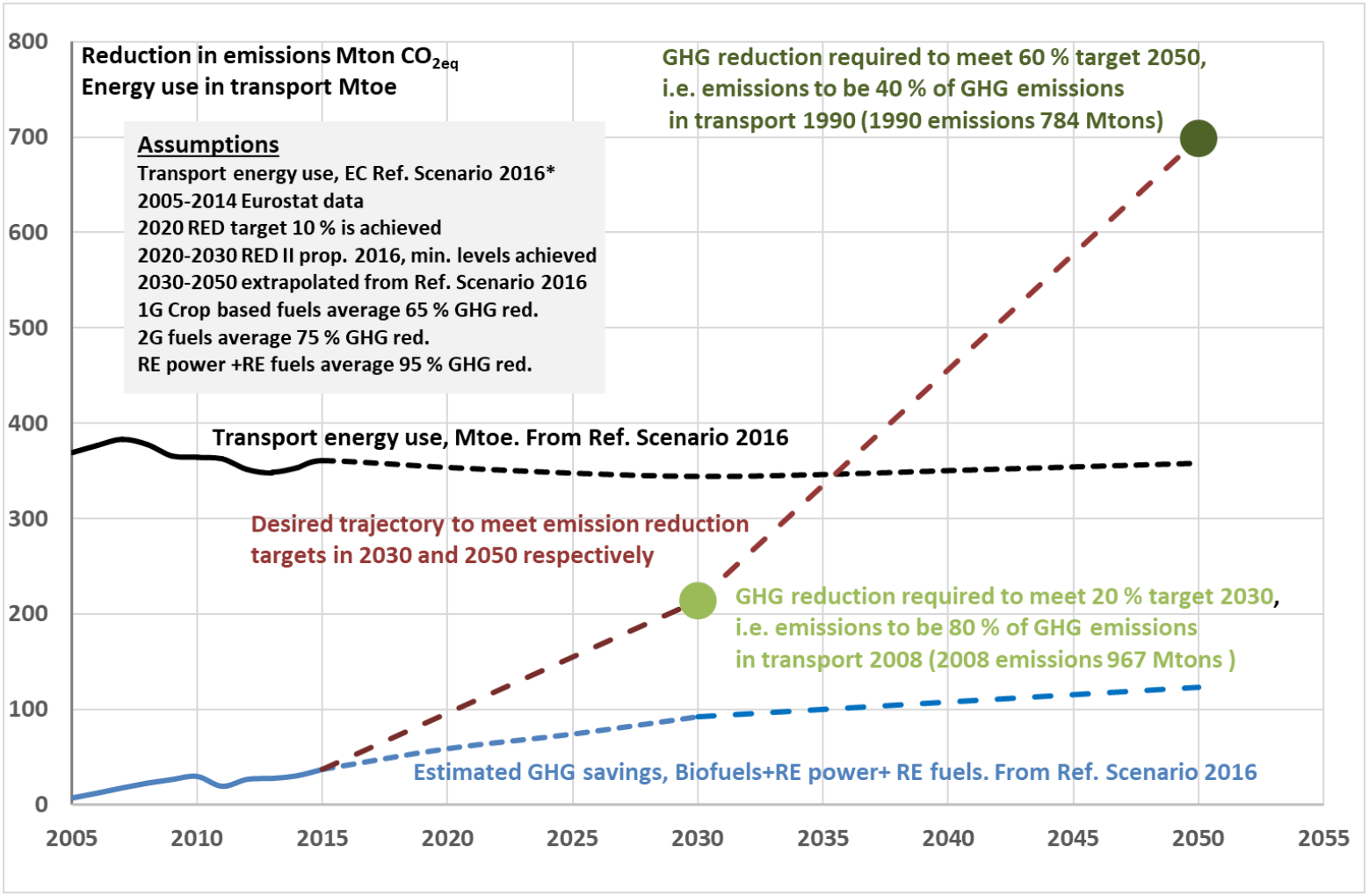
EU GHG emissions from transport 2050 to be maximum 40% of what it was in 1990

From: A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final.

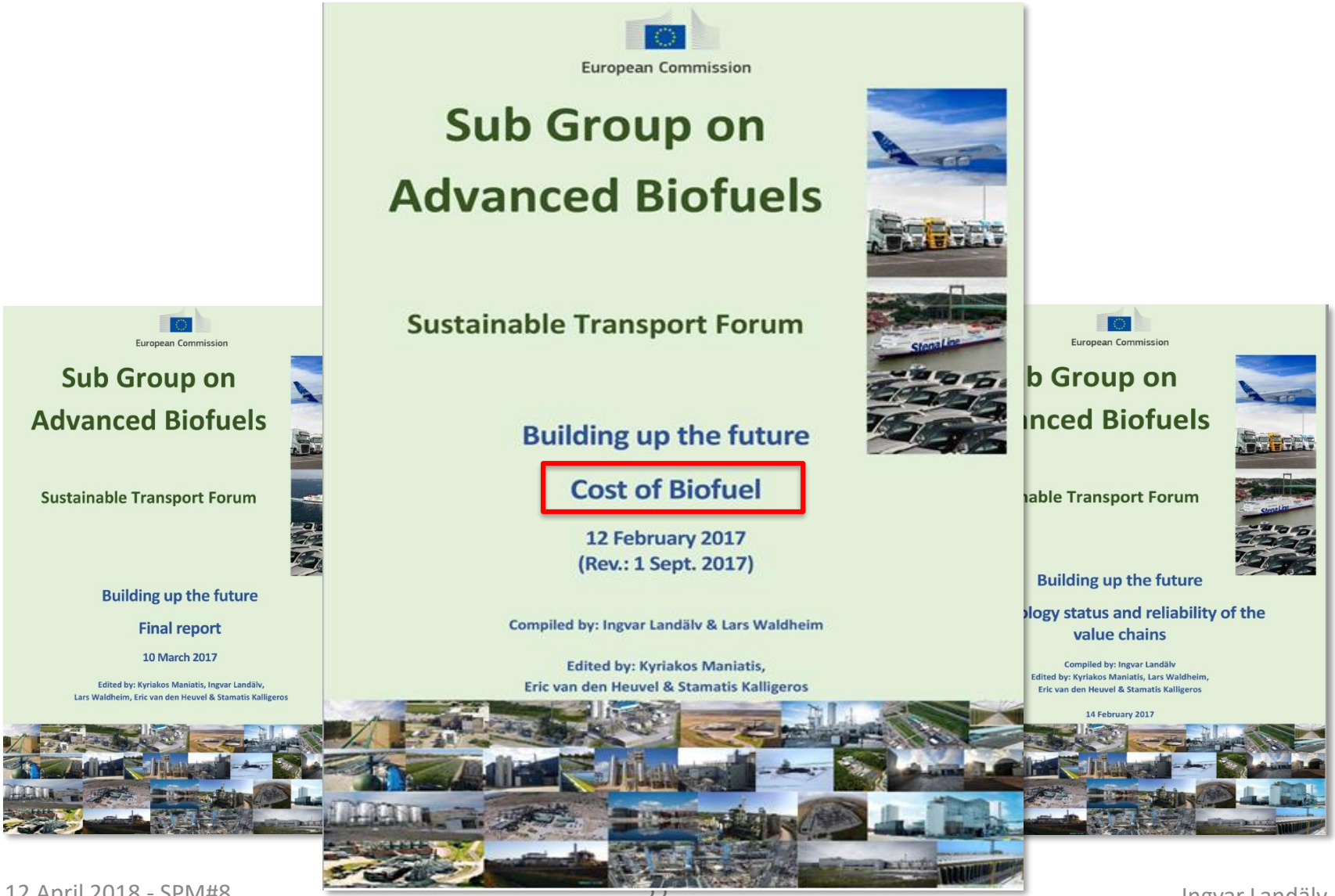


GHG reduction compared to the policy targets

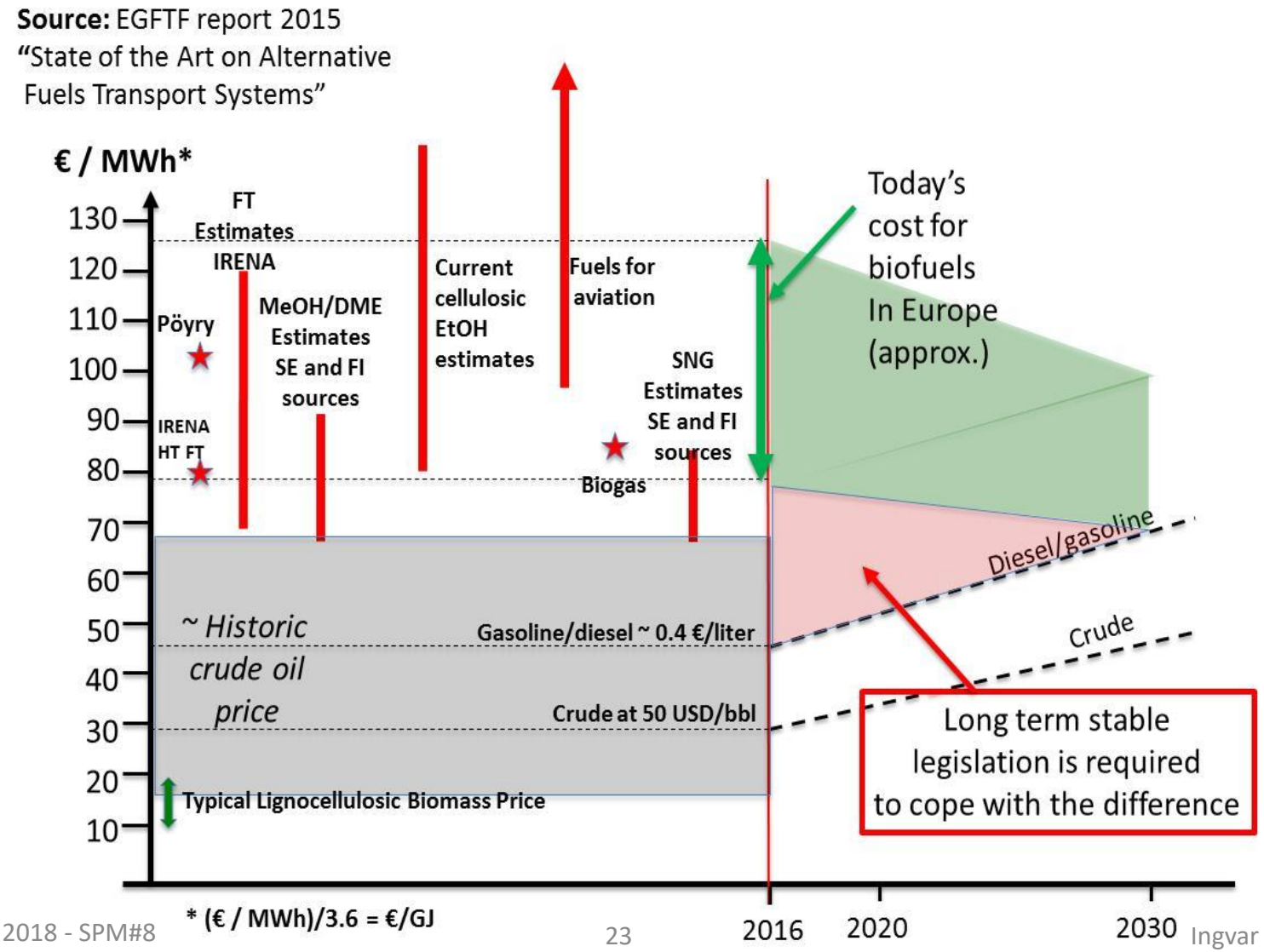
(EU target vs current trend)



Report: “Cost of Biofuels”



Starting Point: Cost of some selected biofuels (various sources) and how they relate to fossil fuels



Messages to initiate discussion

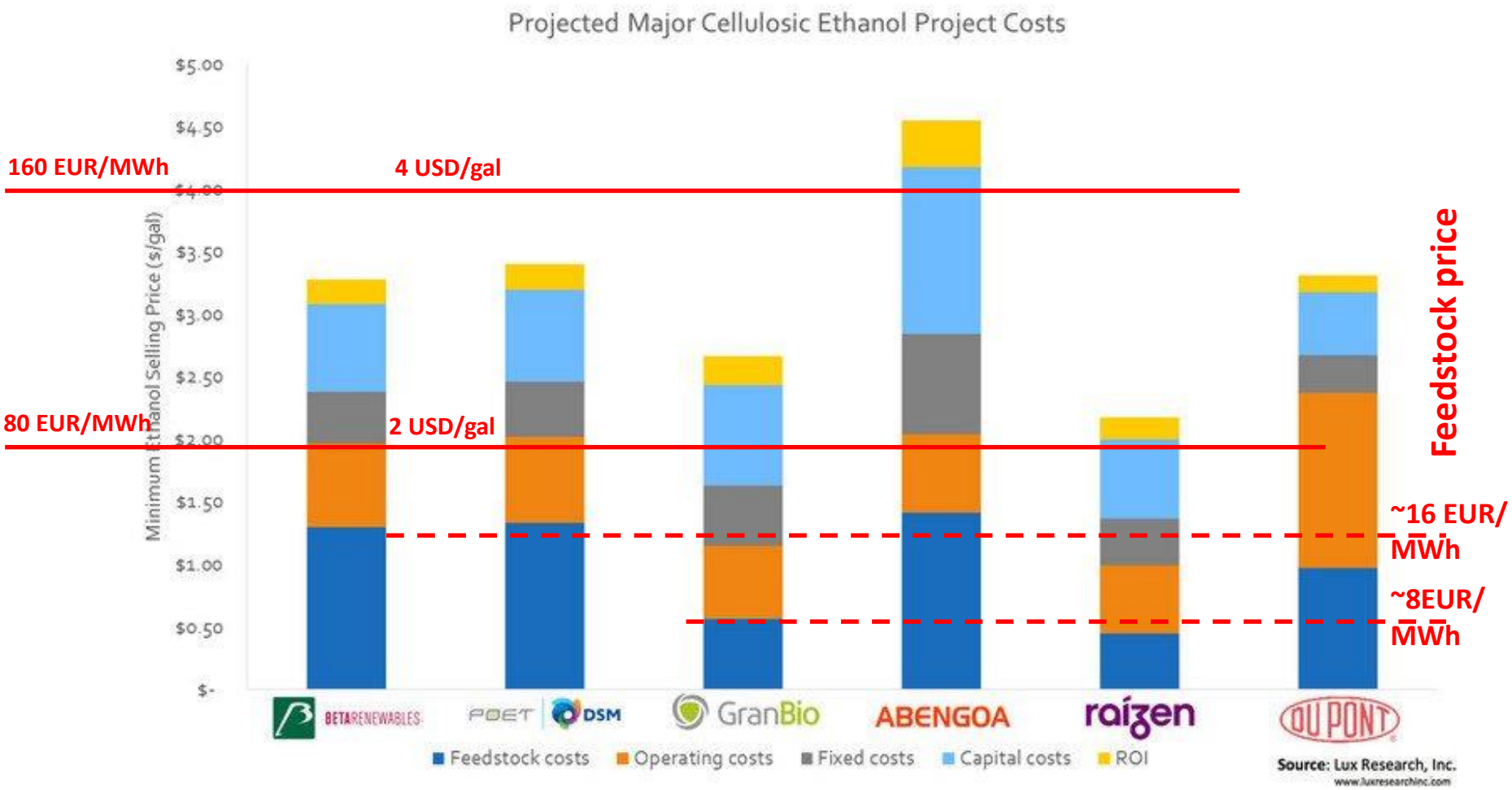
(relate to previous figure)

- **Production cost** of various types of advanced biofuels **varies substantially**.
- **Current production cost** of biofuels lies in the **interval of 80-120 EUR/MWh**. There are some lower data points but to initiate construction of First of kind plants (FOAKs) the quoted interval is realistic.
- **Current lowest production cost** of advanced biofuels is at least 50-100% higher than their crude oil based alternatives (70-90 EUR/MWh compared to about 45 EUR/MWh).
- **Typical biomass price** in Europe: 10-20 EUR/MWh.
- In a 15-year period **production cost of biofuels can be expected to be lowered due to increased experience**. This however implies that construction of full sized plants is initiated without further delay. The green area indicates a cost reduction of about 15%.
- A **crude oil price increase** during the coming 15-year period is given as an illustration. The dotted line shows **90 USD/bbl in 2030**. A corresponding increase in gasoline and diesel process are also indicated.
- **The red area** is an indicator of minimum difference in assumed production cost of biofuels and the (assumed) price of fossil fuels.

Actions for SGAB members

- **Review and comment the approach**
- **Insert other sources of information with respect to production cost of advanced biofuels**
- **Source to include cost of fuel e.g. as EUR/MWh or €/GJ (lower heating value)**
- **Source should also reveal at least**
  - **- cost of capital**
  - **- cost of feedstock**
  - **- O&M**

Production cost for 2nd generation Ethanol
(From PennEnergy Feb 24, 2016)

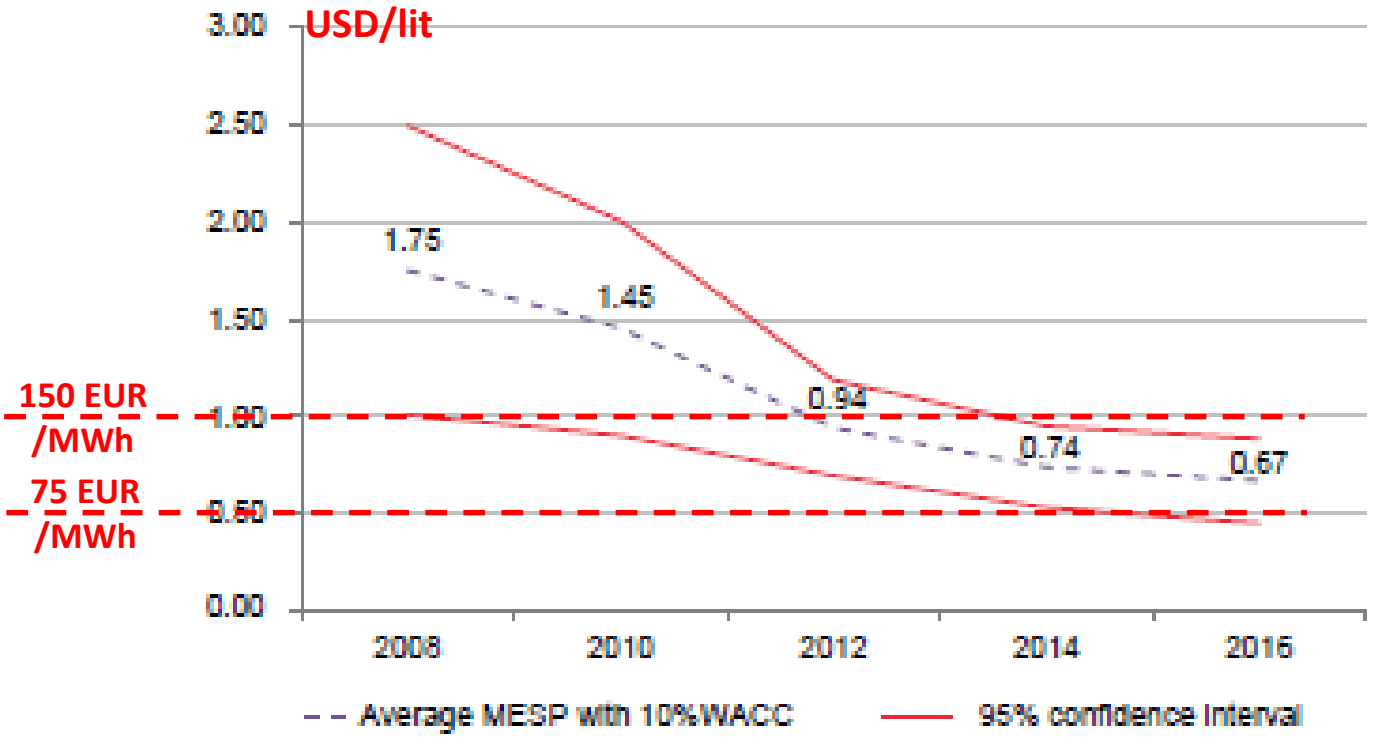


Source: http://www.pennenergy.com/marketwired-power/2016/02/24/raizen-has-lowest-price-as-cellulosic-ethanol-hinges-on-feedstock-cost.html

Minimum 2nd generation ethanol selling price

(Source: Blomberg's *Cellulosic ethanol costs: Surveying an industry,* March 2013)

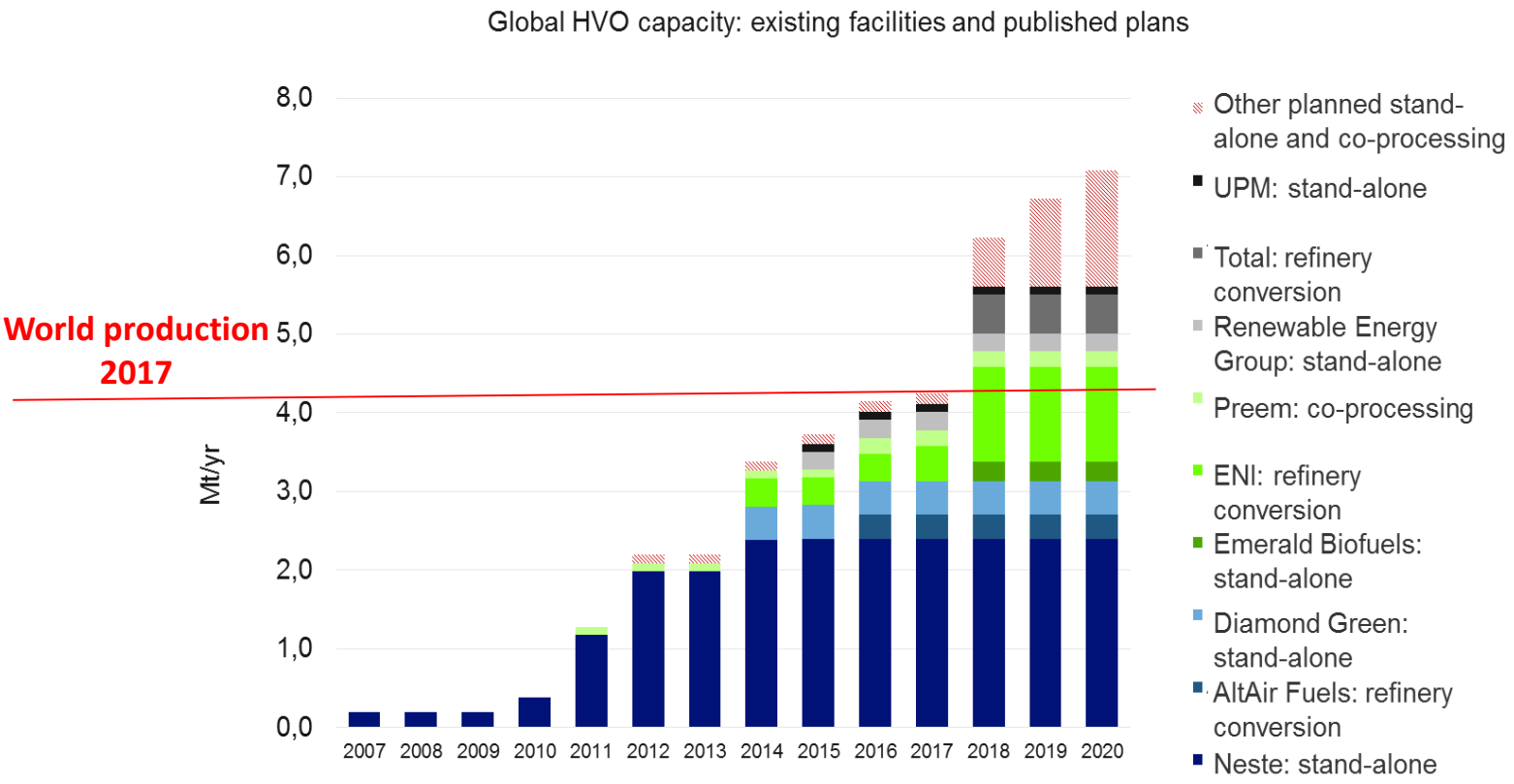
Capital: 10% WACC
Feedstock: 75 USD/mt (dry) ~ 13 EUR/MWh



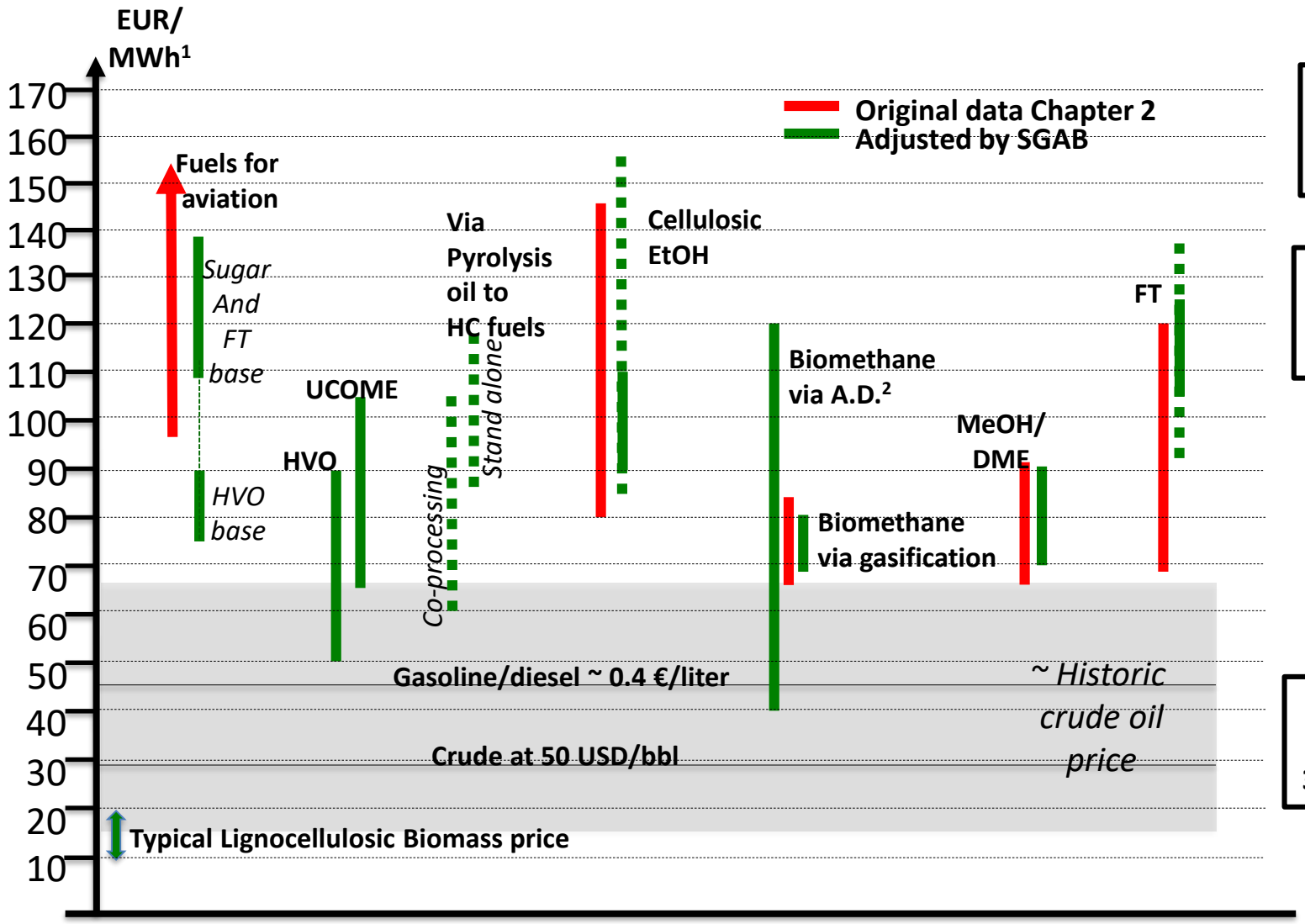
Source: Bloomberg New Energy Finance Notes: the 95% confidence interval represents the area in which 95% of the survey participants' MESPs fell into – or two standard deviations from the mean; the MESP includes capex costs at 10% WACC; and feedstock costs are fixed at $75 per dry tonne.

Global HVO capacity 2007-2020

(Neste estimation based on public sources)



Summary of Production Costs



Biomass:
50-100 EUR/dry metric ton

Capital:
10% / 15 years or IRR 13.3%

O&M:
% of total investment per year. Varies

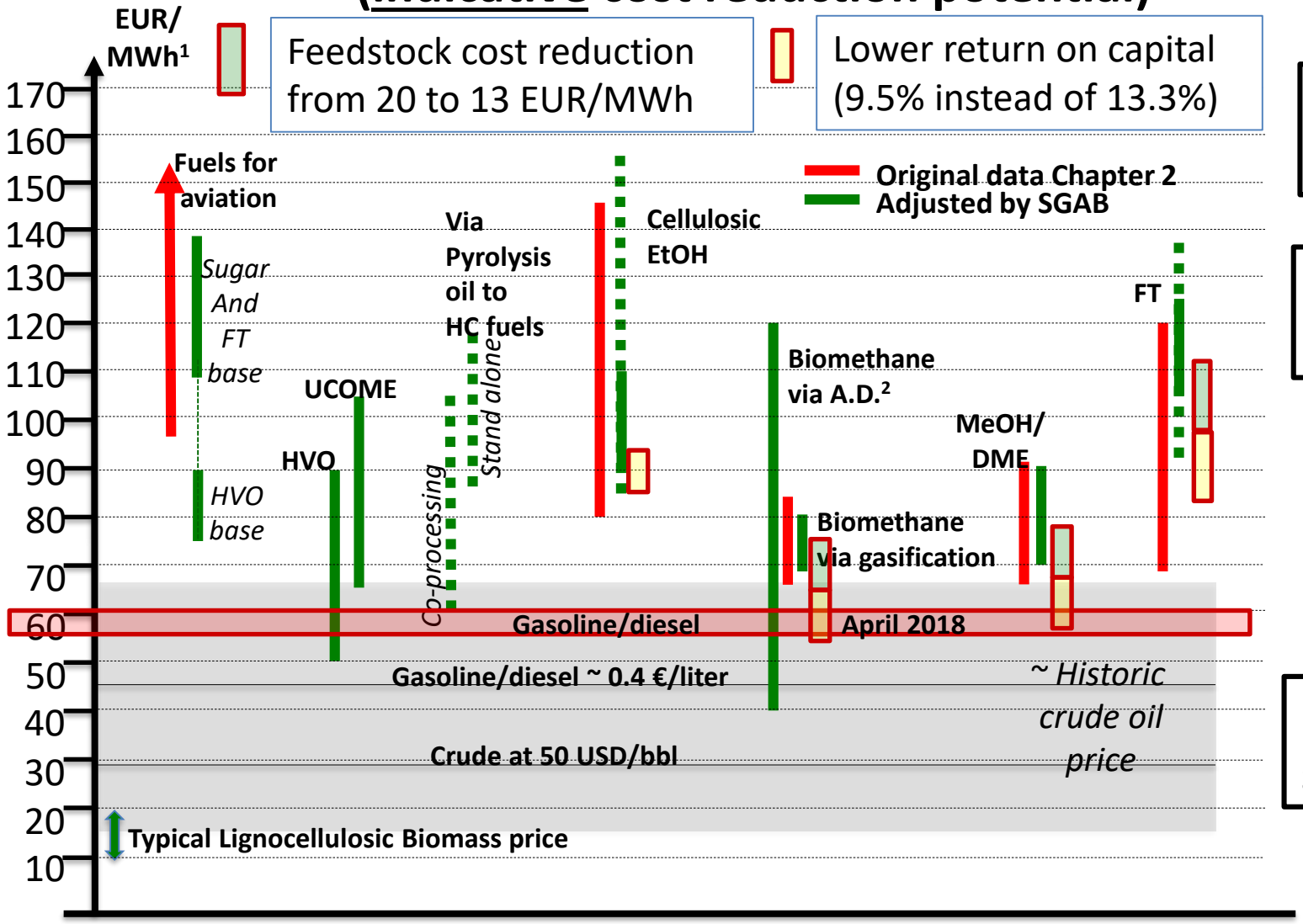
100 EUR/MWh approx. 3.75 USD/gal g.e.

[1](EUR / MWh)/3.6 = €/GJ

[2]Anaerobe Digestion
(large span due to very different feedstock costs)

Summary of Production Costs

(indicative cost reduction potential)



Biomass: 50-100 EUR/dry metric ton

Capital: 10% / 15 years or IRR 13.3%

O&M: % of total investment per year. Varies

100 EUR/MWh approx. 3.75 USD/gal g.e.

[1](EUR / MWh)/3.6 = €/GJ

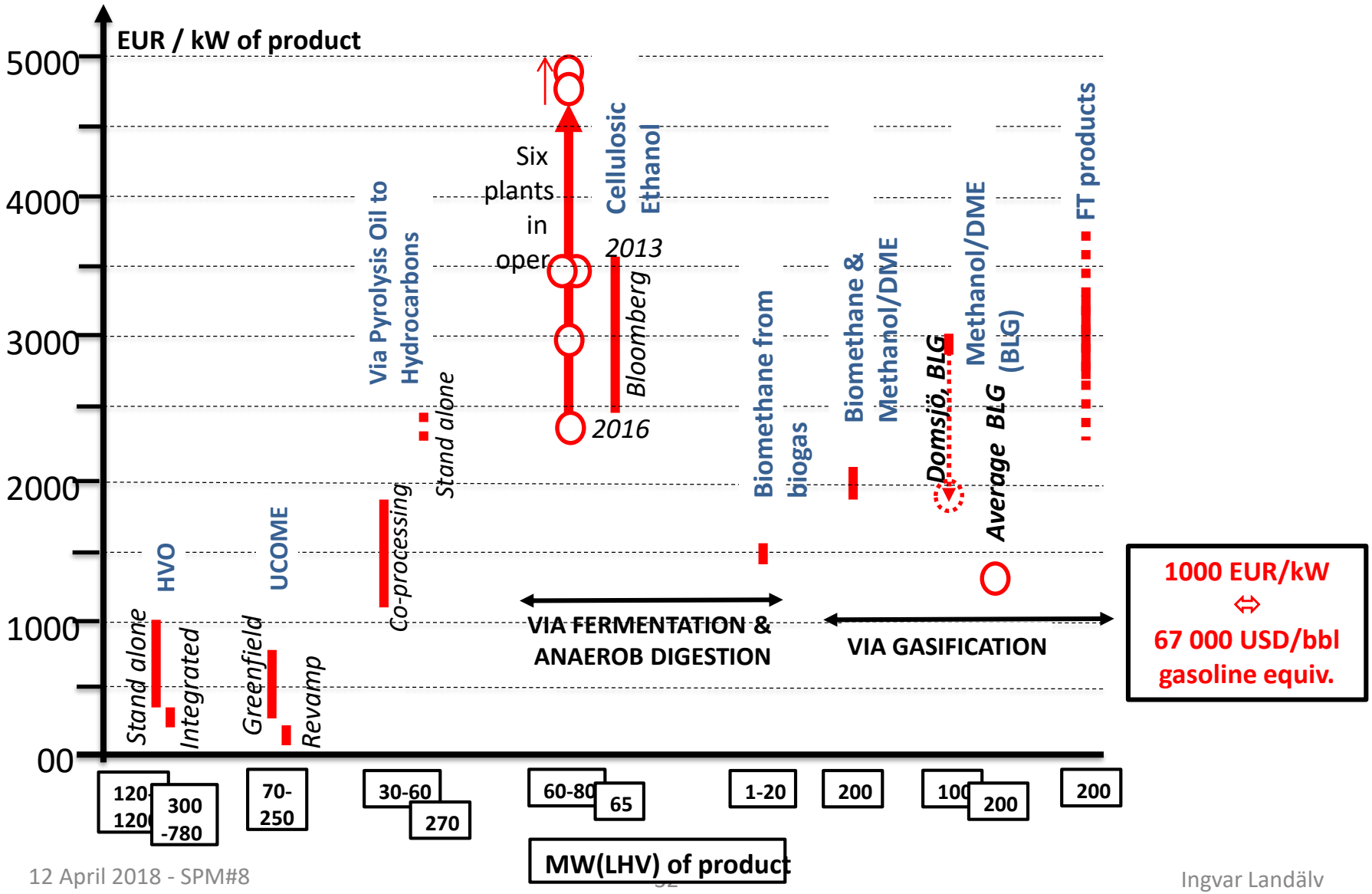
[2]Anaerobe Digestion (large span due to very different feedstock costs)

Table 1. Summary of Biofuels Production Costs (from Cost of Biofuels)

Biofuel type production costs		Feedstock price EUR/MWh	Production cost range EUR/MWh	Production cost range EUR/GJ
Aviation HEFA		40-60	80-90	22-25
Aviation:	Sugar fermentation FT synthesis	Sugar: 65-85 FT: 10-20	110-140	31-39
HVO liquids (and approx. UCO)		40 60	50-70 70-90	14-19 19-25
Biomethane from biogas		0-80	40-120	11-34
Cellulosic ethanol		13 10	103 85	29 24
Biomethane & ethanol from waste		(1)	67-87	19-24
FT liquids from wood		20 10-15	105-139 90-105	29-35 25-29
Biomethane, methanol or DME (Dimethyl Ether) from wood		20 10-15	71-91 56-75	20-25 16-21
Pyrolysis bio-oil co-processing		10-20	58-104	14-27
Pyrolysis bio-oil stand alone		10-20	83-118	23-33

([1]) Base: Net tipping fee of 55 EUR/ton, energy content of 4.4 MWh/ton, Conversion efficiency of 50%

Investment intensity for different conversion routes (EUR per kW of product)



Cost of Biofuels - Key Messages

Biofuels will remain more expensive than fossil fuels unless the costs of mitigating climate change are going to be factored in the cost of fossil fuels.

Some few conversion routes can compete today and some others are getting close if cost of capital and feedstock costs are decreased.

- The cost of biofuels is mainly governed by the cost of the resource (feedstock) and cost of capital (the investment) and only value chains based on waste streams with zero or negative cost offer possibilities for competitive cost production at present.

<u>Commercially available biofuels</u>

- Biomethane produced from waste streams and via biogas (anaerobic digestion) has at present the lowest cost at about 40-50 €/MWh. In certain niche markets it can be competitive to fossil fuels.
- Hydrotreated Vegetable Oils (HVO) have a production cost in the range of 50-90 €/MWh subject to the cost of the feedstock.
- Aviation HEFA can be produced at a cost of 80-90 €/MWh

<u>Cellulosic ethanol at the stage of early commercialisation</u>

- The production cost of cellulosic ethanol is estimated in the range of 90-110 €/MWh (subject to low feedstock costs).

<u>Biofuels in the stage of first of a kind (FOAK)</u>

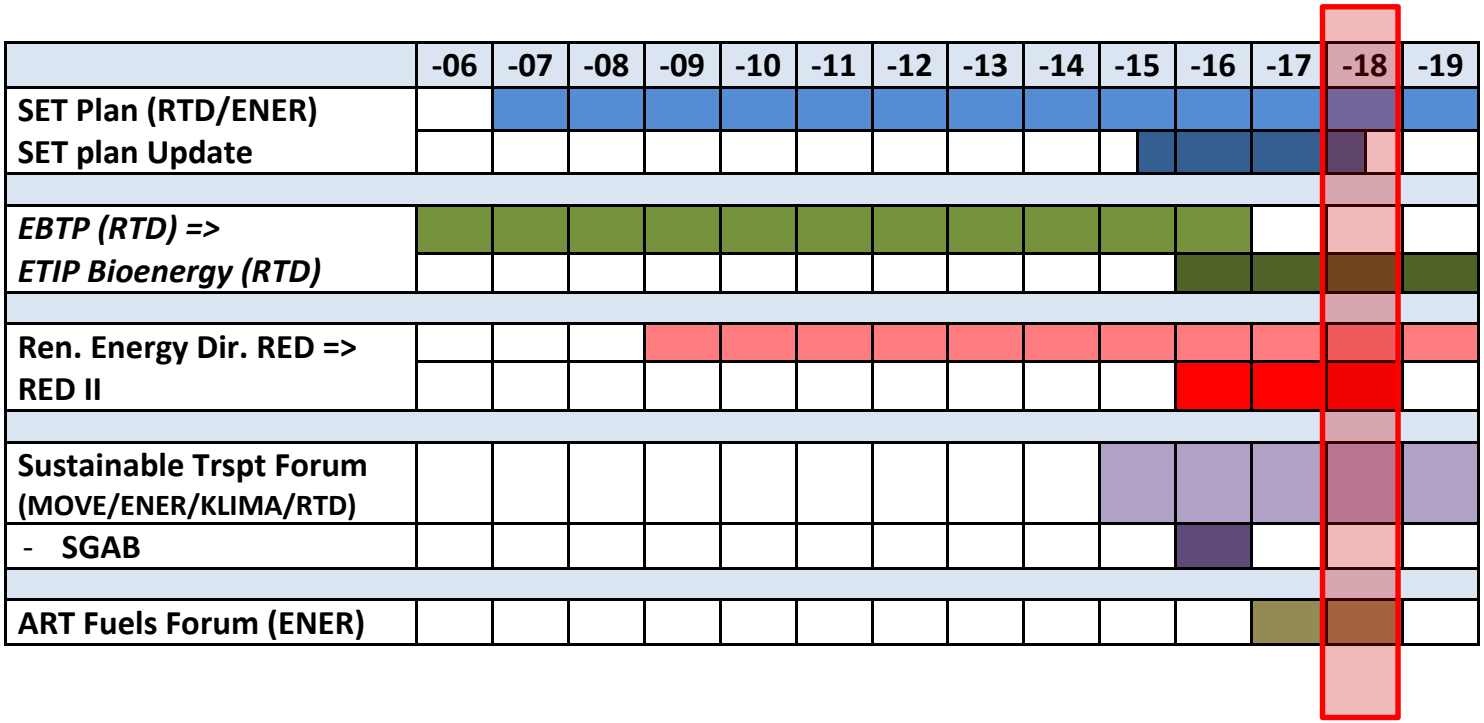
- Biomethane, methanol, DME and ethanol from waste and biomass via gasification have a production cost of 60-80 €MWh.

Reports can be downloaded through the following links*

- **Final report:** http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=33288&no=1
- **Technology Status report:** http://www.gastechnology.org/tcbiomass/tcbiomass2017/SGAB-Technology-Report.pdf
- **Cost of Biofuels:** http://www.gastechnology.org/tcbiomass/tcbiomass2017/SGAB-Cost-of-Biofuels-Report.pdf

*All reports will be possible to downloaded from the EU website within short

An important year, 2018!



Thank you!

Acknowledgement:

❑ **Co-author Lars Waldheim**, Waldheim Consulting

❑ Financial support to my work by Swedish Energy Agency