Sustainability of Fatty Acid Methyl Esters (FAME)

Assessment of Improving Options

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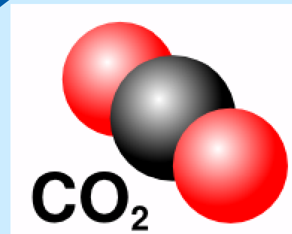
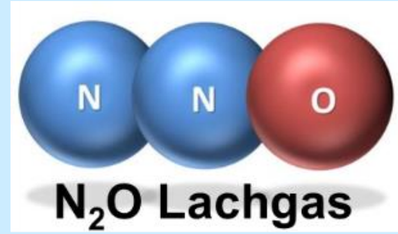
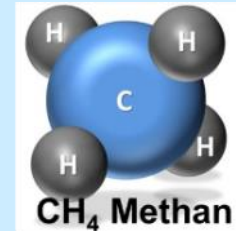
National Workshop Biofuels

Vienna, September 29, 2016

The HT!

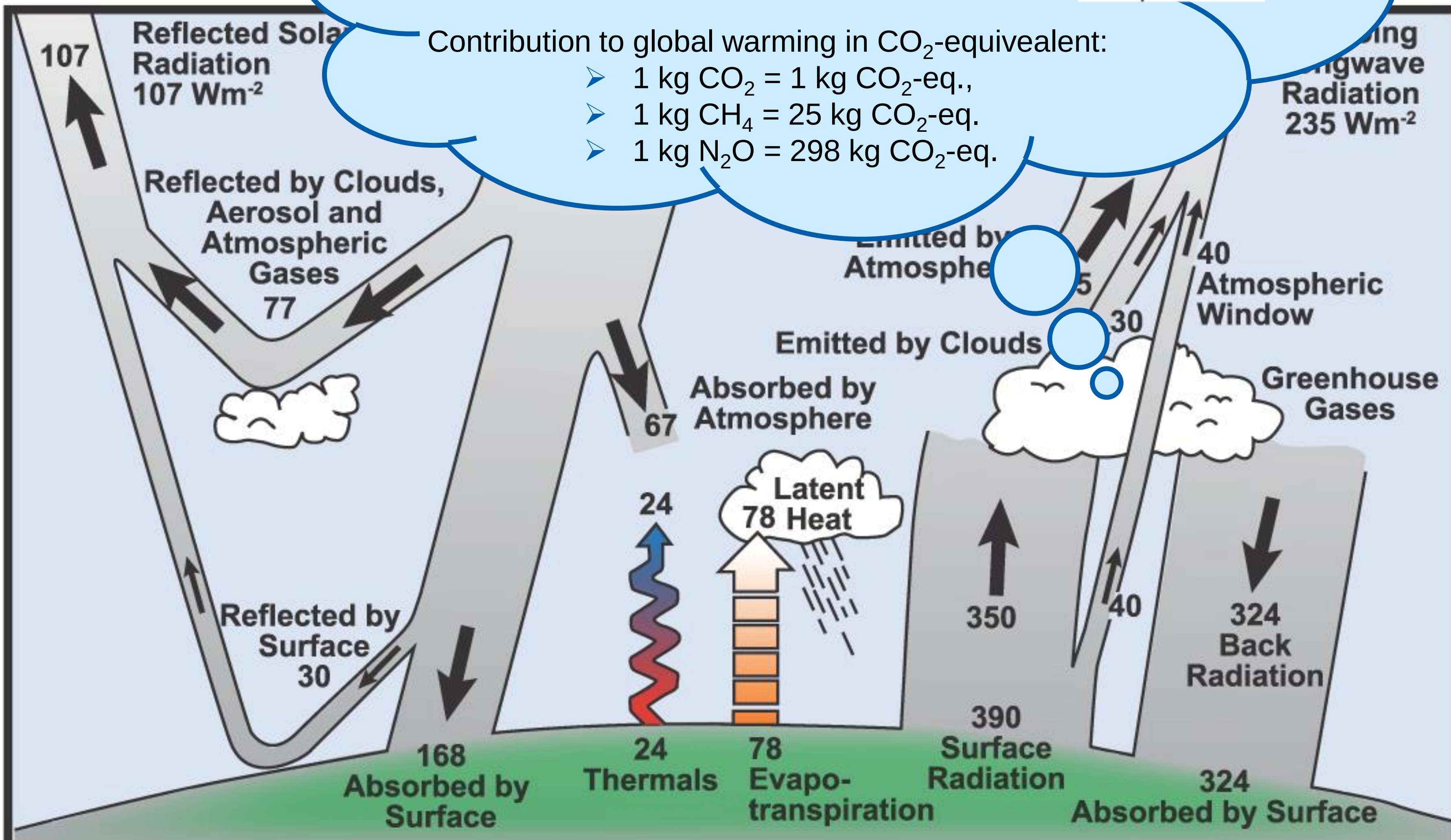






Contribution to global warming in CO_2-equivealent:

- 1 kg CO_2 = 1 kg CO_2-eq.,
- 1 kg CH_4 = 25 kg CO_2-eq.
- 1 kg N_2O = 298 kg CO_2-eq.



Source: IPCC 2001

European Commission

Fraunhofer UMSICHT

WAGENINGEN UR For quality of life

BDI

JOANNEUM RESEARCH LIFE

The FOUR Factors ... ing Greenhouse Ga...

Future Energy System

$$tCO_{2eq} = t \ldots \; \ldots vic \ldots / P * P$$

Activity focus of **NEW** Research Group

„Future Energy Systems & Lifestyle“

since January 1, 2016

JOANNEUM RESEARCH LIFE

...or ...ewable energy)

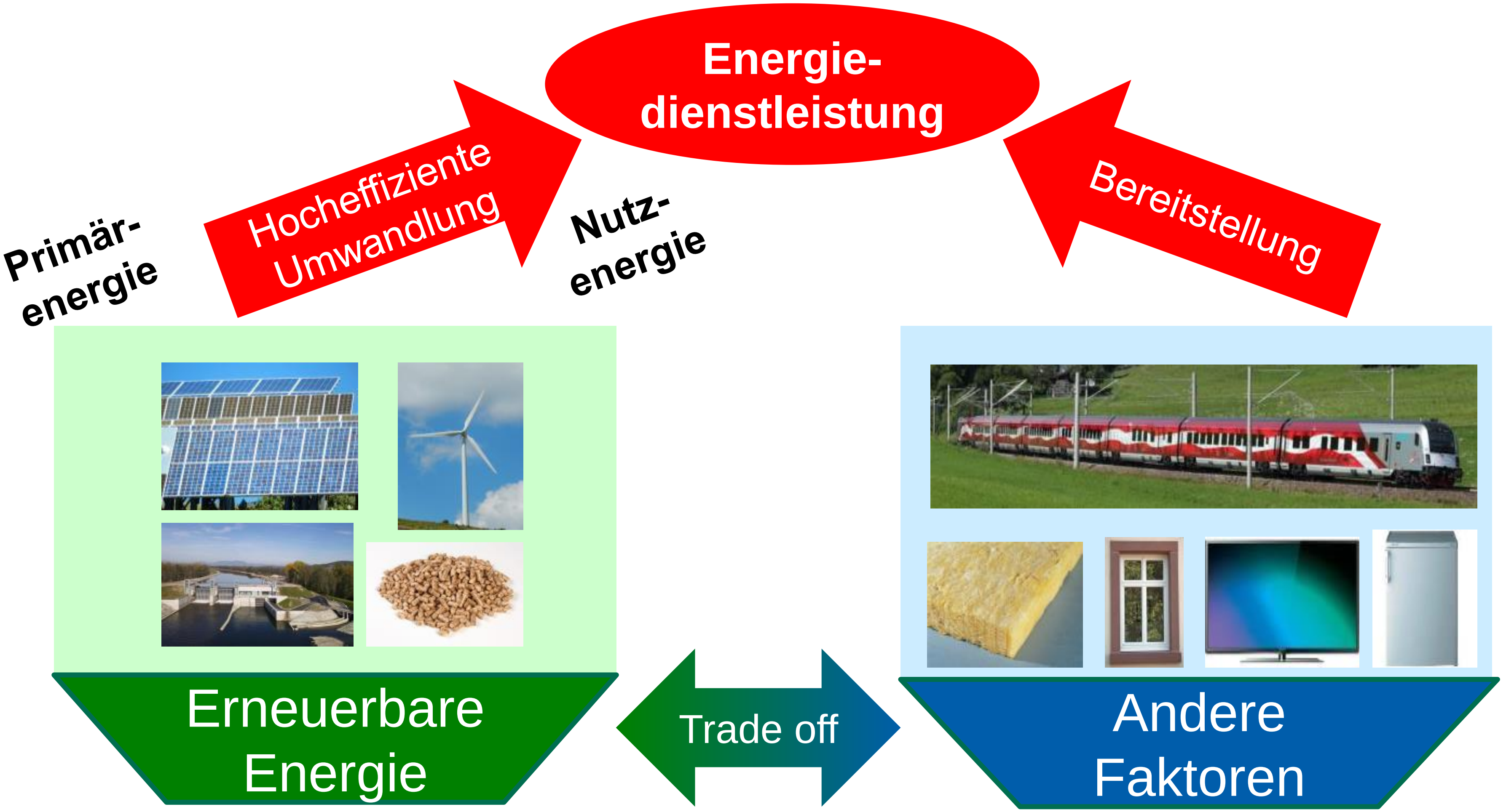
2) Energy-efficiency

3) services per person

4) number of people

Source: based on “IPAT-Formel” of A. & P. Ehrlich

Kennzeichen zukunftsfähiger Energiesysteme



Kennzeichen der Lebensstile

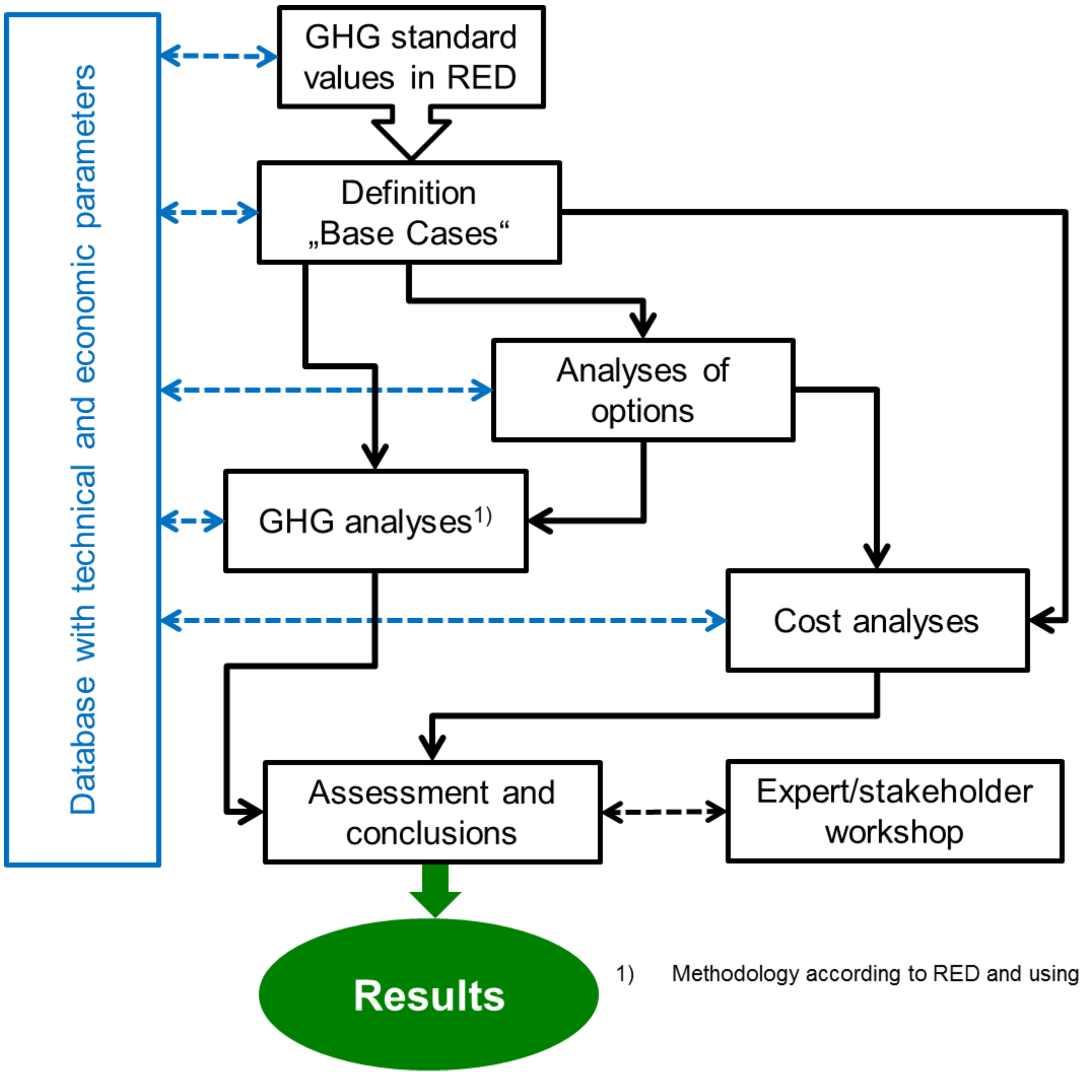
Aims

- **Greenhouse Gas (GHG) balances of FAME** from various resources have been set in the RED.
- Due to technology and scientific progress it is feasible that there are several ways to **improve the GHG balances of FAME**.
- This Supporting Action aims at analysing the **various options available in improving the GHG balance of FAME**.
- **Assessment of 10 options** to improve the GHG balance of biodiesel.

10 Options to improve the GHG balance of FAME

1) **"Biomethanol"** to substitute fossil methanol in FAME production
2) **"Bioethanol"** to substitute fossil methanol for production of FAEE
3) **"CHP residues / Renewable heat & CHP"** to provide power&heat
4) **"Plant species"** increasing biomass weight without effect on oil seed
5) **"Bioplastics&chemicals"** made from process residues and straw
6) **"Advanced agriculture"** for N_2O-reduction and soil-C accumulation
7) **"Organic fertilizer"** Use of organic instead of mineral fertilizer
8) **"FAME as a fuel"** for cultivation, transportation and distribution
9) **"Retrofitting multi feedstock"** in single feedstock FAME plants
10) **"Green electricity from PV plant on site"** for FAME production

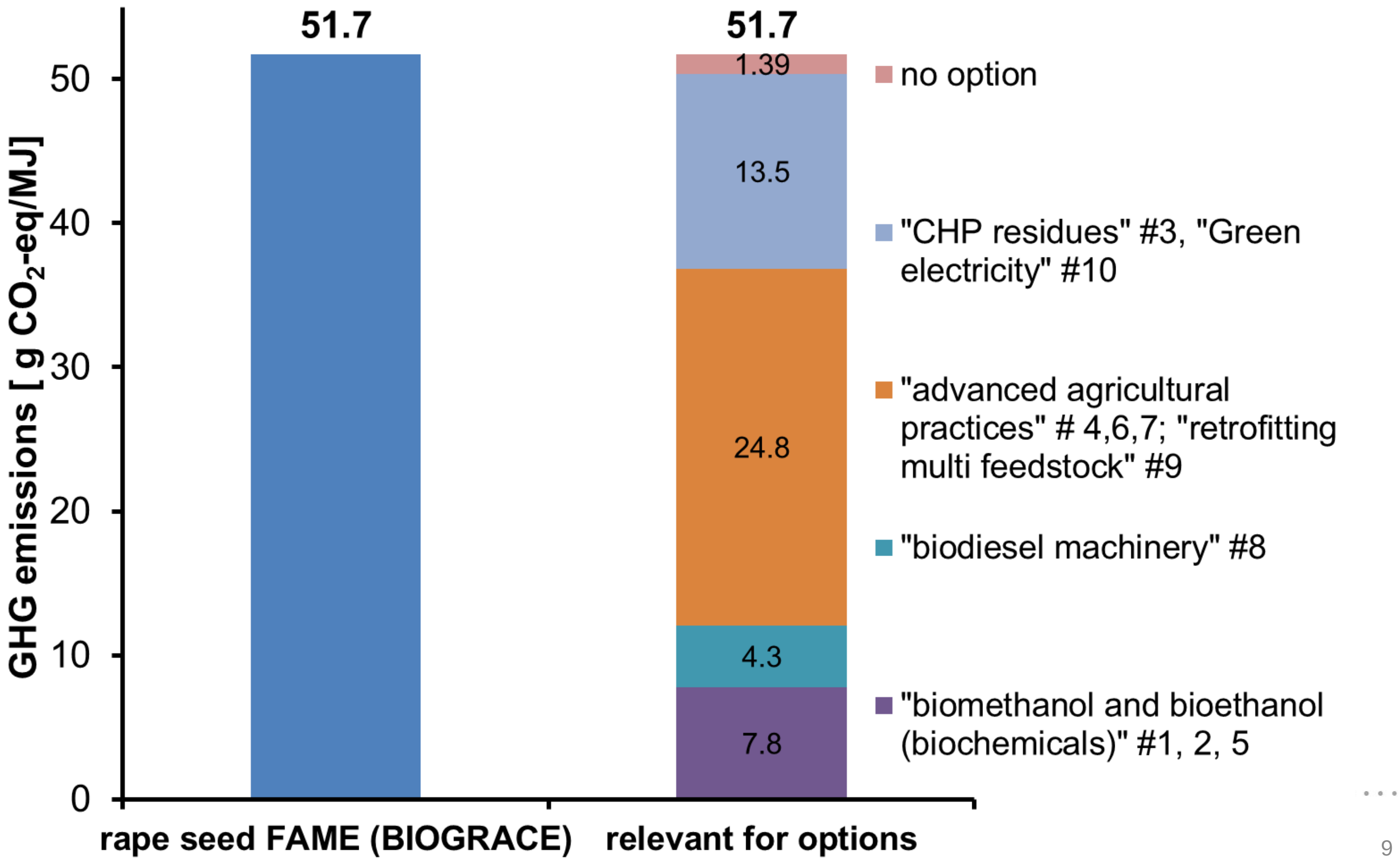
Approach



1) Methodology according to RED and using the BioGrace calculation tool

- GHG standard values from RED
- Definition “base cases” using BAT
- Specification and analyses of options to improve the GHG balance of FAME
- Database
- GHG analyses
- Cost analyses
- Overall assessment, “Fact Sheet of options” and conclusions
- Expert/stakeholder workshop

GHG Emissions Adressed by Options



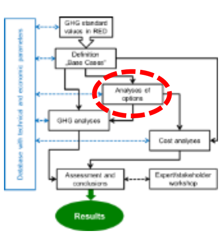
Definition of 14 “base cases”- characteristics & combinations

- **feedstock** types
  - Rapeseed
  - Sunflower
  - Palm oil
  - European soybean
  - American soybean
  - Used cooking oil/animal fat
- **3 FAME production capacities**:
  - 50,000 t/a
  - 100,000 t/a
  - 200,000 t/a

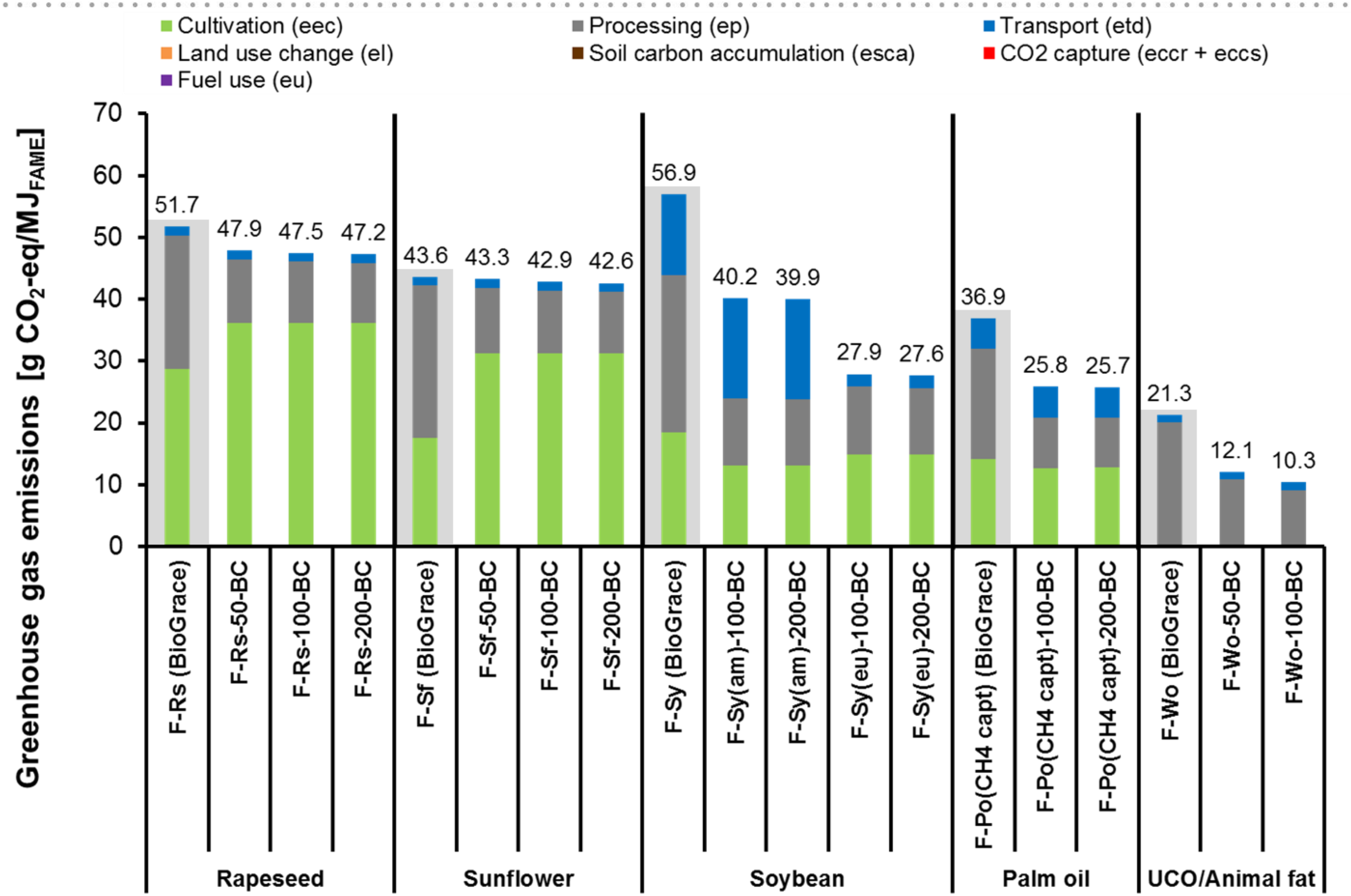
#	Short Name	Feedstock	Capacity [1,000 t/a]
1	Rs-50-BC	Rapeseed	50
2	Rs-100-BC	Rapeseed	100
3	Rs-200-BC	Rapeseed	200
4	Sf-50-BC	Sunflower	50
5	Sf-100-BC	Sunflower	100
6	Sf-200-BC	Sunflower	200
7	F-Sy(am)-100-BC	American soybean	100
8	F-Sy(am)-200-BC	American soybean	200
9	F-Sy(eu)-100-BC	European soybean	100
10	F-Sy(eu)-200-BC	European soybean	200
11	F-Po(CH4 capt)-100-BC	Palm oil	100
12	F-Po(CH4 capt)-200-BC	Palm oil	200
13	F-Wo-50-BC	UCO / animal fat	50
14	F-Wo-100-BC	UCO / animal fat	100

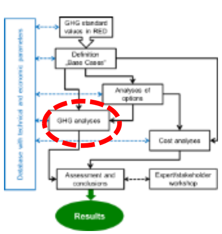
Specification of 39 GHG reduction options
Example: “Chemicals” and “Energy supply”

#[1)	Improvement option	Rapeseed			American soybean	Palm oil (CH4 capt)	New plant species	UCO / animal fat		Short name
		50	100	200	100	100	100	50	100	
	CHEMICALS									
1	**Biomethanol**									
1a	Biomethanol from wood residues as process chemical		x							F-Rs-100-Op1a
1b	Biomethanol from straw as process chemical		x		x				x	F-Rs-100-Op1b F-Sy(am)-100-Op1b F-Wo-100-Op1b
1c	Biomethanol from glycerol as process chemical		x							F-Rs-100-Op1c
2	**Bioethanol**									
2a	Bioethanol from wheat as process chemical			x						F-Rs-100-Op2a
2b	Bioethanol from straw as process chemical			x						F-Rs-100-Op2b
5	**Bioplastic & -chemicals**									
5a	Pharmaglycerol 99.5+		x						x	F-Rs-100-Op5a F-Wo-100-Op5a
5c	Succinic acid from straw + glycerol	x		x						F-Rs-50-Op5c F-Rs-200-Op5c
	ENERGY SUPPLY									
3	**CHP residues**									
3b	CHP with refined vegetable oils+ steam boiler with vegetable oils			x						F-Rs-200-Op3b
3c	Steam boiler with vegetable oils			x						F-Rs-200-Op3c
3f	Wood-to-steam boiler			x						F-Rs-200-Op3f
3d	CHP with distilled glycerol + co-incineration of FAME distillation residue (BHA) in steam boiler							x		F-Wo-50-Op3d
3e	Co-incineration of FAME distillation residue (BHA) in steam boiler							x	x	F-Wo-50-Op3e F-Wo-100-Op3e
10	**Green electricity**		x	x				x	x	F-Rs-100-Op10 F-Rs-200-Op10 F-Wo-50-Op10 F-Wo-100-Op10

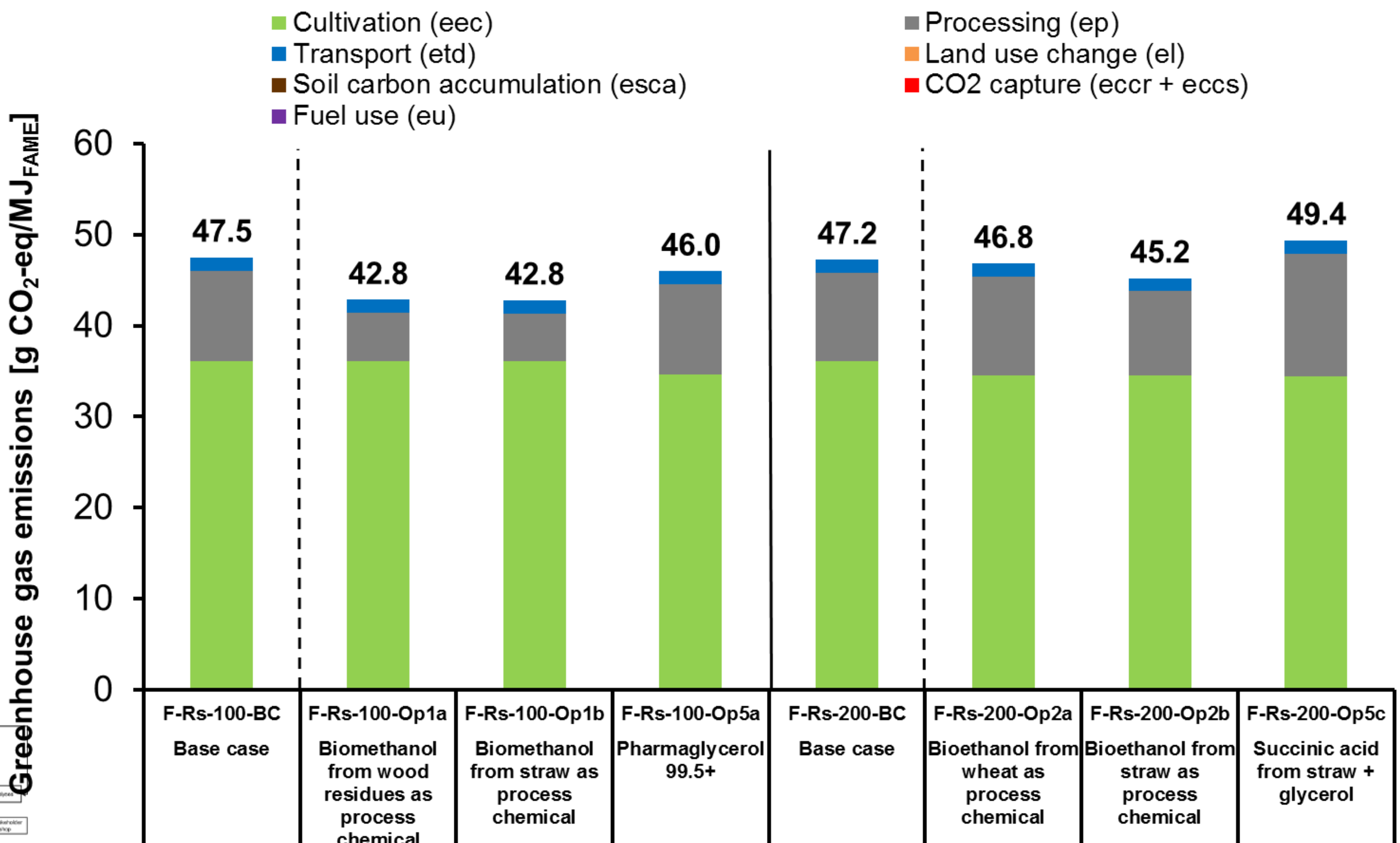


Greenhouse gas emissions of base cases compared to RED values with background data from BioGrace

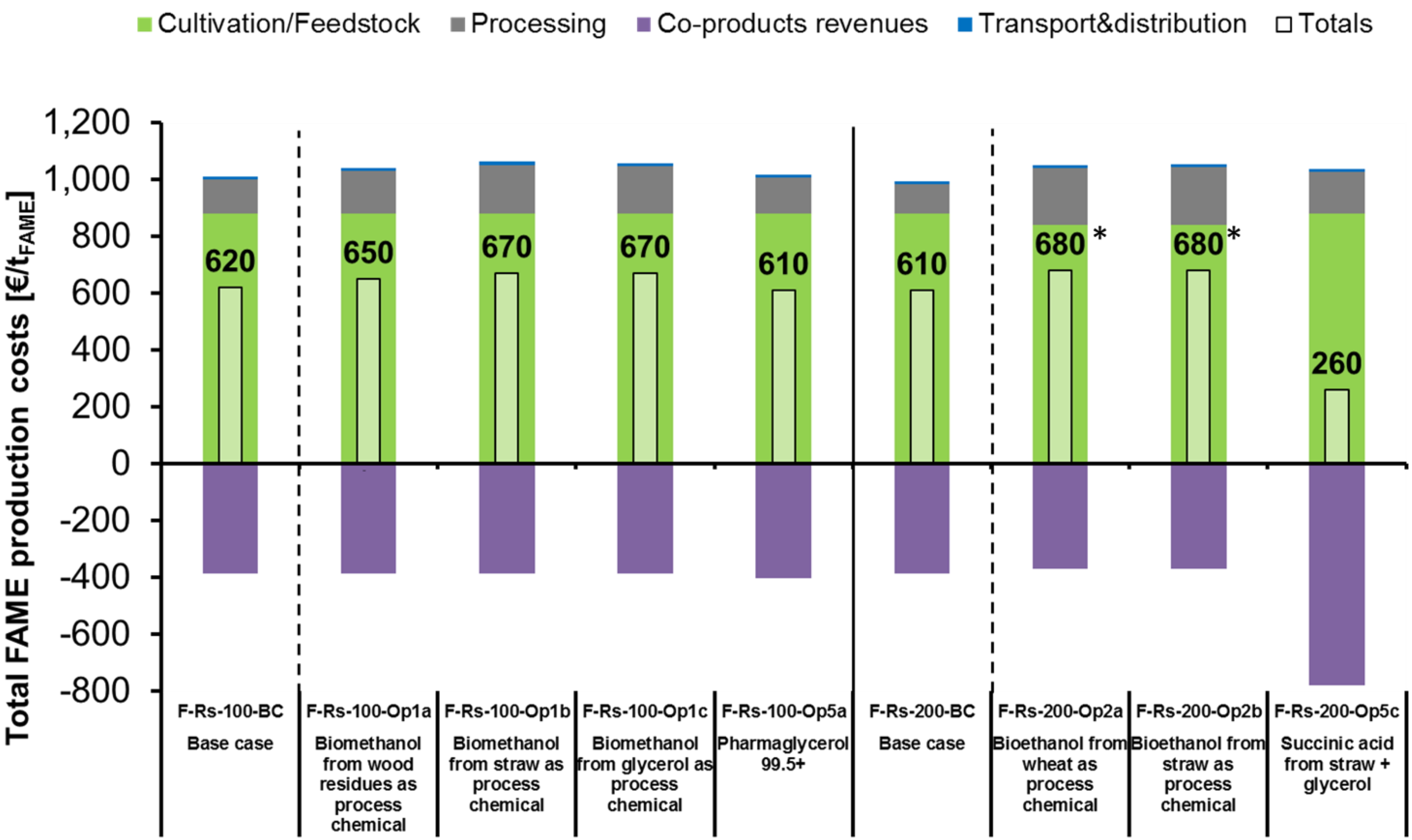


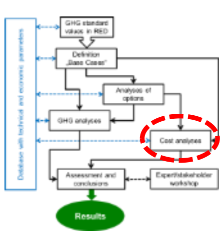


GHG emissions of improvement options “Biomethanol”, “Bioethanol”, “Biochemicals” (I)



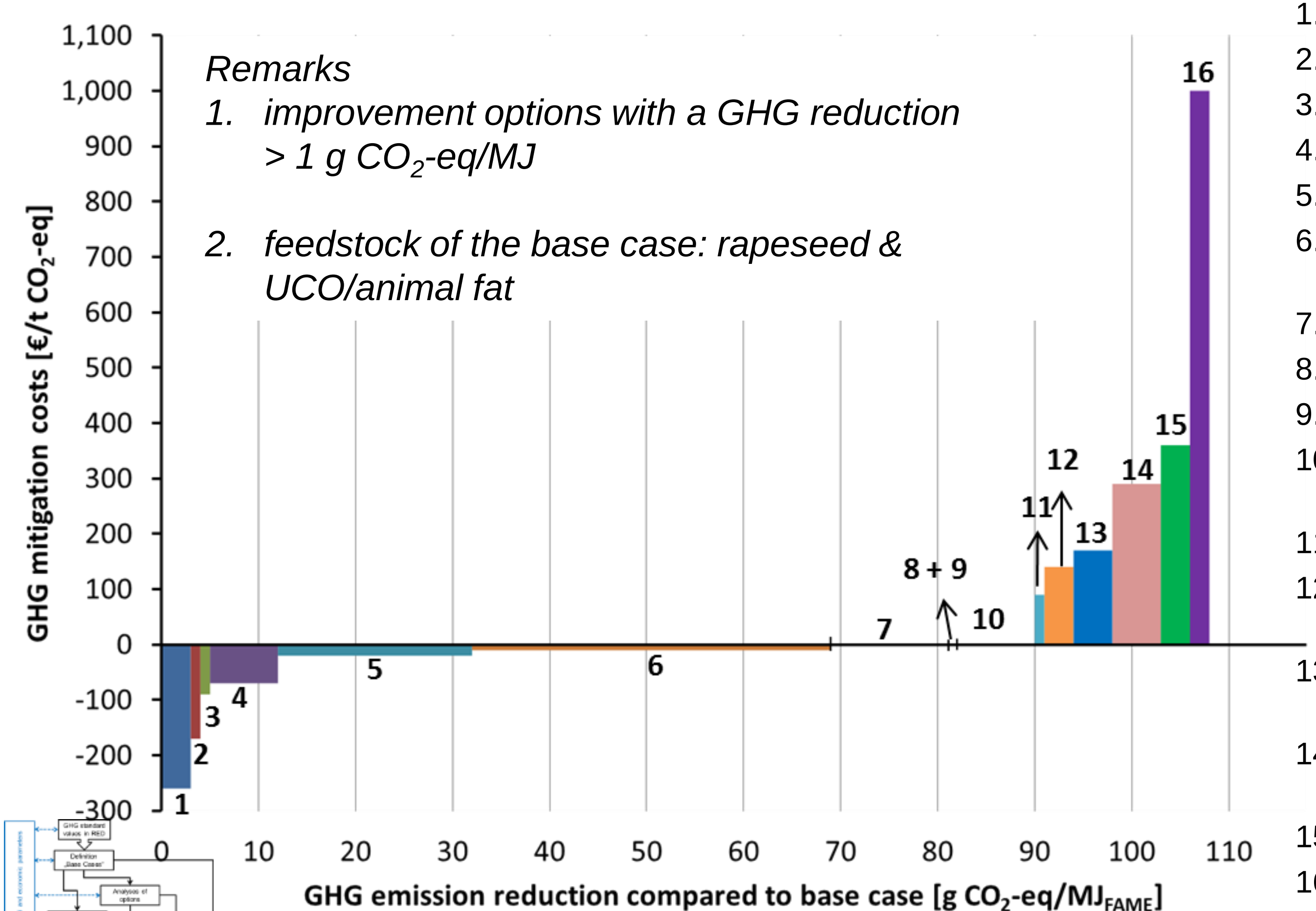
FAME production costs of improvement options “Biomethanol”, “Bioethanol”, “Biochemicals”

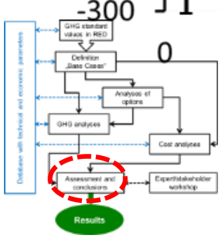




* Process output is FAEE

GHG mitigation costs and GHG emission reduction of selected improvement options

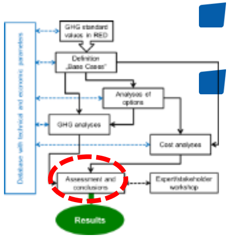




1. Balanced fertilization (100 kt/a)
2. Pharmaglycerol 99.5% (100 kt/a)
3. Wood-to-steam boiler (200 kt/a)
4. Reduced tillage (100 kt/a)
5. Crop residue management (100 kt/a)
6. Complete modification to UCO/animal fat (80 kt/a)
7. Organic fertilizer (100 kt/a)
8. BHA steam boiler (50 kt/a)
9. BHA steam boiler (100 kt/a)
10. Partial modification to UCO/animal fat (200 kt/a)
11. FAME in cultivation (100 kt/a)
12. CHP with distilled glycerol + BHA steam boiler (50 kt/a)
13. Biomethanol from wood residues as process chemical (100 kt/a)
14. Biomethanol from straw as process chemical (100 kt/a)
15. Nitrification inhibitors (100 kt/a)
16. Bioethanol from straw as process chemical (200 kt/a)

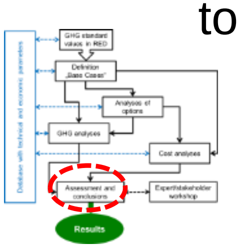
Key aspects of SWOT analysis (I)

- **Biomethanol**: Due to economy of scale biomethanol production at the FAME plant not feasible
- **Bioethanol**: For FAEE fuel certification is missing according to EN14214
- **CHP residues**:
  - All investigated system are commercial solutions
  - FAME processing needs most of the heat on temperature levels above the temperature level generated by CHP solutions
- **New plant species**: Production chains for new emerging crops are under development: demonstration needed and biorefinery approach due to large set of co-products
- **Bioplastic- and biochemical**:
  - Succinic acid - performed on production scale with a mixture of sugar & glycerol
  - Pharmaglycerol - well established and offers an alternative usage for glycerol

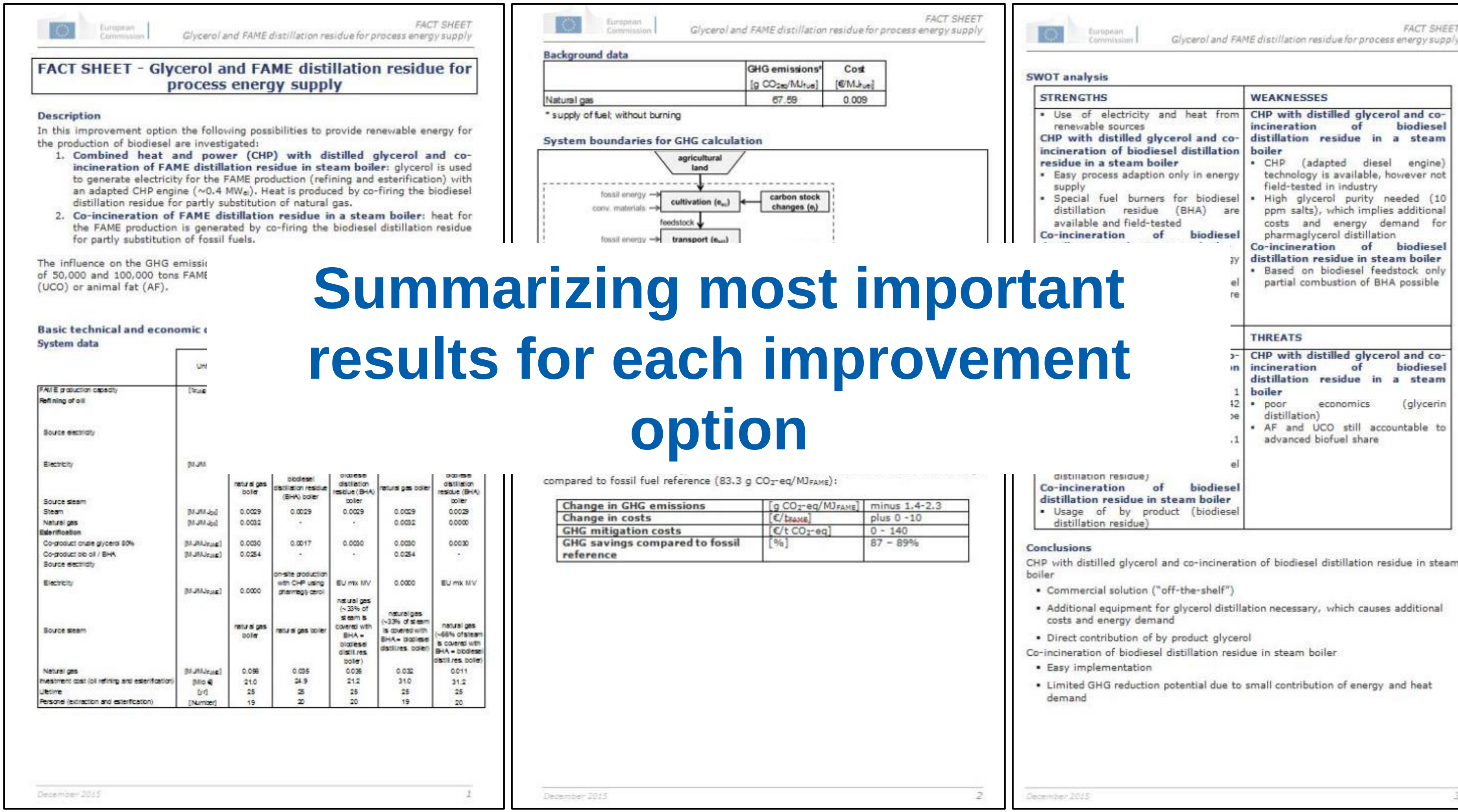


Key aspects of SWOT analysis (II)

- **Advanced agriculture & organic residues**: The current GHG emissions calculation scheme for biofuels does not support the use of advanced agricultural practices and some of the investigated options might be implemented already.
- **FAME as fuel**:
  - No adaption of the FAME production process itself needed
  - Engines must be adjusted to 100% FAME
- **Retrofitting**:
  - Commercial solution
  - Implementation depends on the availability of UCO/animal fat.
- **Green electricity from PV plant on site**: Without storage it is not possible to provide 100% of the electricity needed for FAME processing



Fact Sheet



Summarizing most important results for each improvement option

Recommendations for future development of the RED GHG-calculation methodology

1. **Global warming potential** of N_2O and CH_4: actual CO_2-eq factors
2. Application of **energy allocation**:
   - ✓ Use of by-products for biorefineries excluded from analyses: e.g. biochemicals, bioplastic
   - ✓ straw, crude glycerin → all used co-products
   - ✓ Also apply to: e_{sca}, e_{ccs}, e_{ccr}
3. GHG emissions of **Best Available Technology**: BAT emission factors in RED;
4. Actual GHG value of **fossil reference**:
   - ✓ > 83.4 g CO_2-eq/MJ
   - ✓ actual calculation&documentation;
5. Emissions from the **fuel in use**:
   - ✓ $e_u \neq 0$ include CH_4 and N_2O-emissions from vehicle
   - ✓ CO_2 from fossil methanol in FAME
6. Use of **biomethane** from the natural gas grid: accordingly to renewable electricity
7. Manufacture of **machinery and equipment**: to be included to avoid “underestimation” (mainly electric and H_2-vehicles)

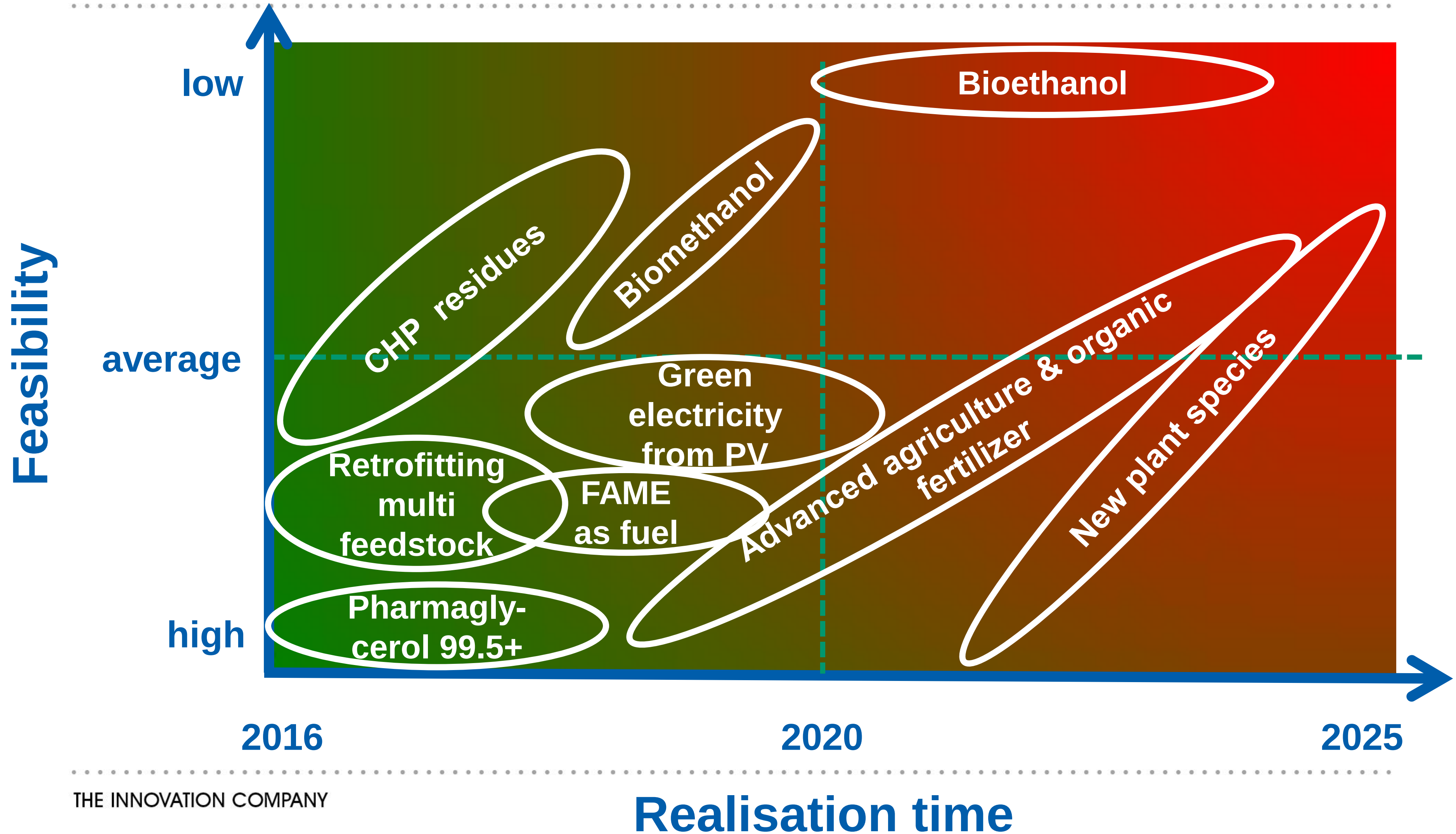
Summary of Results

- **Significant GHG reduction** in processing possible if **Best Available Technology (BAT)** is used in processing steps compared to data in BioGrace

- GHG **reduction options**
  - **agriculture**: relatively **high** reduction potential
  - **processing**: relatively **low** reduction potential

- **DOWNLOAD**: https://ec.europa.eu/energy/en/studies

Overall assessment of the improvement options based on feasibility and realisation time



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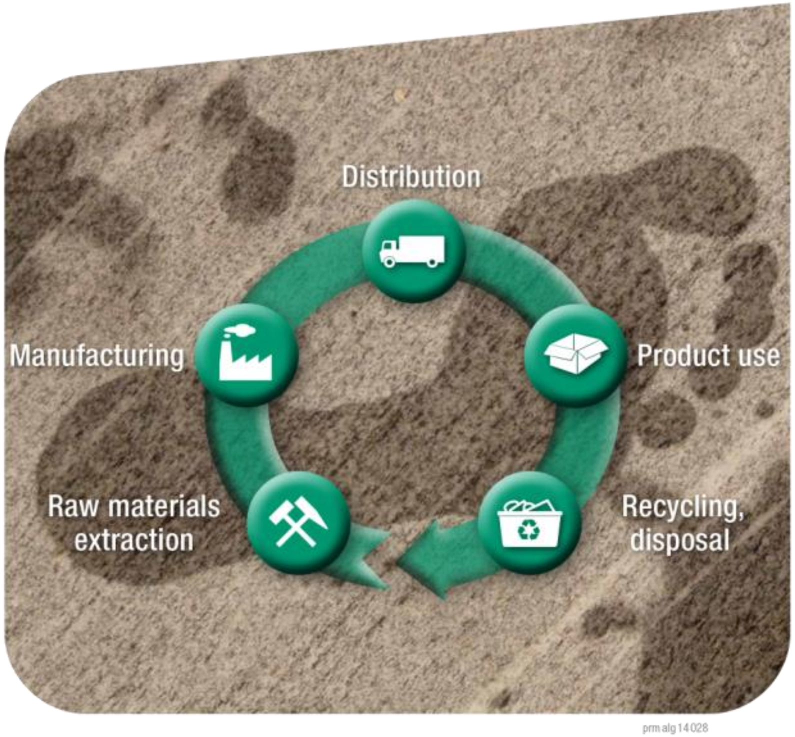

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