



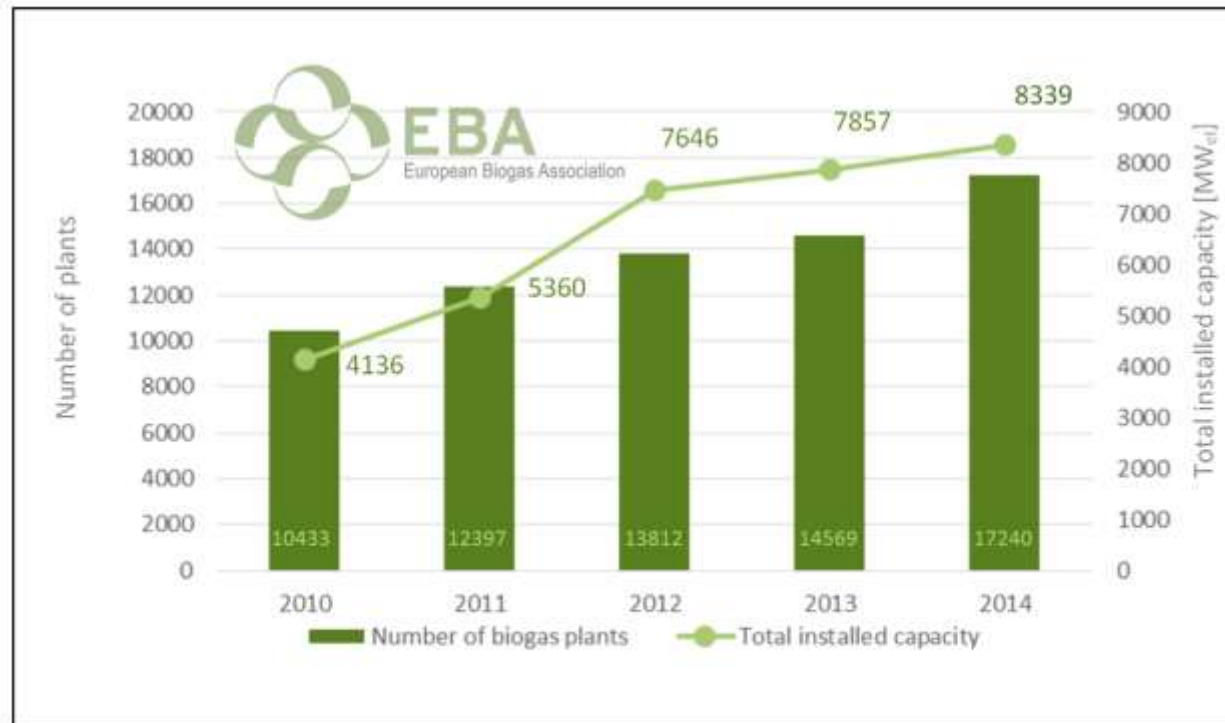
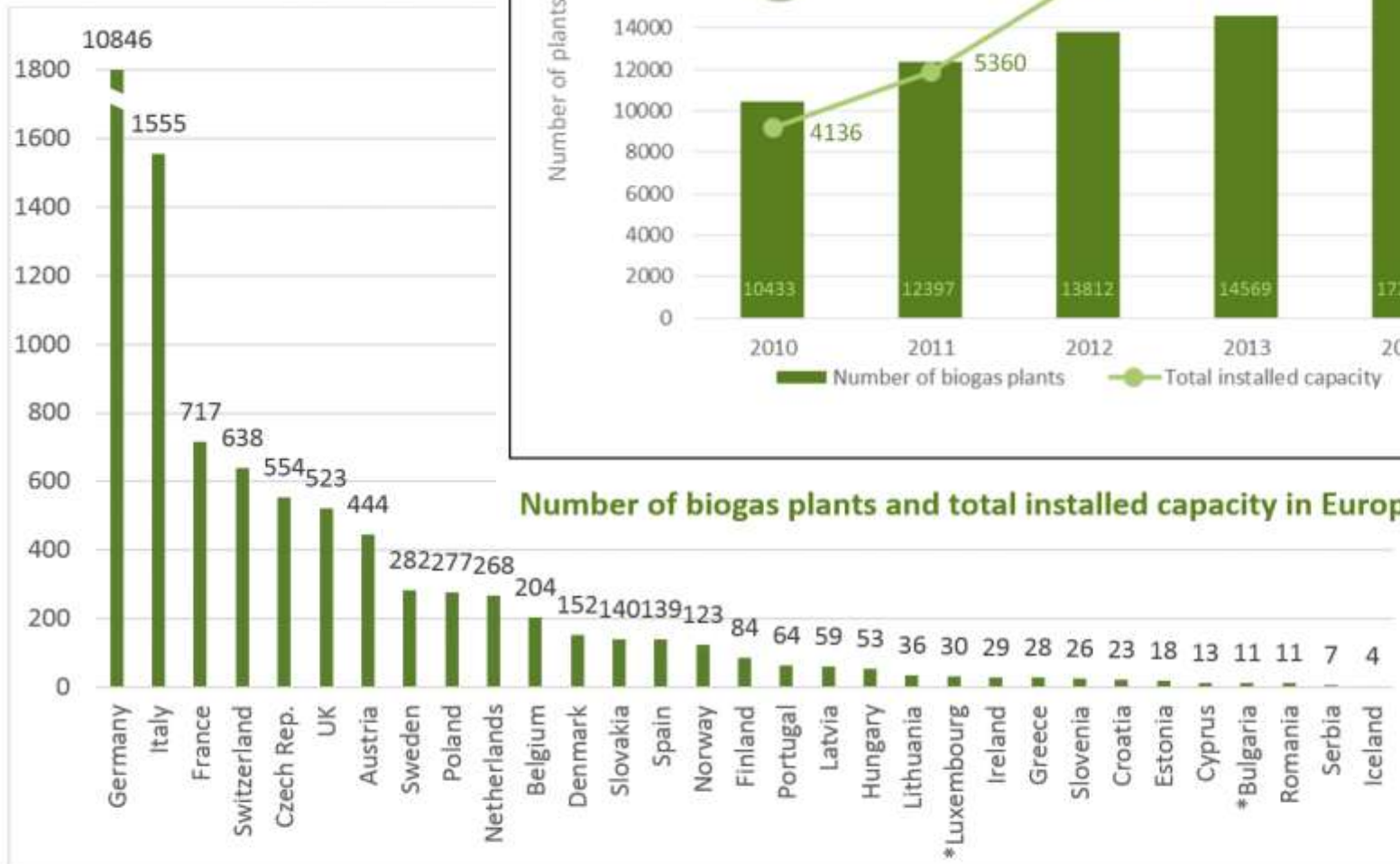
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# **Is anaerobic digestion a truly sustainable solution for organic wastes in Europe?**

**Dr. Sigrid Kusch**

**ADNet Research Colloquium  
11-12 September 2017  
University of Southampton**

## AD plants in Europe



**17,358 biogas plants in Europe (31/12/2015)**  
**Total installed capacity of 8,728 MW<sub>el</sub>**

# AD plants in Europe

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## → Avoided greenhouse gas emissions:

- renewable energy substitutes fossil fuels: 63.6 TWh electricity from AD in 2014 in EU = consumption of 14.6 million households + 30 TWh heat + 2.8 billion Nm<sup>3</sup> biomethane (EBA statistical report, EurObserv'er)
- digestate substitutes energy-intensive mineral fertilisers,
- avoided emissions from landfills

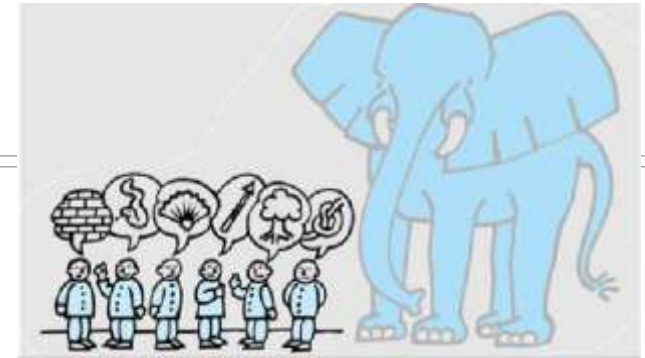
## → Recycling of biomass to organic fertiliser/ soil improver

## → Additional income from waste

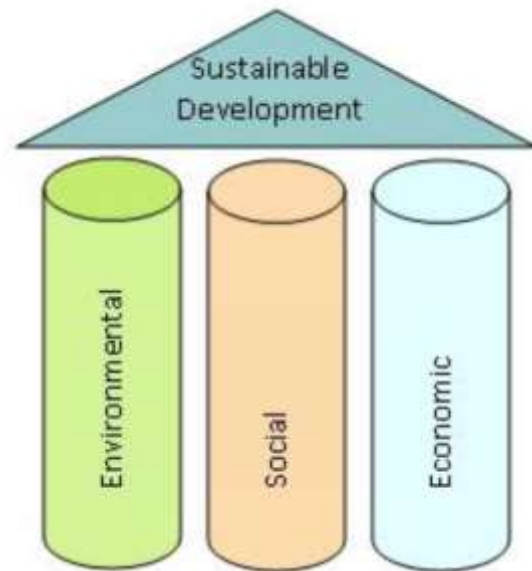
## → 70,000 jobs in AD in EU alone, many in disadvantaged rural areas

## Truly “sustainable”...

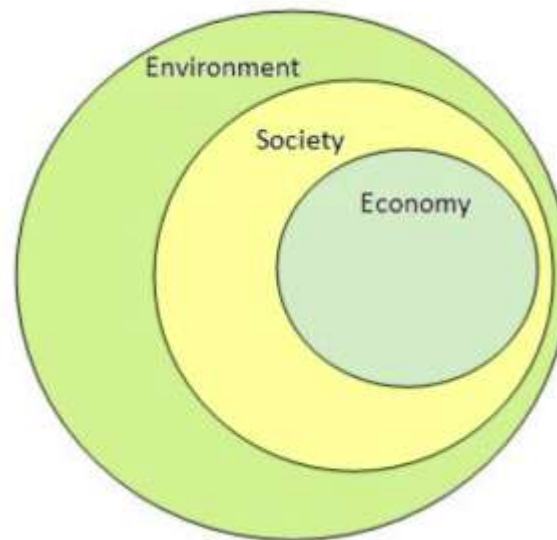
- ❖ Triple bottom line of sustainability:  
Environmental,  
Economic,  
Social dimension



Source of figure: unknown



Three pillars  
model of SD



Nested circles  
model of SD

Source of Figures: Stakeholder Forum, 2014

**LCA**  
Life Cycle Analysis  
(Environmental)

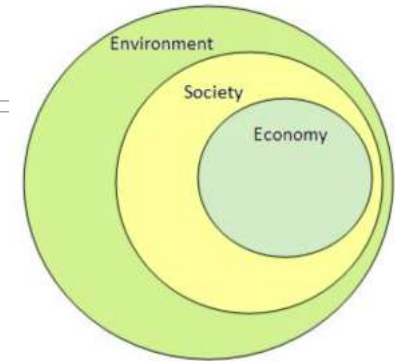
**LCC**  
LCA-type  
Life Cycle Costing

**SLCA**  
Social Life Cycle  
Assessment

## Truly “sustainable”...

Can AD create benefit in all three dimensions?

Environmental, Economic, Social



→ Yes, it is possible.

→ → And does it? And might alternative schemes create higher value?

Environmental schemes need to

- ❖ generate real benefits for the environment
- and need to successfully integrate
- ❖ economic efficiency and
- ❖ socially acceptable burdens.

## Truly “sustainable”...



## Organic wastes/ residues

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**Waste:** “any substance or object which the holder discards or intends or is required to discard”

(EU Waste Framework Directive)

**Product:** all material that is deliberately created in a production process

**Production residue:** a material that is not deliberately produced in a production process but may or not be a waste

**By-product:** a production residue that is not a waste

**Organic residues = biomass residues:**

→ bio-waste + similar materials generated in areas such as forestry, agriculture, sewage schemes, waste management  
(German Advisory Council on the Environment SRU)



# Organic wastes/ residues

## Sources of Organic Residues

### Sphere of Responsibility of Local Authorities

- Bio-waste (collected in bio-waste bins)
- Green waste (from gardens, parks)
- Sewage sludge

### Agriculture and Forestry

- Manure, slurry
- Straw, harvest residues
- Vegetables processing, trimming and storage residues

### Industry

- Food supply
- Beverage production
- Pulp and paper production
- Pharmaceutical industry
- ...

## Is that waste?



# Organic wastes/ residues

## Sources of Organic Residues

### Sphere of Responsibility of Local Authorities

**WASTE**  
(at least by definition...)

→ Waste management, focus: limit adverse impacts on environment and human health (Composting, AD, thermal processes)

### Agriculture and Forestry

Traditionally no occurrence of waste, closed-loop practices

Crop residues and manures traditionally maintained in value chain

### Industry

**WASTE or NOT WASTE**

- Business model
- Markets
- Incentives
- ...

AD is assumed to be added value

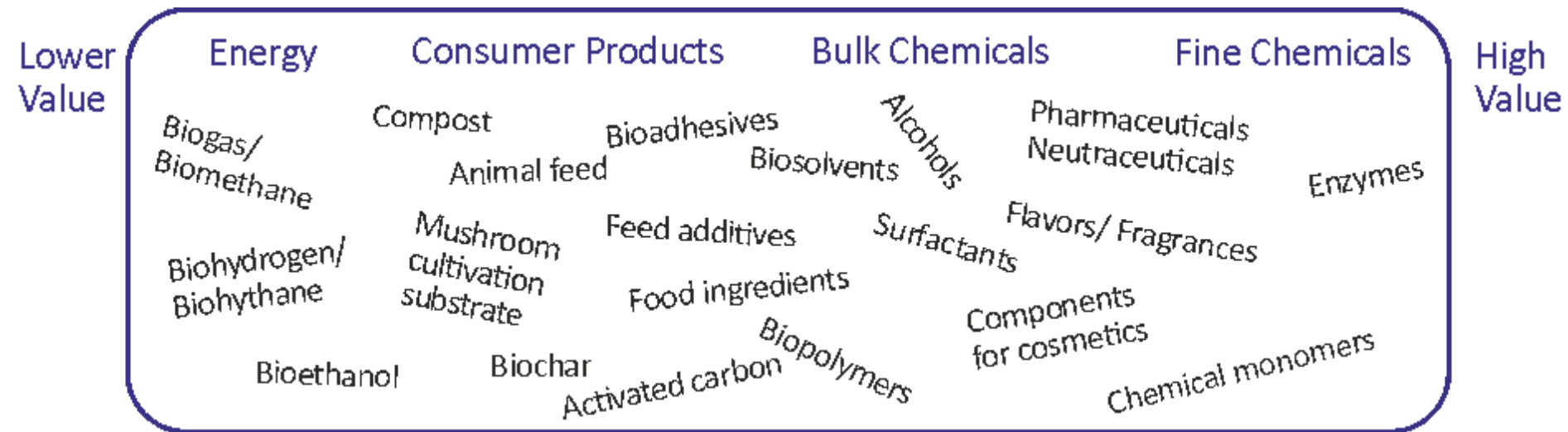
AD might be added value, or reflects diversion of a resource to energy instead of material use

## Some examples of bio-residues in industry (beverage production)

	<b>non-utilised raw material at production unit</b>	<b>Types of residues</b>
Fruit and vegetable juice production	20-50 % (w)	Peels, pomaces (apple, tomato), leaves
Red and white wine production	15-30 % (w)	Grape pomace (pressed skins, seeds, stems, disrupted cells), spent wine yeast
Beer production	30 % (w)	Brewer's spent grains, spent hops, spent yeast
Distillery beverages	20-50 % (w)	Exhausted grape pomace, malt distillers grain (barley) or other spent grains (wheat, corn); yeast sludges

Source: Kusch et al. based on literature and further assessments. Book chapter in preparation, Valorization of byproducts and residues from beverage production, in: Emerging Trends and Developments in Beverage Science (2018)

# What to do with those materials?



Source: Kusch et al. Book chapter in preparation, Valorization of byproducts and residues from beverage production, in: Emerging Trends and Developments in Beverage Science (2018)

To really implement a Circular Economy that creates wealth:  
 → “Keep products and materials at their highest utility and value at all times” (Ellen McArthur Foundation)

# What to do with those materials?



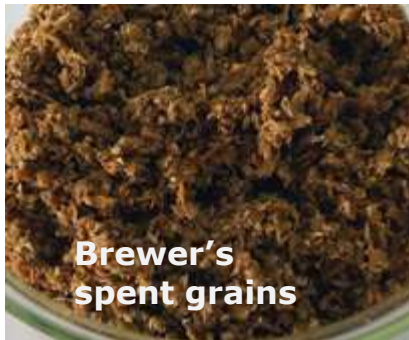
Aim must be to

- tap potential for use of each bio-residue type as far as possible
- by employing optimum combination of processes in each case

Seeking to generally promote a particular process is questionable.

Industrial residues to be assessed differently than bio-waste from households with view to suitability of AD!!! Example: food waste

Incentives create impacts! ++++ or -----???



**Brewer's  
spent grains**



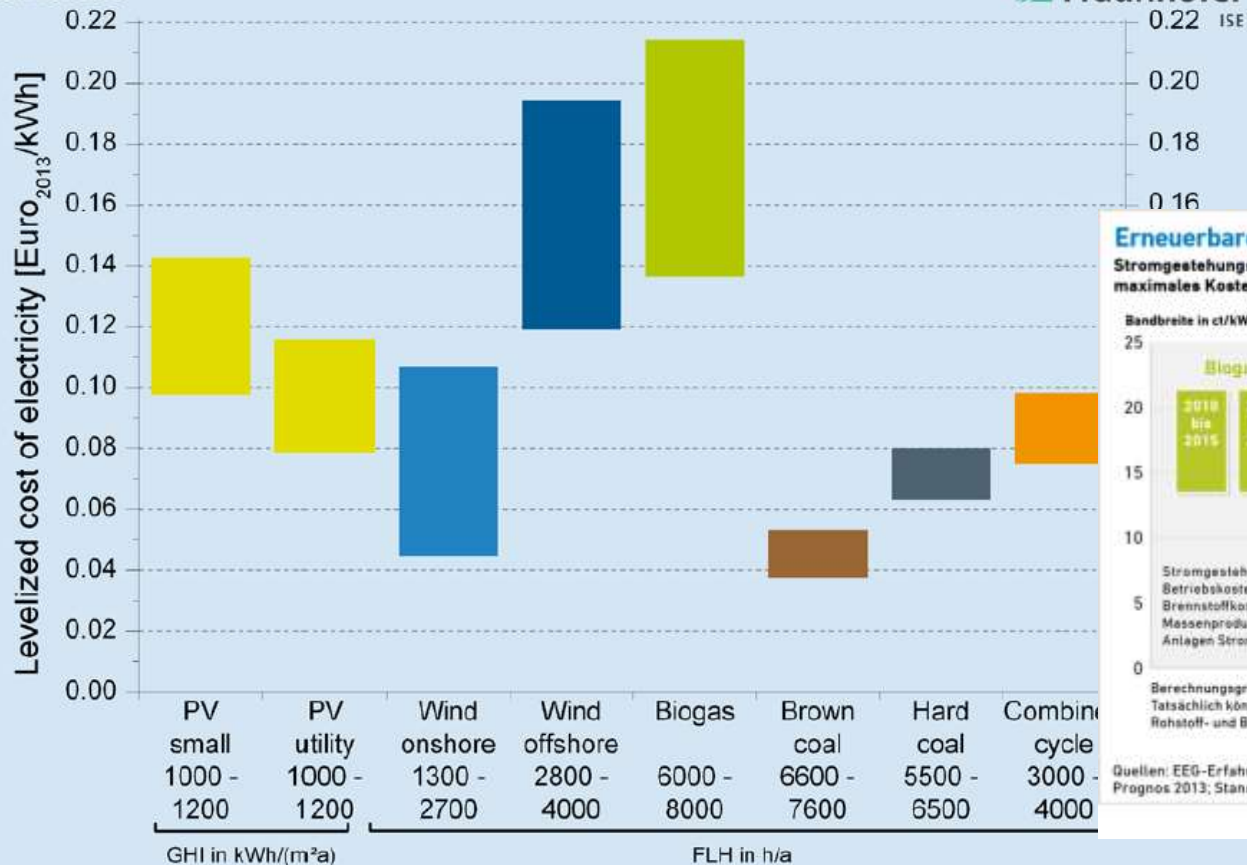
**Whisky  
draff**



**Fruit  
pomace**

Animal feed...  
...now often AD.

→ Impact on supply  
of animal feed?



## Costs of biogas electricity

### Erneuerbarer Strom wird billiger

Stromgestehungskosten typischer, neu errichteter Anlagen sowie maximales Kostensenkungspotenzial



**Figure 1: LCOE of renewable energy technologies and conventional power plants at locations in Germany in 2013.** The value under the technology refers in the case of PV to the insolation global horizontal irradiation (GHI) in kWh/(m²a), for the other technologies it refers to the number of full load hours (FLH) for the power plant per year. Specific investments are taken into account with a minimum and maximum value for each technology.

Source: Fraunhofer ISE: LEVELIZED COST OF ELECTRICITY - RENEWABLE ENERGY TECHNOLOGIES, 2013

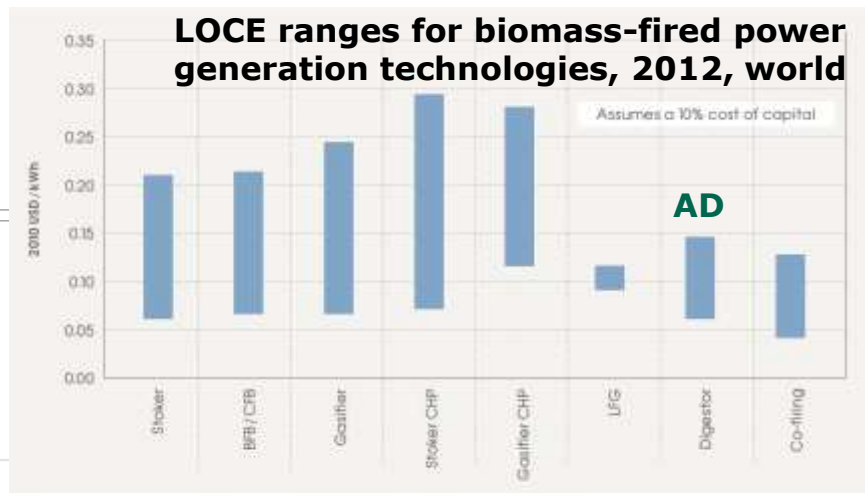
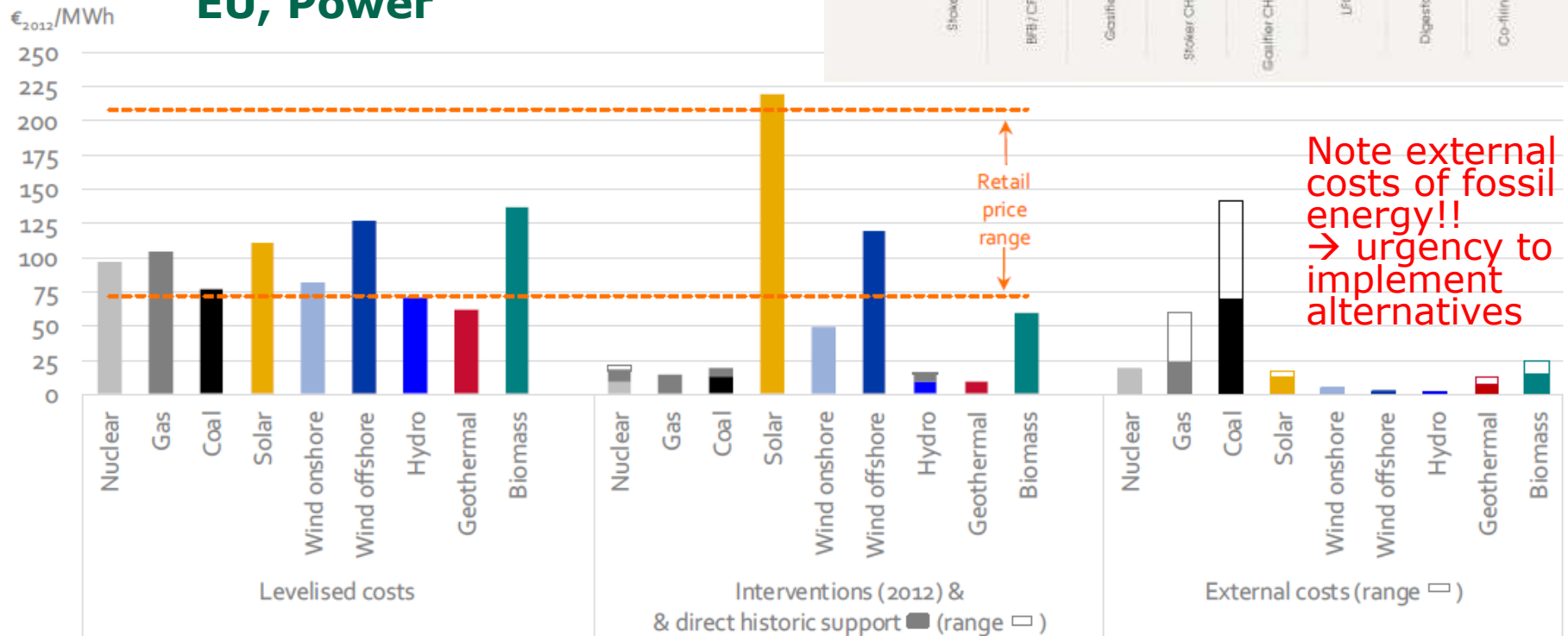
Task for industry:

Can AD costs be reduced?



→ If energy were the only goal, AD rather expensive...

## EU, Power



Source: IRENA: Biomass for Power Generation, 2012

**Figure 4-3: Levelised costs, total interventions, external costs split by technology 2012 and divided by production (in €/2012/MWh).**

Source: Alberici et al.: Subsidies and costs of EU energy. Ecofys for the European Commission, 2014

Bioenergy suitable choice today, but rather role of energy of transition.

## Bio-waste: a special case

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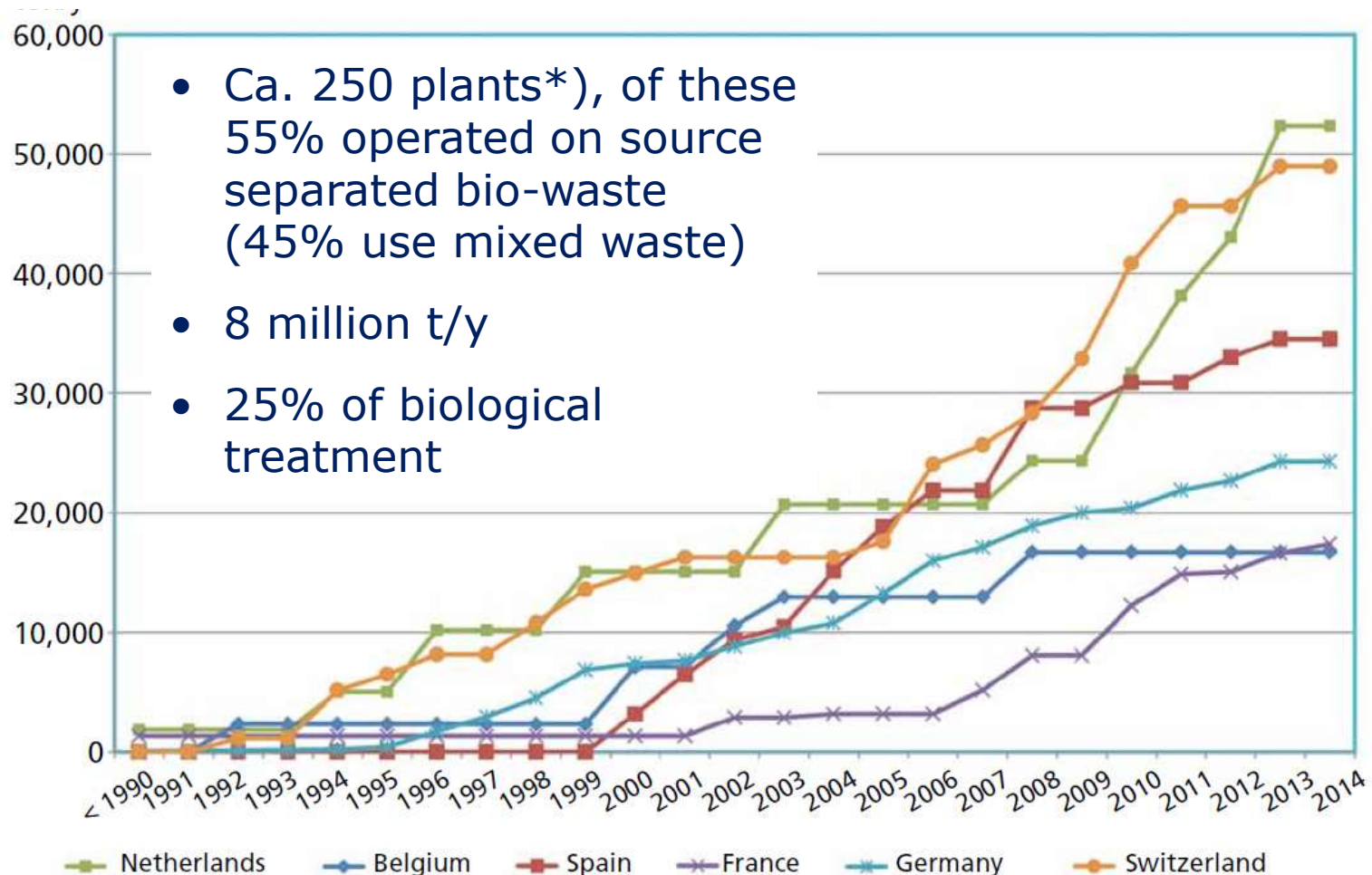
(Economic) assessment: against alternative waste treatment costs, not primarily against renewable energy generation schemes

- Costs for bio-waste treatment lower compared to treatment of residual waste (DE: 30-80 EUR /t bio-waste, vs. 70-150 EUR/t res. waste)
- Separate collection of bio-waste reduces amount of residual waste with comparably higher treatment costs
- Extraction of bio-waste and green waste from residual waste as far as possible, but considering local circumstances, socially acceptable burdens
- Optimisation of waste flows for most appropriate recovery procedure (e.g. Germany: ca. 1,000 larger/ = >1,000 t/a composting plants, ca. 100 AD plants for bio-waste)



# AD of bio-waste (OFMSW) in Europe

## Evolution of installed capacity, per million inhabitants [t/y]



Source: De Baere, L., Mattheeuws, B.: Anaerobic Digestion of the Organic Fraction of Municipal Solid Waste in Europe, 2015

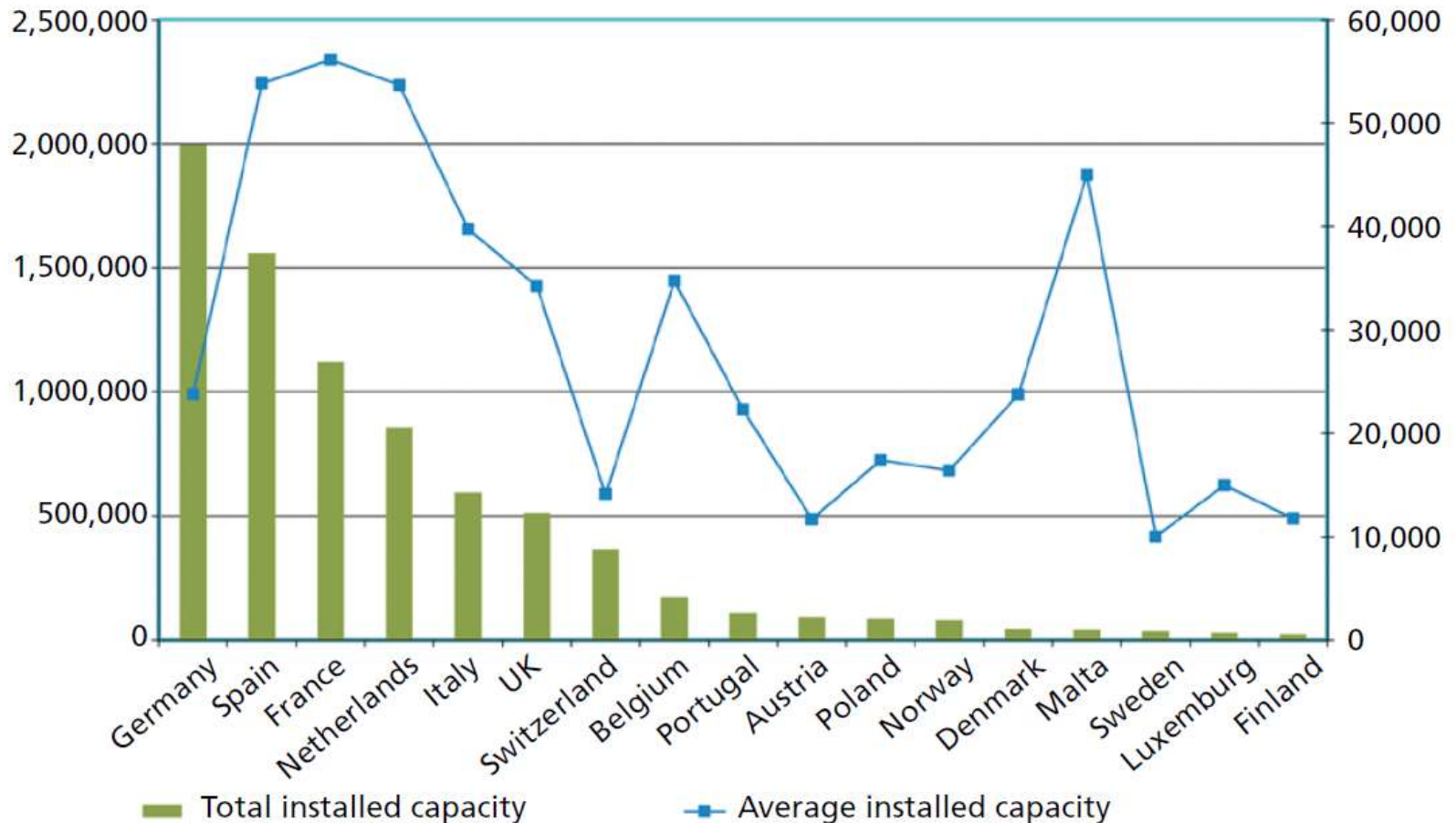
Is AD a truly sustainable solution for organic waste in Europe? ADNet Colloquium Sept 2017, Southampton, Dr Sigrid Kusch

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\*) Probably some more, German AD plants operated on mixed waste (ca. 45 plants) seem not to have been considered in this study

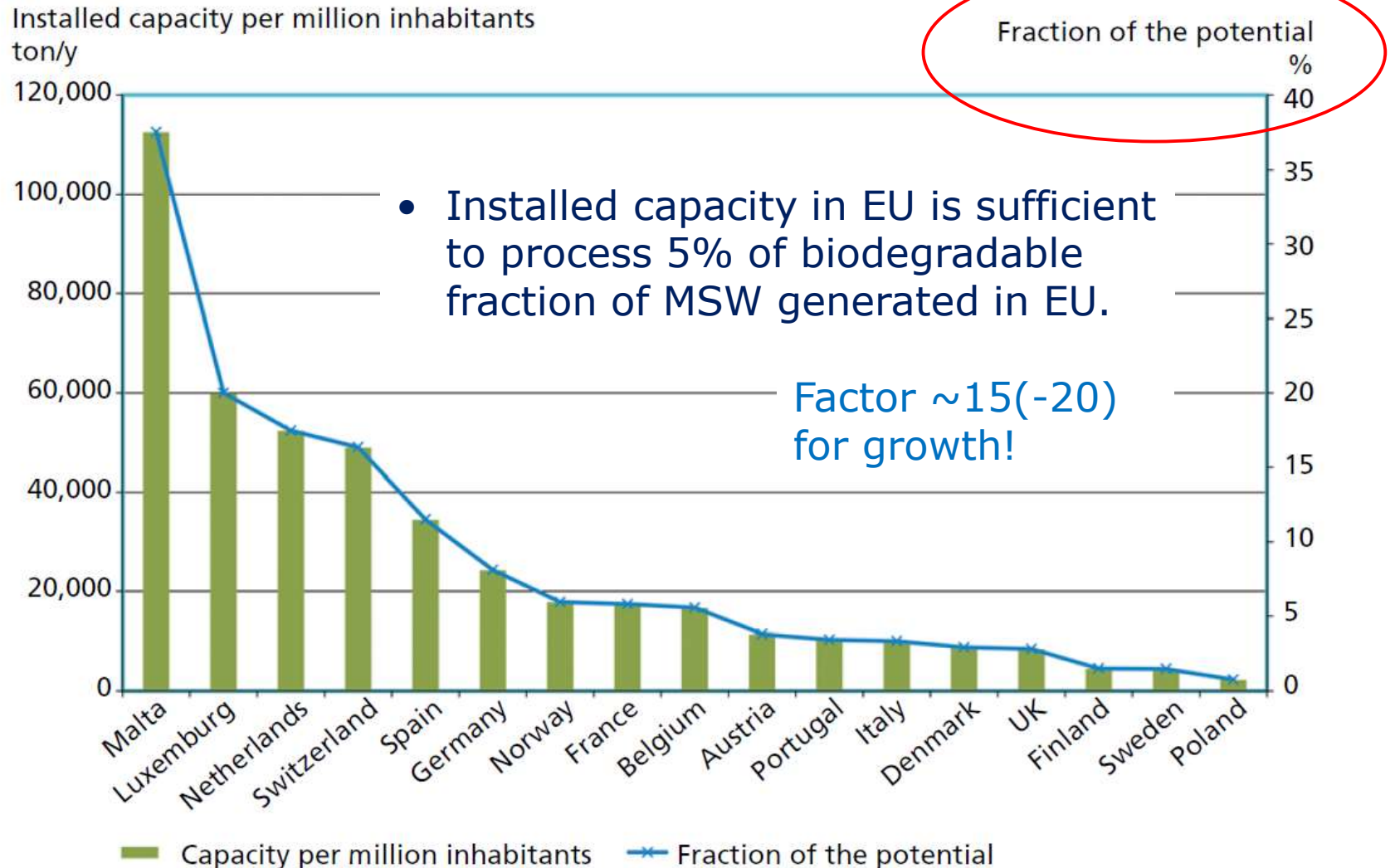
## AD of bio-waste (OFMSW) in Europe

### Cumulative capacity [t/y] and average installed capacity [t/y]



Source: De Baere, L., Mattheeuws, B.: Anaerobic Digestion of the Organic Fraction of Municipal Solid Waste in Europe, 2015

## AD of bio-waste (OFMSW) in Europe



Source: De Baere, L., Mattheeuws, B.: Anaerobic Digestion of the Organic Fraction of Municipal Solid Waste in Europe, 2015

## Existing separate collection for bio-waste (biobin)

YES

NO

Optimisation potential reached?

Might be justified in rare cases

1. Specific amounts collected exceed 60 kg/res\*a.
2. More than two thirds of households are covered by the system.
3. The quality of the material collected is sufficiently good (less than 5 percent impurities)
4. Financial incentives for separate collection are included in the waste and charges statutes.
5. Home composting is encouraged, but also regulated.
6. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).
7. The waste advisory service and publicity regularly addresses the subject of bio-waste (foreign language information sheets where necessary).

1. There are comprehensible reasons for not introducing a separate collection system for bio-waste (for example, because of the settlement structure).
2. More than two thirds of households have their own well-functioning composting systems (verified by inspection).
3. Very high specific collection of green waste (more than 100 kg/res\*a).
4. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).

Separate collection of bio-waste!

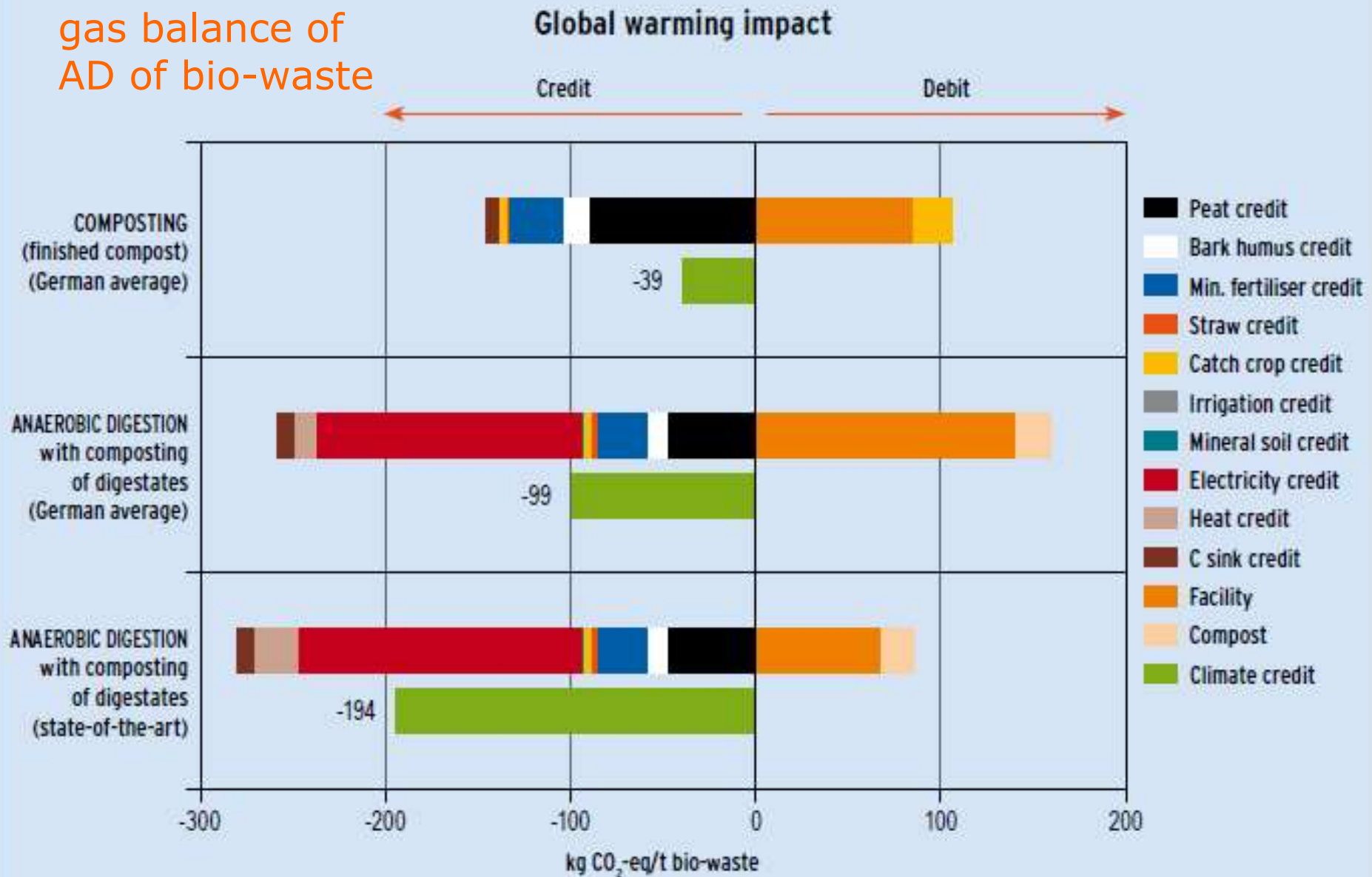
!! Quantity + quality of material

EU: ca. 120-140 million t/a bio-waste occurring

Only ca. 25% recycled (composting +AD)



# Greenhouse gas balance of AD of bio-waste



Source: ifeu (Institute for Energy and Environmental Research) 2012: Optimising organic waste recovery (UFOPLAN 3709 33 340), modified

## Summary

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- Improved technical and operational measures at AD plants have significant potential to further increase benefits
- Cost reduction desirable, but can costs be further reduced without endangering environmental performance?
- For bio-waste (mainly food waste) from households, AD currently in most cases best choice (in particular in the form of high-grade cascaded process: AD followed by after-composting)
- More efforts to separately collect bio-waste from households!

## Summary

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- For industrial organic wastes/ residues, other alternative valorisation pathways to be assessed with priority.
- Incentives that turn by-products to waste to be criticised.
- AD is state-of-the-art, nevertheless more research and development clearly highly beneficial. Example for lack of data in economic dimension of biogas: external costs

**Thank you very much for your attention  
and  
for the invitation to the ADNet Colloquium!**