Recirculation & bioutilisation
Energy, carbon & more

SOLUM®

CIRCULAR ECONOMY SINCE 1986

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Biogas

Anaerobic digestion is simply natures way of recirculating organic matter.

It can be argued, that natural gas, is simply just old (as in VERY old) biogas.

On a high level, and with some variations, controlled anaerobic digestion:

- produces a gas with roughly 60% methane and 40% CO2
- assists in handling a waste issue, and potential pollution and GHG emission
- prepares the source material for recirculation by making nutrients more accessible
  - offsetting use of chemical fertilizer
- reduces the smell of the digestate

A note on biogas per se

Biogas in itself is **not energy**. Biogas is a **fuel**. And like any other fuel it is:

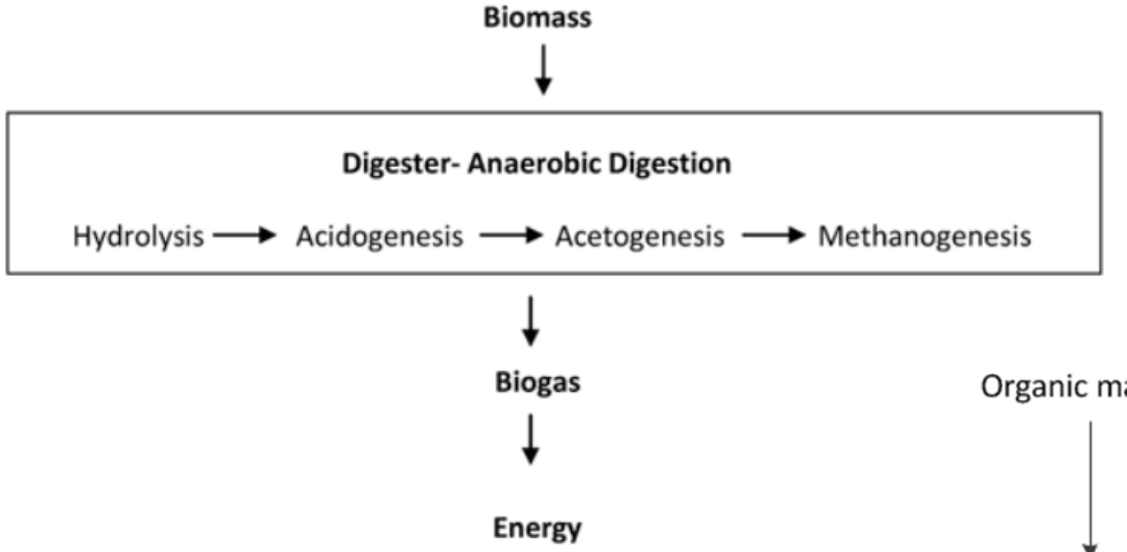
- Storable
- Transportable
- Flexible

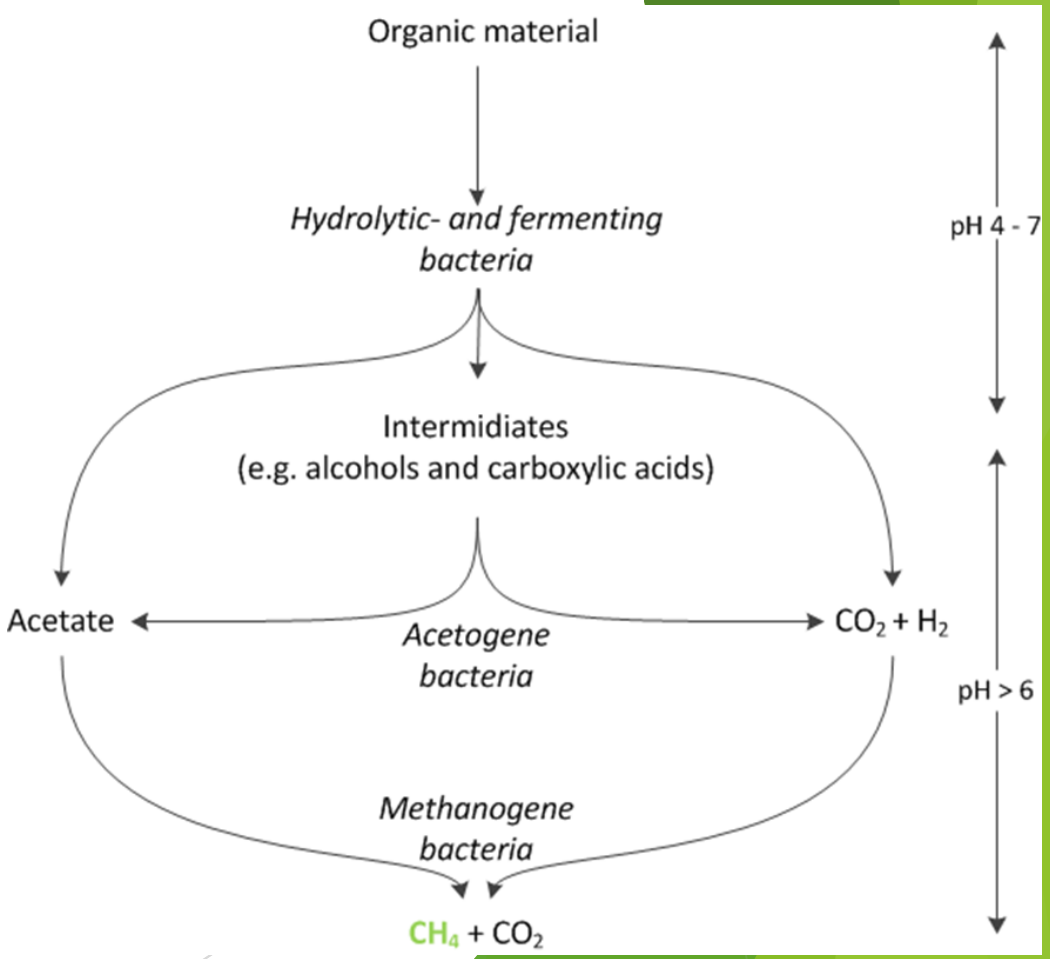
And it is **recirculation at its best**, connecting production, consumption, waste handling and more.

Biogas is the simplest saturated hydrocarbon.

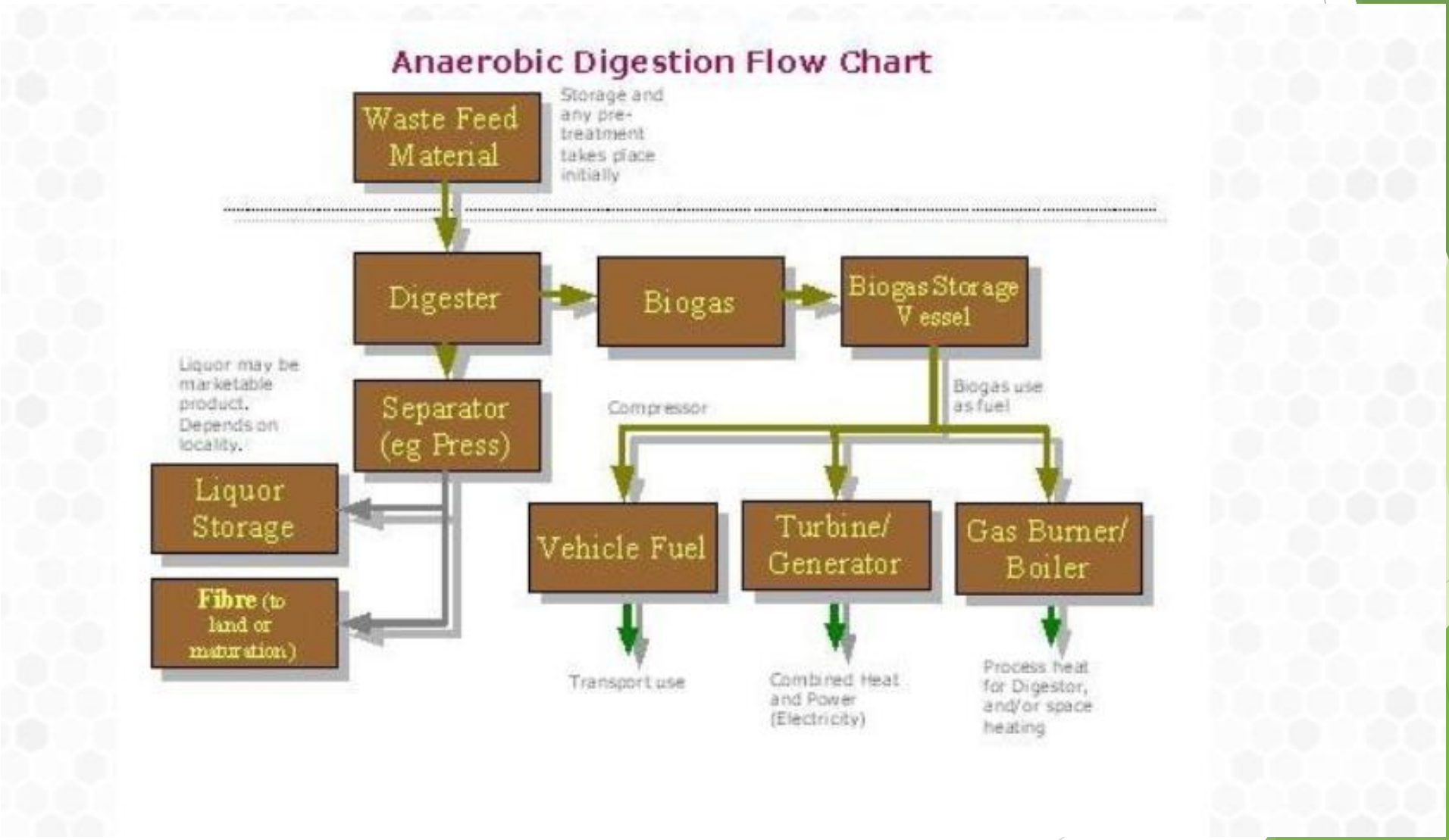
CH4 as such is a building block, and is a first step in creating complex gasses or more advanced liquid biofuels, for instance using P2X.

Chemical process





Physical process



Source: www.anaerobic-digestion.com

Gas development in Denmark

As in most countries, development of the energy sector has been based on necessities and opportunities.

In 1853 the first gas production took place in Denmark in Odense, based on coal, to produce the gas. This is no longer done in Denmark (although we aren’t free of coal yet), and close to 40% of all electricity worldwide is still coal based (IEA).

Fossile and import based for many years, but oil crisis's gave paved way to both a large gas production from the North Sea, establishment of a high quality grid, as well as a push to biogas. Initially, biogas was not only driven by the energy production but by the extra yield in farming the digestion could achieve.

Biogas DK – Version 1.0

In the mid-80's around 20 larger biogas facilities were established, often with financial guarantees from central- or local government and based on farm residues.

These contributed to the creation and accumulation of Danish know-how and best practices on biogas technology.

The biogas was typically used in a gas engine for district heating, giving both revenues on electricy and heat – at least some part of the year.

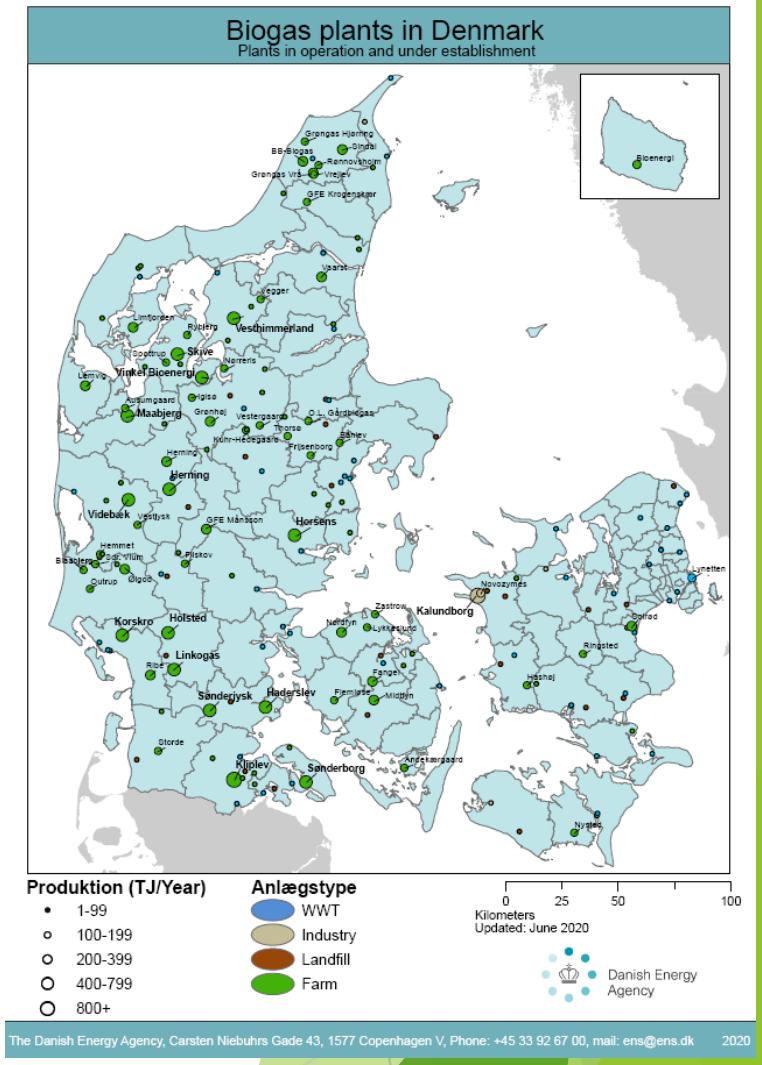
- It is a typical issue for biogas to district heating worldwide, that the summer-offtake in terms of heat either limits the maximum production or causes a loss of energy in the summertime.

Biogas in DK – V. 2.0

- Biogas was initially (with high energy prices) percieved as a competitor to natural gas, but the development of the sector stalled in the end of the 90's due to financial distress.

- Greater and greater focus on sustainable fuels and energy, and in 2012, new regulation led to a surge in **injection to grid of cleaned biogas (upgraded)**, and as such considerable quantities of green biofuel is now being brought to the European market via the distribution- and transmission grid.

- In total, there is around 170 biogas facilities in Denmark currently, and roughly 30 of these inject to the grid. Also, the ones injecting, are by far the largest, basically exploiting the fact, that the grid always has room for more.



Technology choice

Denmark can be said to no. 1 in several areas.

- Green gas and green electricity are both such.
- Waste amounts per capita is another (Because we have had an easy solution in burning it all?).
- Pigs per capita a third.

DK has app. 6 mill. inhabitants, but produce yearly just short of 30 mill. pigs. And at any given time, there is roughly 1.5 mill. cows as well.

- Hence, we are blessed with massive amounts of animal waste…
- It is only natural, that our biogas production is largely based on the waste and nutrient issues, these productions lead to.

Wet, Dry or something **In-between**

Anaerobic digestion under different circumstances

Fundamentals

Wet Anaerobic Digestion

All input material must be pumpable.

Average load 8-10 % DM at any given time (in first digestion step).

As such, gas production happens in digestion tanks.

Impurities are (without add-ons) removed prior to digestion.

Dry Anaerobic Digestion

No input material is pumpable.

Average load 25-40 % DM at any given time plus a volume of water or slurry, which is evaporated. No digestion tanks.

As such, gas production happens in process modules.

Impurities are (without add-ons) removed after digestion.

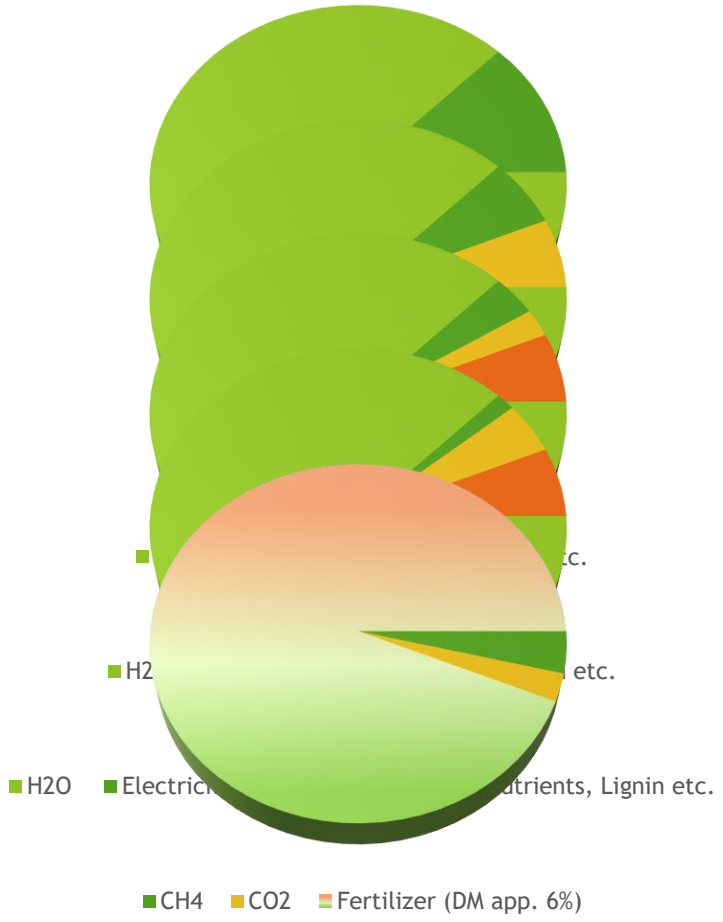
Pros and Cons

Wet is suitable where abundance of wet waste streams but requires a lot of transport.

Dry is a very simple setup! Has limitations in terms of land usage, and care should be taken with regards to methane leaks.

Different paths to digestion…

Wet Anaerobic Digestion



Input

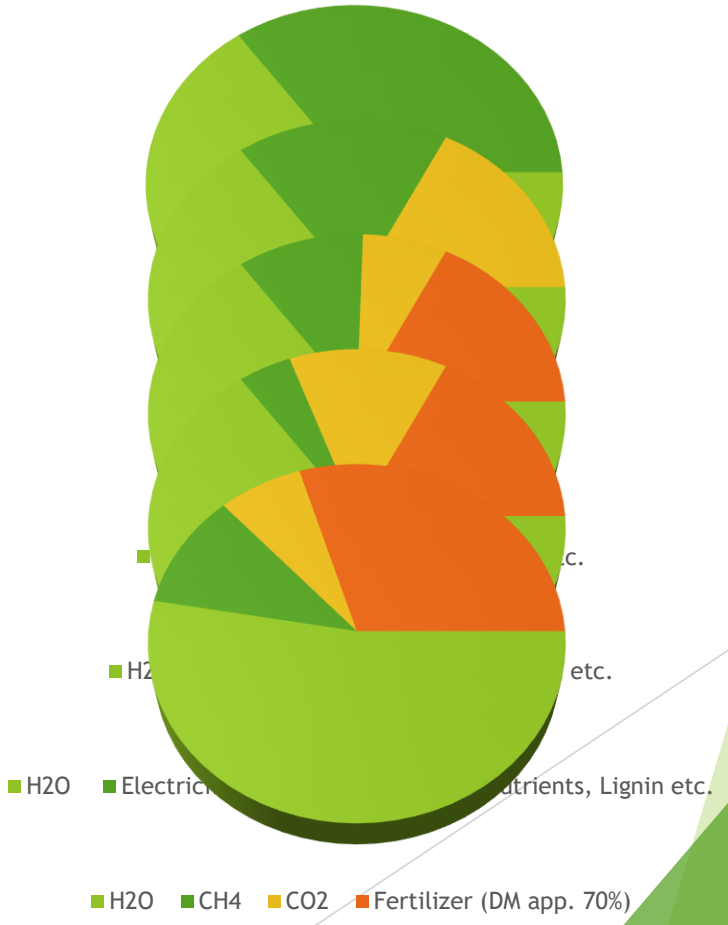
Dry Matter Split

Carbon Split

Energy Split

Output

Dry Anaerobic Digestion



Advanced digestion

Advanced Wet AD

Identical until and including digestion but DM load is completely flexible, and reactors may be of a different build.

Digestate is separated.

Dry part may be used for land application directly or composted first.

Nutrients may be recovered from wet part, and water reused or sent to purification.

Advanced Dry AD

Input material can be pumpable but does not have to.

Average load 25-40 % DM at any given time in process modules, AND 2-3% in digestion tanks.

Digestion happens primarily in digestion tanks (70-90%) and remaining in process modules.

Impurities are (without add-ons) removed after digestion.

Pros and Cons

Advanced Dry is suitable in areas where residual waste after digestion should be minimized. From a chemical perspective it utilizes different PH requirements of the processes. May have limitations in terms of land usage and to some extent CAPEX.

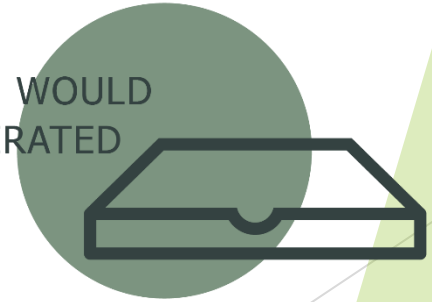
Advanced wet can be applied almost anywhere since it is completely flexible in terms of input. However, it will require investment into more advanced techniques like RO, UF or membrane reactors.

Robustness and flexibility

BIOPLASTIC BAGS, WHICH ARE SEGREGATED IN OTHER PLANTS

WASTE PAPER FROM THE KITCHEN, SUCH AS COFFEE FILTERS, TEA BAGS, AND TISSUE PAPER

PIZZA BOXES, WHICH WOULD OTHERWISE BE INCINERATED



POTTED PLANTS AND MULCH

General pitfalls

Like any other industry, biogas and bioenergy can be produced in very good ways, as well as less good ways. Five essential points are:

- **Beware of methane leaks**! Methane is roughly 30 times worse than pure CO2 in terms of GHG effect.
- Secondly, use of digestate should still be monitored! It yields roughly 10% higher produce in fields compared to animal waste directly, but if overly supplied still can give problems with washing out.
- **Methane itself doesn't smell.** But animal waste, food waste and H2S does! So keep the smell indoors and clean the ventilation.
- Biogas should be based **exclusively** on waste ressources. Don't base production on energy crops.
- Biogas and biorefining has many positive externalities that are valuable. Making the gas pay for them all, makes it appear unfairly costly.

Different digestion methodologies for different markets

Wet Anaerobic Digestion

If large quantities of wet organic waste streams are abundant **locally** – e.g. slurry and manure, Wet AD (advanced or standard) may be preferable.

Transport should be highly efficient i.e. at least 30 tons payload if a standard solution is applicable.

This typically means, that farming must highly industrialized, and at the same time used to handling liquid fertilizer. If not, an advanced wet solution could be applied, having nutrient extraction and concentration.

Dry Anaerobic Digestion

If organic waste is more abundant in dryer streams, e.g. food waste, source separated MSW, crop residues, an advanced dry solution may be preferable.

This is also the case, if water is a scarcer resource, or if transport or fertilization with large quantities of wet fertilizer is problematic or uncommon in a market, and advanced wet AD is too complex for the market.

Highly industrialized or highly developing

Wet Anaerobic Digestion

Input material is in general more homogenous, leading to a more easily adapted industrialized standard, including higher flows at the cost of more machinery and pumps to maintain. The latter is not a problem if the cost of capital cost is low and machinery spares are easy to obtain.

The facilities will typically be located near farm-land to reduce transportation.

In short, it can be claimed, that efficient wet AD requires highly developed markets and logistical opportunities.

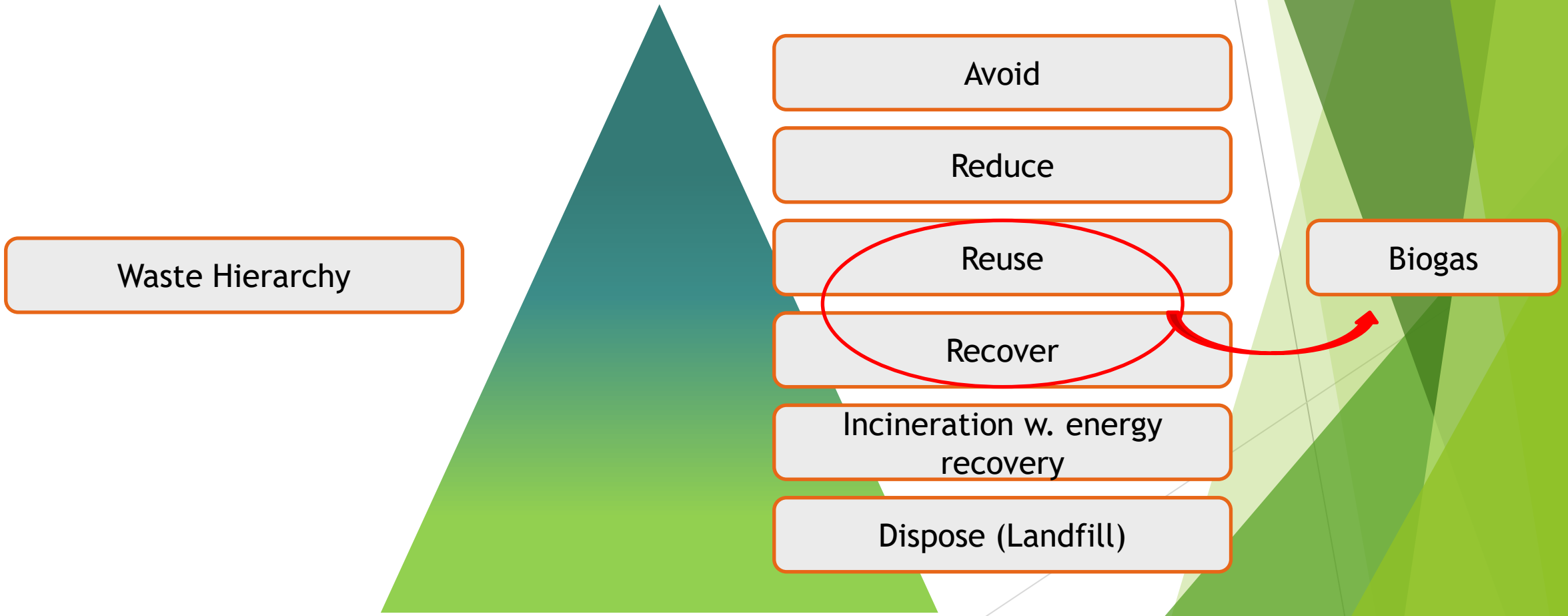
Dry Anaerobic Digestion

The input materials organic quality may vary to whatever extent the market supplies and may as such be quite inhomogeneous. The simplicity of the facilities yields simple opportunities for replacement of parts etc. and requires little of local logistical circumstances.

The facilities are often found near landfills that are being slowly phased out.

Dry solutions can be better suited, to handle markets that are still developing rapidly.

Biorefining leaps upwards in the Waste Hierarchy



Biogas production is flexible

Biogas production in itself is easy… Put organic matter in an airtight container and allow it to heat a bit, and eventually you will have biogas.

Almost anything goes in terms of input, as long as it is organic. But it is all about doing it efficiently and fit the process to the input. Any and every region have different resources available, as well as of course differing systems of collection, applications, policies etc.

This means, that there is no “one size fits all”. Solutions must be adapted to local circumstances.

The way I see it, bioenergy facilities of today are a bit like LEGO®; we have a lot of different building blocks which we can combine in different ways to result in different products to fit any market.

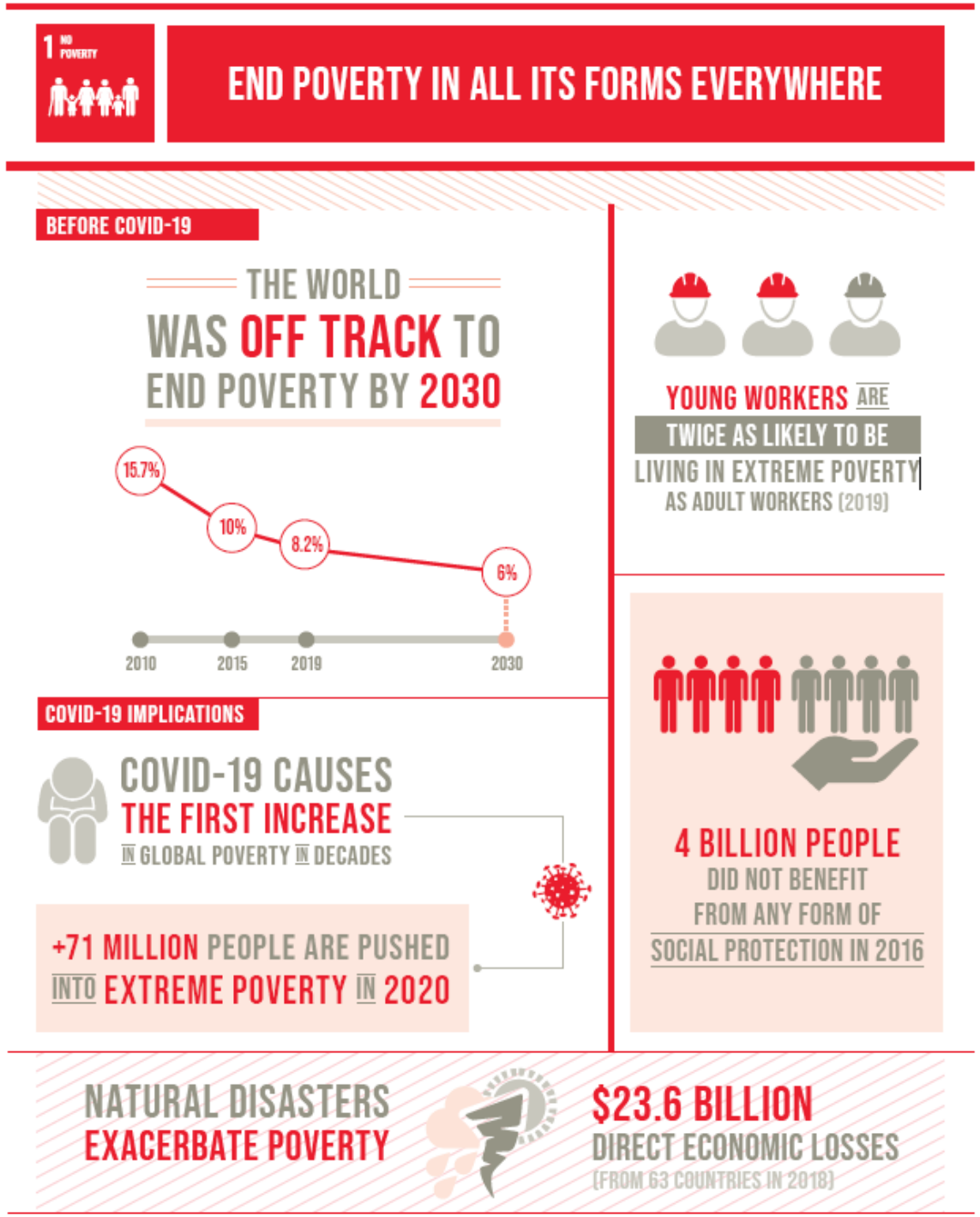
Concluding remarks

Latest report from UN on the SDGs reveals, *that the world is **not** on track to achieve the global Goals by 2030. **Before the COVID-19 outbreak, progress had been uneven, and more focused attention was needed in most areas**. The pandemic abruptly disrupted implementation towards many of the SDGs and, in some cases, turned back decades of progress.*

And further, *The COVID-19 pandemic is highlighting the urgent need for affordable and reliable energy … At the same time, the crisis is certain to stymie efforts towards Goal 7… In addition, plummeting oil prices are likely to discourage growth in renewable energy.*

I.e. not a very encouraging read, but all the more reason to push harder for sustainable developments around the globe.

Source: https://unstats.un.org/



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Extras

Solum®

The Solum Group was founded in 1986, thus having more than 30 years of experience in recycling and circular economies. Today, almost all types of waste are treated, except toxic waste. Circular economy and sustainability is, and always has been, the core DNA of the company.

The group is Demarks largest supplier of compost, growth media and grass nurturing products. We create value by integrating waste handling, bioenergy production, nutrient recirculation and bioenergy production as well as counselling regarding soil improvement products and sustainability. **The group's activity is dispersed in all of Denmark, several of the Nordic countries, and in projects around the globe.**



Aikan®

In the beginning of the millennium, the first Aikan® installation was created. Aikan® is a combined waste-to-X technology for food waste and other organic material. The technology is specifically designed to handle complex dry waste streams but can also handle wet organic material. Nevertheless, the technology is known as Dry Anerobic Digestion. The Danish installation near Copenhagen is 100% owned by Solum A/S.

Aikan® is waste handling, recirculation, climate protection and bioenergy without the need of moving large amounts of water. Hence, the amount of transport pr. produced is much smaller than traditionally wet-based technologies. **As such, Aikan® yields larger CO2-equivalent reductions than wet digestion technologies as well as creating a cleaner fertilizer.**