Friday, 27 November 2020
10:00 – 11:30 CET

CAN WASTE-TO-ENERGY BECOME CARBON NEGATIVE?

A conversation with

- David Kearns, Global CCS Institute
- Jannicke Bjerkas, Fortum Oslo Varme
- Maria Velkova, European Commission

Moderated by

- Patrick Clerens, ESWET

ESWET Members

CAN WASTE-TO-ENERGY
BECOME CARBON NEGATIVE?

PRESENTATIONS

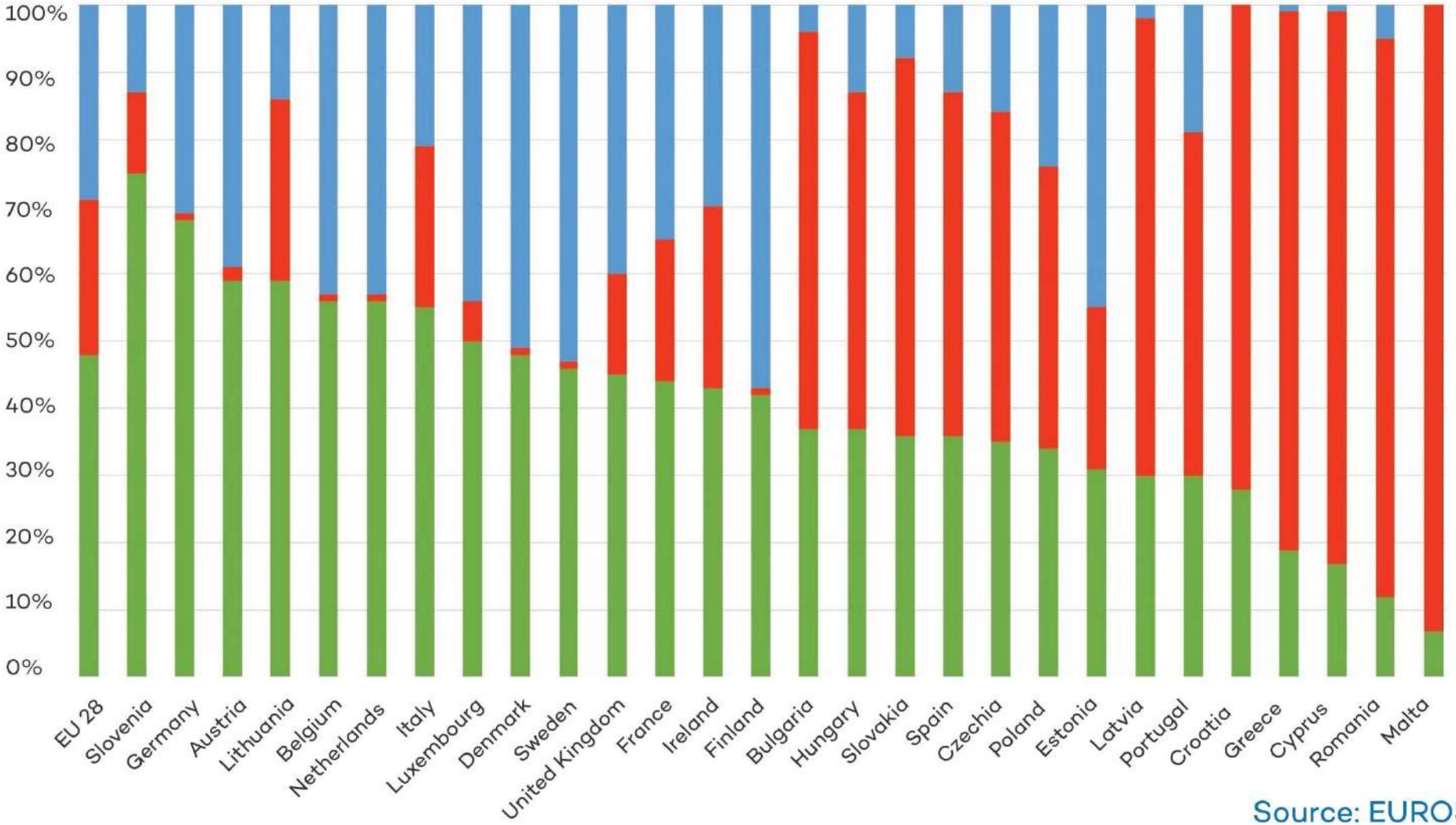
- **Patrick Clerens, ESWET**
  Municipal Waste Treatment in Europe
- **David Kearns, Global CCS Institute**
  Overview on CCS and Waste-To-Energy
- **Jannicke Bjerkas, Fortum Oslo Varme**
  From Waste-to-Energy to negative emissions
- **Maria Velkova, European Commission**
  EU-funding opportunities for CCS and WtE

How is Municipal Solid Waste treated in Europe?

Patrick Clerens,
ESWET Secretary-General

2018

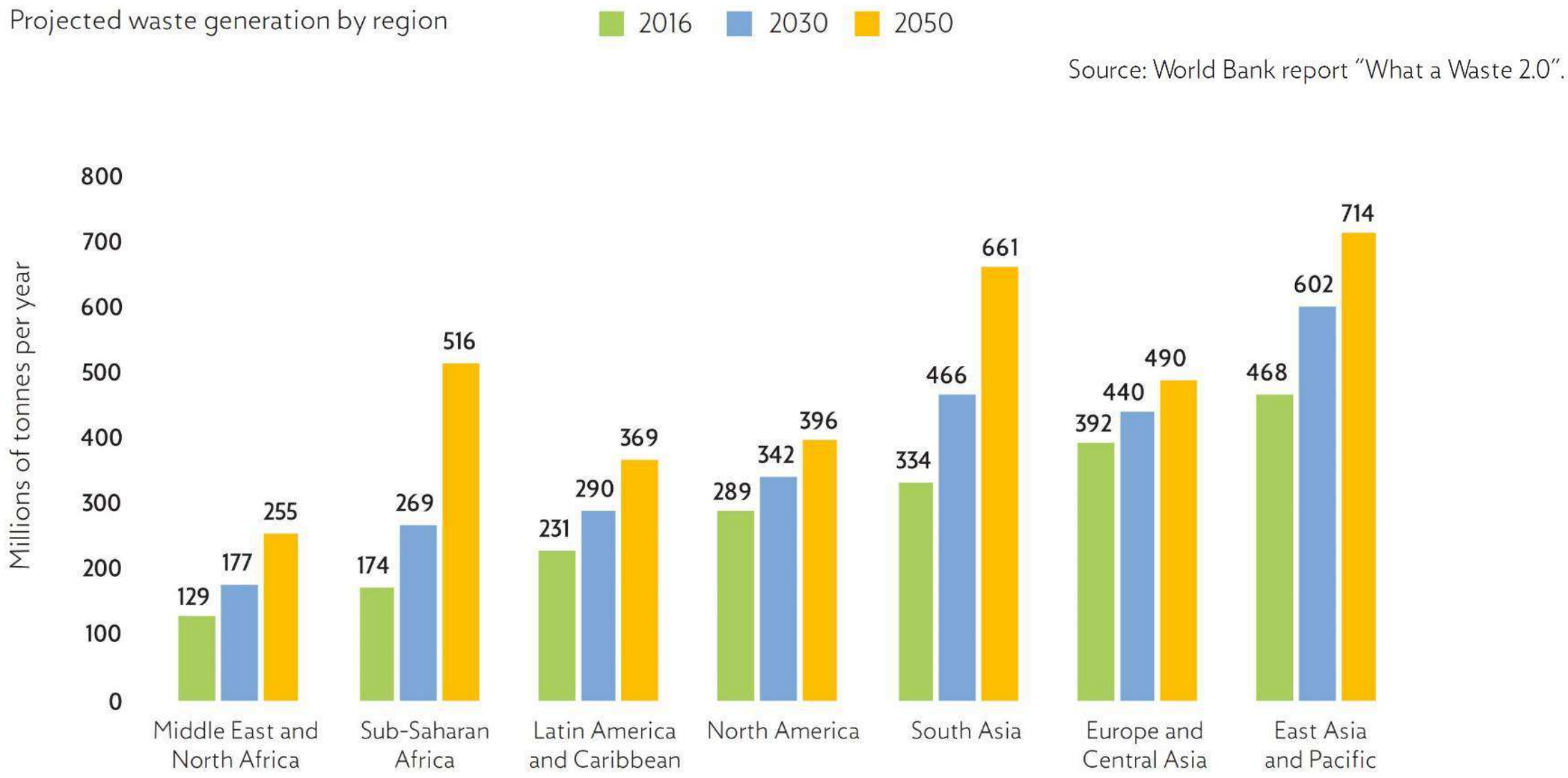
EU-28: 48% Recycling | 29% Waste-to-Energy | 23% Landfills



Source: EUROSTAT

Waste is a global problem

Projected waste generation by region



Source: World Bank report "What a Waste 2.0".

2019

70% of waste generated worldwide is dumped!

2050

Global waste generation will increase by around 60%

Residual waste

- Not every waste is recyclable – for many reasons: recycled too many times, polluted waste, made of composite products…
- Waste which is not suitable for recycling is called residual waste

Then, what happens to this residual waste?

Example of waste collection in Brussels, Belgium

Landfilling comes with an environmental cost:

- Landfills are responsible for methane emissions, and methane is a greenhouse gas up to 84 times more potent than CO2 over a 20-year period!

- Landfills risk to pollute soil and water; they occupy land and emit odor nuisance

- Waste dumped in landfills does not generate any added value!

The advantages of Waste-to-Energy

- In Waste-to-Energy plants, residual waste is **used as a resource**:

  - **Recovery of energy** turned into electricity, heat and steam;

  - **Recovery of secondary raw material** re-injected in the economy.

- Waste-to-Energy is **complementary to recycling.** Waste-to-Energy treats waste that cannot be recycled or re-used.

Global CCS Institute

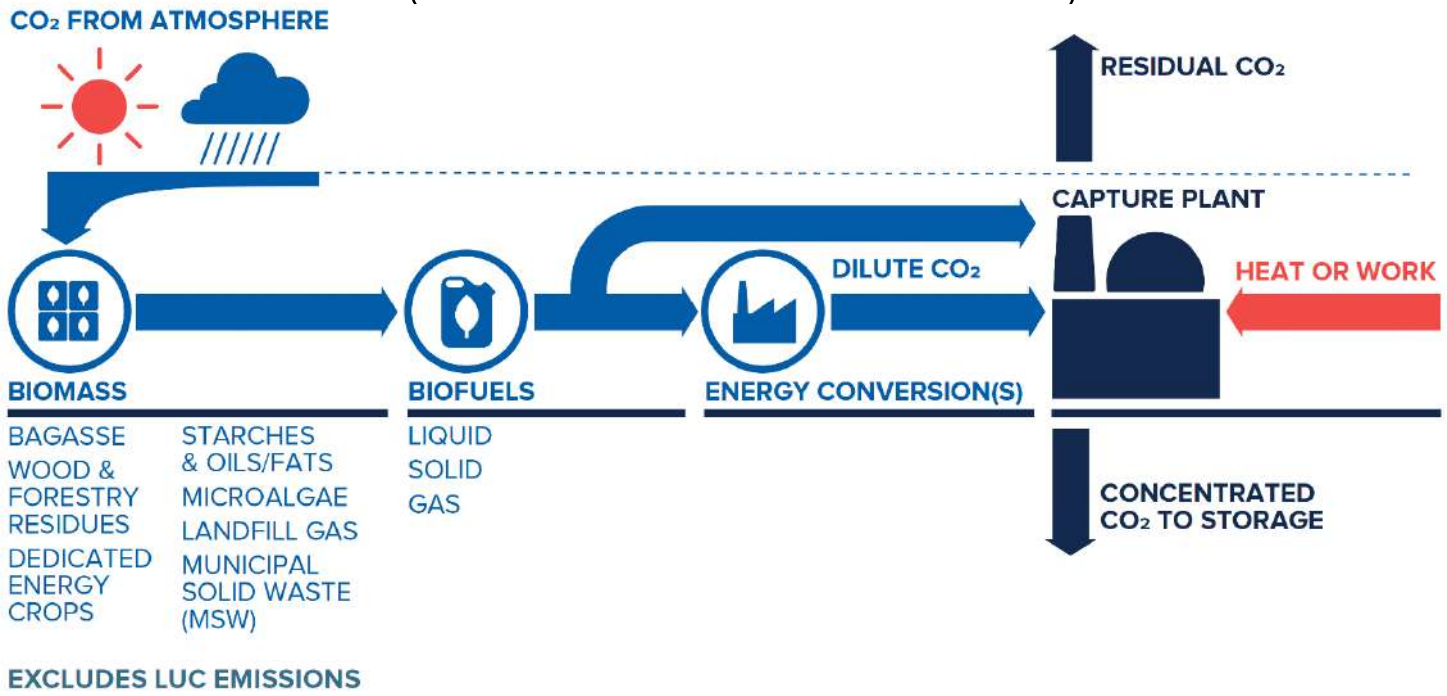
David Kearns – Senior Consultant, CCS Technology

ESWET

European Suppliers of Waste-to-Energy Technology

Waste to Energy with CCS - overview

- Carbon Capture and Storage (CCS) is a suite of technologies to separate CO_2 from emissions streams (capture) and store them safely underground to keep CO_2 out of the climate system.
- Bioenergy with CCS (BECCS) is special because it offers potential for “negative” emissions.
- A way to cause net removal of CO_2 from the atmosphere (Carbon Dioxide Removal – CDR).
- WtE is a form of BECCS, though it does also combust fuel of fossil origin. If fraction of CO_2 captured exceeds the fossil fuel fraction of fuel, the process becomes carbon negative.



Capture and storage – how does it work?

Flue gas CO_2 concentration in the order of 10-15%. Diluted with N_2, residual O_2, water and other trace components. Needs to be >95% for compression and storage.

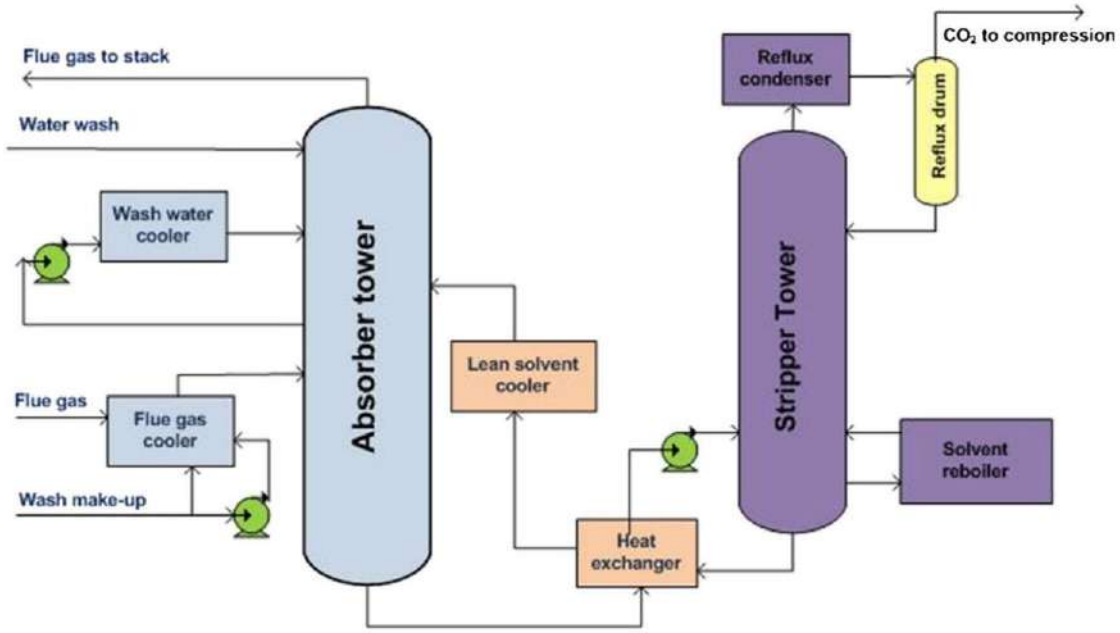
"Capture" means to separate and purify CO_2 from rest of flue gas.

Solvent (absorption) based CO_2 capture best suited to WtE applications.

Solvents typically an aqueous amine solution – e.g. Monoethanolamine (MEA), monodiethanolamine (MDEA) or proprietary solvents.

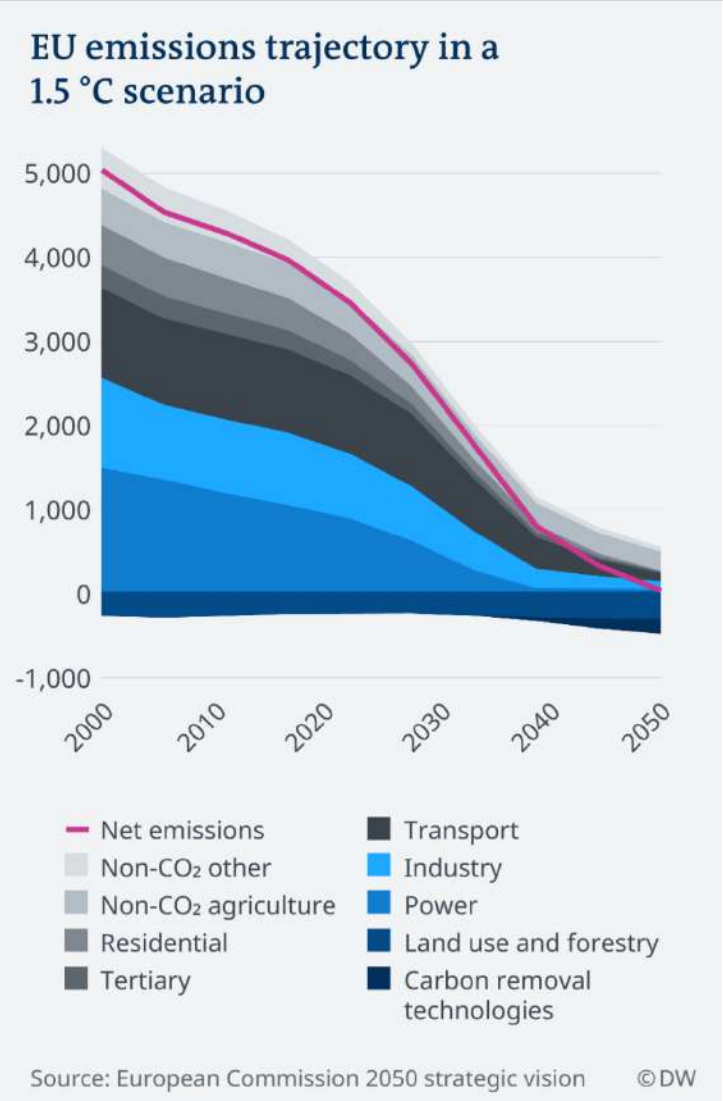
Process requires energy input – electricity for pumps and steam to regeneration solvent (stripper reboiler).

Also downstream – transport is either dense-phase (>74 bar) or liquid – both require electricity for CO_2 compression or refrigeration.



Sabouni, Rohani and Kazemian, *Env. Sci. Poll. Res* (Dec 2013)

Negative emissions – the unrelenting arithmetic of Net Zero



Even by 2050, a net zero future requires negative emissions to balance residual positive emissions from hard-to-abate sectors (aviation, cement, steel, industrial heat etc.).

Also need to the (smaller) offset life cycle emissions of solar & wind developments.

Options:

- Afforestation / reforestation.
- Direct Air Capture (DAC)
- Bioenergy with CCS (BECCS)

All these options will be needed. WtE sector is a well placed industry for BECCS because:

- Technology available today.
- Not limited by land availability.
- Biomass supply (MSW) is not only available but will continue to grow to 2050 with urbanisation and economic development.
- Also prevents future landfill methane GHG emissions.

Fortum Oslo Varme’s CCS project

From waste-to-energy to negative emissions

Jannicke Gerner
Bjerkås Director CCS

Fortum Oslo Varme

LONGSHIP; CCS VALUE CHAIN

Infrastructure for Europe

Paris agreement
- Below 2° C
- **CCS key technology**

Carbon Capture in Oslo

- Goal to capture about 400 000 tons CO_2 per year, 90% capture of CO_2
- CCS at Waste-to-Energy plants will capture both fossil and biological CO_2 (50 % BIOCCS)
- CO_2 transport to port via emission free trucks
- Successful pilot testing on real flue gas; 5500 test hours, up to 95 % CO_2 capture
- Technology supplier with full-scale experience (Shell's amine), EPC contractor TechnipFMC

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Waste is one of the world's biggest climate challenges

- **2.2 billion tons of waste produced yearly; 5% of global emissions is from household waste alone**
- **Landfilling has to reduce, and waste-to-energy is the best solution for waste that cannot be recycled**
- **Significant BIO-CCS potential; waste-to-energy with CCS can contribute to achieve negative emissions**
- **EU's targets for recycling and reduced landfills; 40 mill. tons missing capacity of waste-to-energy**
- **New WtE-facilities with integrated CO2 capture**

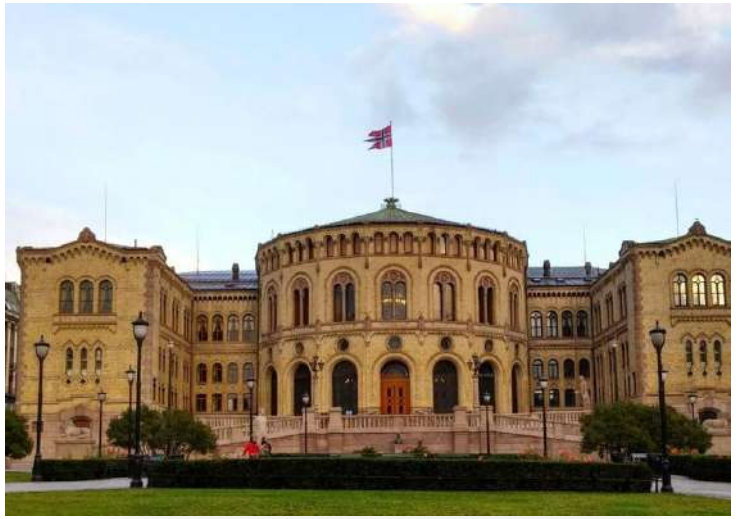
The Government launches «Longship»; State financing of CCS in Norway

- Support to CO2 capture at Norcem (cement) and to the transport and storage part of the project; *Northern Lights*

- **Conditional support** to the capture project at Fortum Oslo Varme provided additional funding from Innovation fund or other sources

    - CAPEX support of **190 million euros (MNOK 2000)**
    - OPEX support of **95 million euros (MNOK 1000) over 10 years**

- IF: 311 projects applying for 21,7 Bill EURO (70 projects advancing to phase 2)



INNOVATION FUND

Driving clean innovative technologies towards the market

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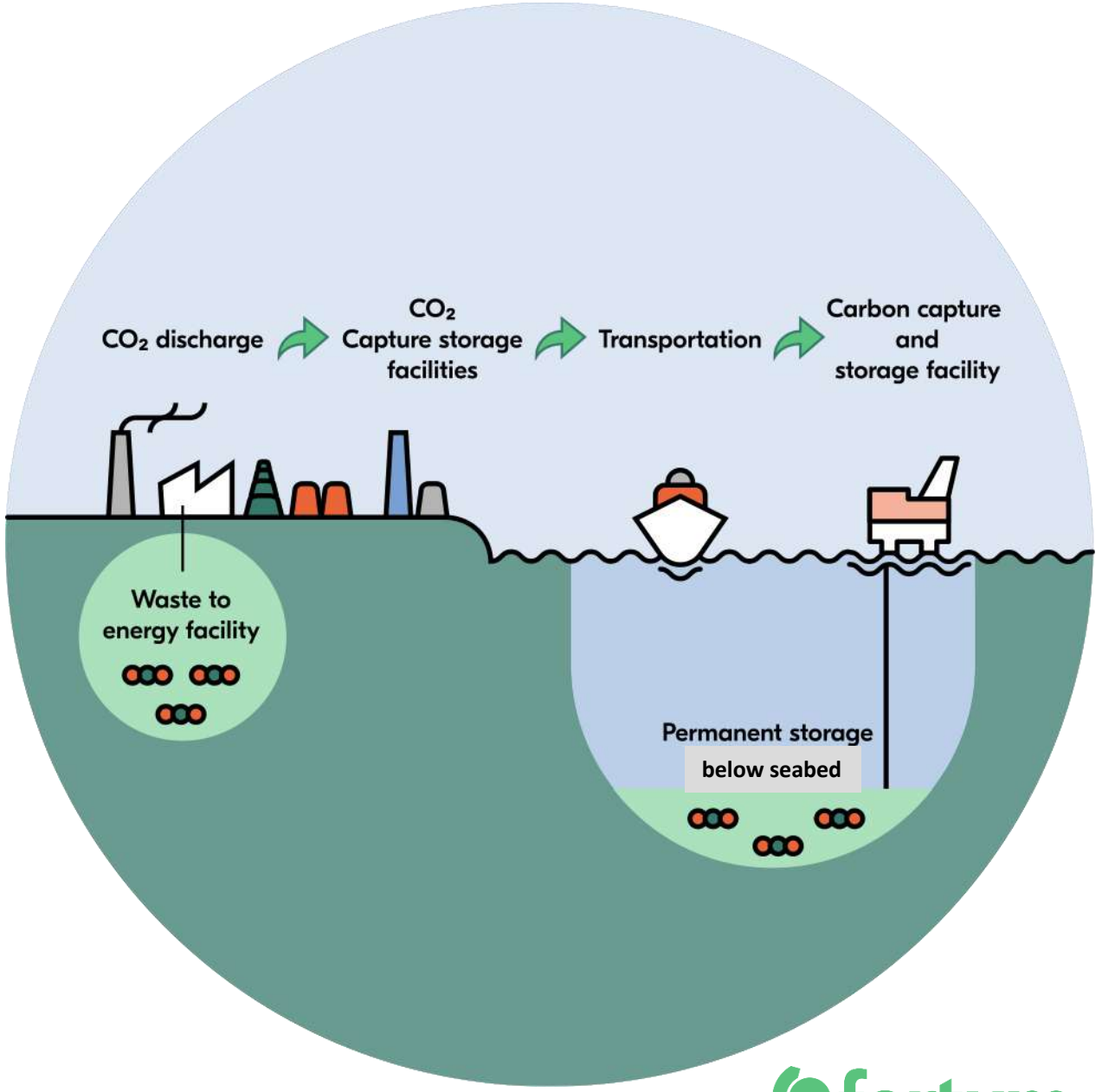
CCS from Waste to Energy (WtE); key take-aways

- CCS is a **safe, proven and effective** solution to mitigate climate change
- CCS on WtE will give **negative** CO2-emissions (**BIOCCS**), and can neutralize other emissions that are difficult to reduce/remove
- **Cities** can cut emissions and mitigate climate change from waste handling, as part of sustainable city solutions



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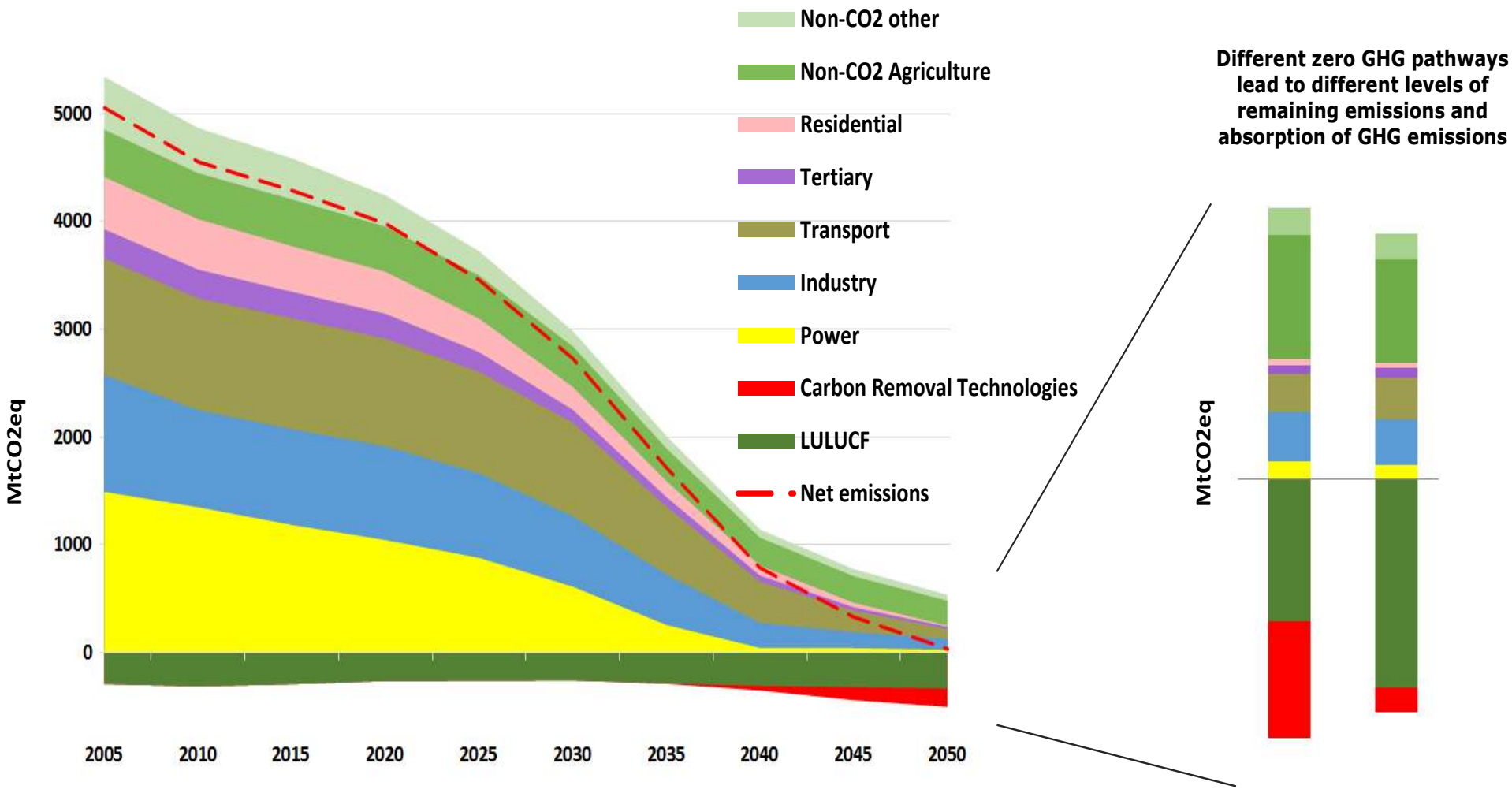
EU-funding opportunities for CCS and WtE

ESWET CCS & WtE event

27 November 2020

Maria VELKOVA – DG Climate Action

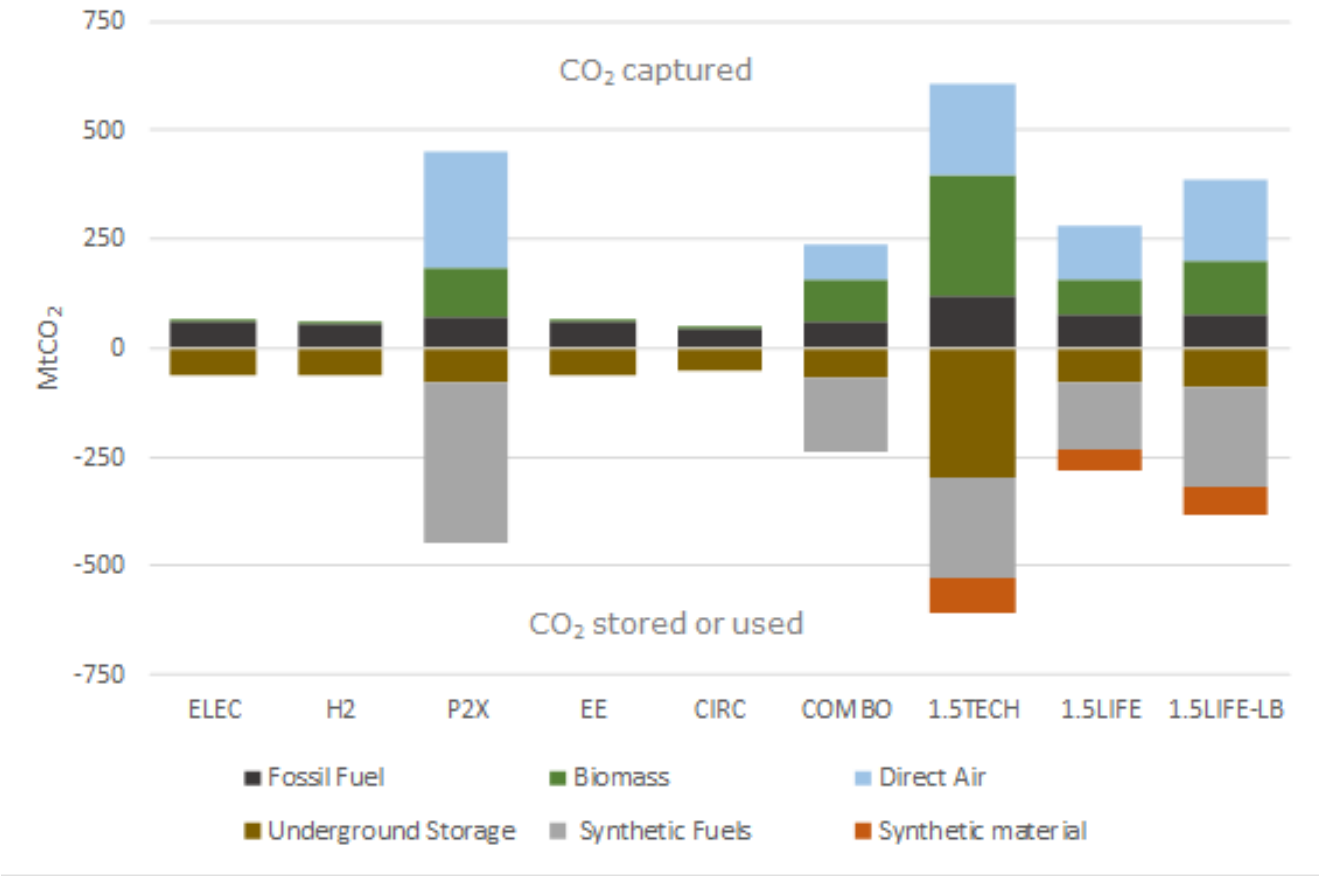
Vision for a Clean Europe by 2050



Different zero GHG pathways lead to different levels of remaining emissions and absorption of GHG emissions

European Commission

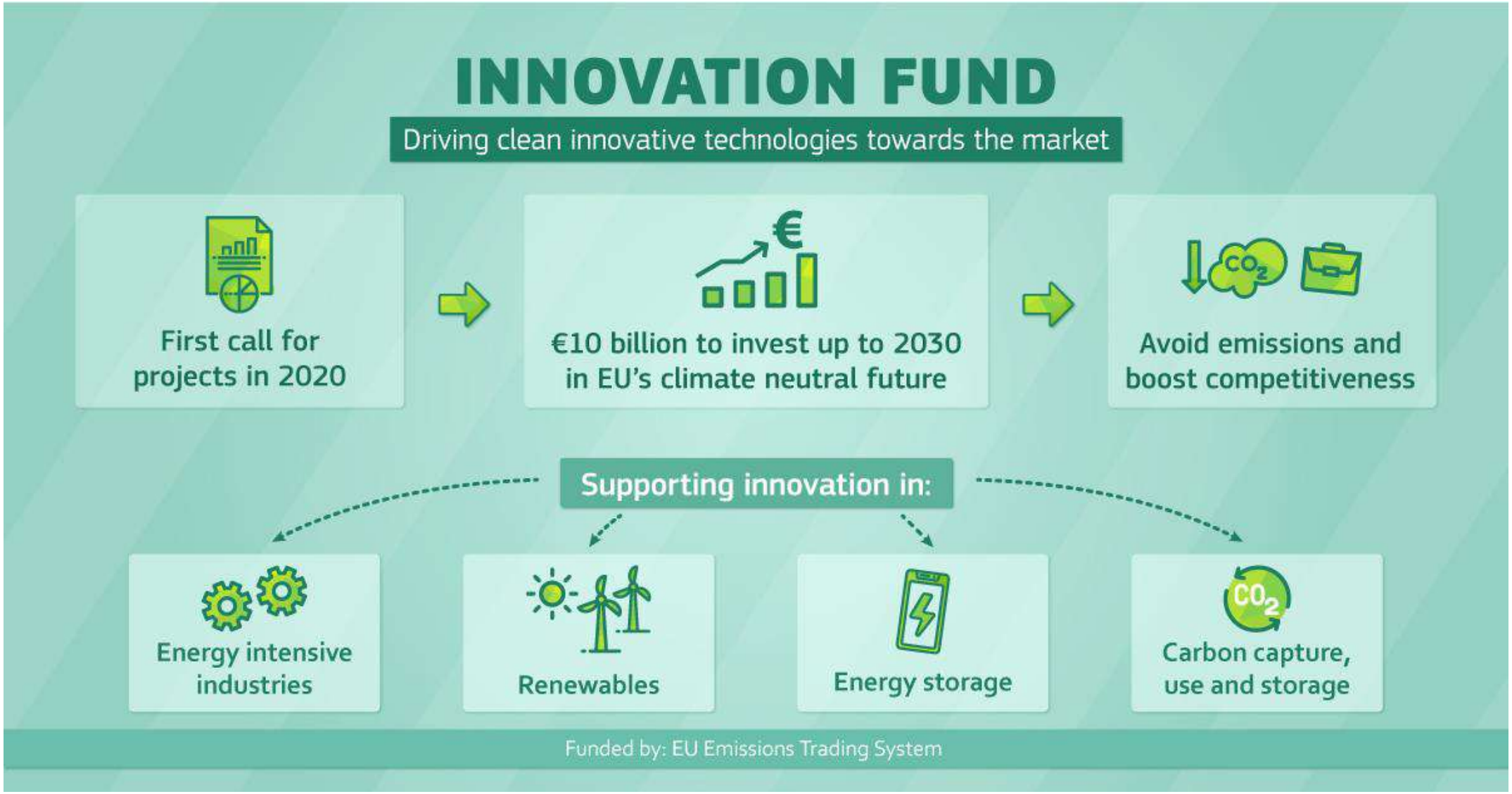
Scenario Analysis Results for CCUS Vision for a Clean Planet by 2050



- CCS will be required to reduce emissions of any remaining fossil fuels use (power sector, industry)
- Necessary for certain hard to decarbonize industrial processes
- CCS combined with biomass is required to generate negative emissions if we are to achieve climate neutrality
- Storage in materials (e.g. in plastics) is also seen as an option
- CCU fuels in some scenarios

EU Policy for CCUS

- Regulatory certainty (2030) and long-term perspective (2050)
- CCS Directive: ensures CCS is done safely for the environment and human health
- EU ETS: allowances do not need to be surrendered when CO2 is geologically stored but WtE mostly not covered and biogenic CO2 excluded
- CCU fuels are encouraged through the Renewable Energy Directive (RED2) as of 2021
- EU certification systems based on the GHG performance for low-carbon basic materials and for carbon removals will be developed: CCU, BECCS
- Dedicated funding: Horizon Europe, Innovation Fund, Connecting Europe Facility



https://ec.europa.eu/clima/policies/innovation-fund_en
#InnovationFund

European Commission

Innovation Fund key features

Volume of at least EUR 10 billion until 2030 (at EUR 20 carbon price)	Support of up to 60% of additional costs related to innovative technology	40% of grant disbursed at financial close
Financed from the revenues of the EU Emissions Trading System	Support of additional capital and operating costs (up to 10 years)	60% of grant disbursed during 10-years operating period against GHG emission avoidance
Annual calls for large-scale and small-scale projects (CAPEX < EUR 7.5 million)	Single applicant or consortium	Project development assistance

European Commission

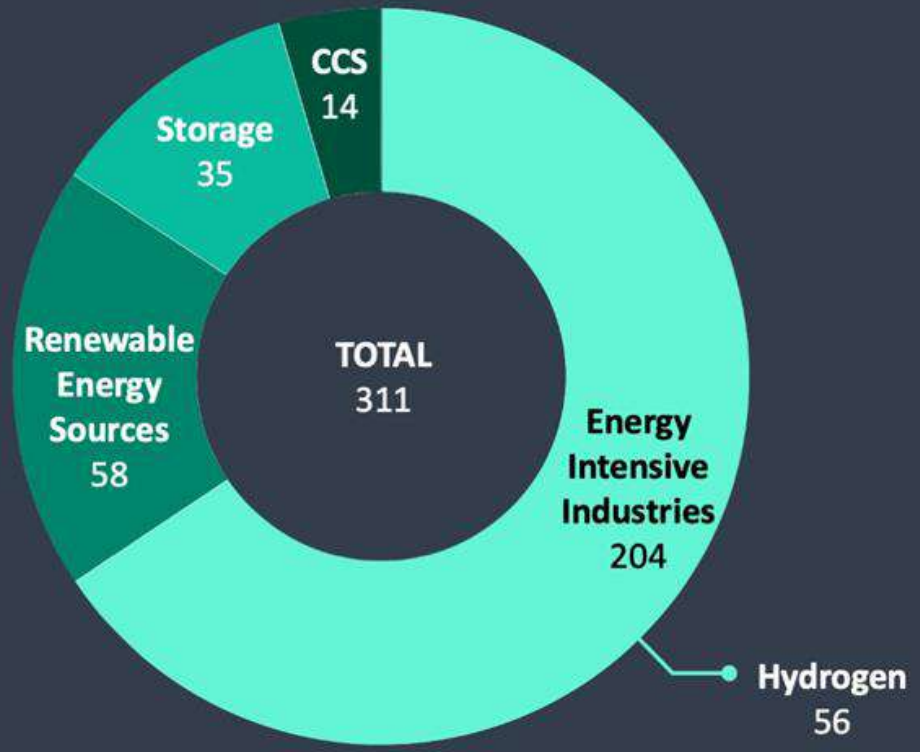
1st call for large-scale proposals applications closed on 29 October 2020

RESULT

311 proposals were submitted requesting in total **€21.7 billion** with the potential to avoid **1.2 billion tCO2e.**

European Commission

Applications to first Innovation Fund call



APPLICATIONS PER ACTIVITY
of which some are cross-sectoral applications

INNOVATION FUND SMALL-SCALE CALL: MAIN FEATURES

Focus on innovative projects close to market

CALL VOLUME

- EUR 100 million (grants)
- Project development assistance

PROJECT SIZE

- Capital expenditure below EUR 7,5 million

ELIGIBLE SECTORS

- Renewables
- Energy-intensive
- Industries and substitute products
- Carbon capture and storage
- Energy storage

GRANT SIZE

- Maximum 60% of capital expenditure

TIMELINE

- Call open 1 December 2020, apply by 10 March 2021!

European Commission

Calendar

Launch of call for small-scale projects
EUR 100 million

1 Dec

9 Dec

Deadline submissions

10 Mar 21

Invitation for grant preparation

Aug 21

3 July — **Launch First Call**
EUR 1 billion

29 Oct — **Submission 1st stage**

Q1 21 — **Invitation 2nd stage**

Q2 21 — **Submission 2nd stage**

H2 21 — **Grant Award**

European Commission

MAIN TAKEAWAYS FROM THE PANEL DISCUSSION AND THE Q&A

Disclaimer

The sentences reported in the following pages summarise the positions and the point of views of the speakers.

They have been attributed to the speakers for the clarity of the readers. However, these sentences cannot be re-used or credited in any way, as they don’t report word by word what was said by the speakers.

For a direct testimony of the event, please watch the video recording:
https://www.youtube.com/watch?v=epHUgMDYSf4&t

What are the costs related to the installation of a carbon capture plant?

Jannicke Bjerkas: The Longship Oslo project's (Fortum Oslo Varme's capture project) total cost is appr. 430 Mill Euros, including both CAPEX and OPEX over 10 years. The project includes specific costs related to the transport of the CO_2 since the plant is not situated at the port (10 km away). There is also a resource perspective: the heat from the capture process needs to be reutilised to recuperate the energy that is given to the capture process. This valuable energy is brought back to the district heating system by using a heat pump, which also brings in extra costs.

Ms. Bjerkas stated that adding cost of CCS technology to the gate fee would about double the gate fee/cost of the Waste-to-Energy process.

David Kearns: The way that costs have worked on CCS projects throughout the worlds shows that they greatly depend on economies of scale. Large projects tend to have lower costs per ton of CO_2 captured than smaller scaled projects. By greatly deploying CCS technology, Waste-to-Energy plants will have an incentive to become bigger as that would be favorable for the economics.
Transport is also an issue for costs, including for pipelines. Pipelines in more densely populated regions, such as Europe, cost more as you cannot build them in a straight line. The costs of compression and refrigeration also need to be taken into account.

As projects are developed and knowledge and experience are shared, costs will decrease. One of the first applications of CCS was in a power generation plant in Canada and the average cost was US$100 per ton of CO_2 captured. A few years later, a similar project's costs in the US were about a third less. The project had a larger scale and lessons were learned from the previous Canadian project.

Mr. Kearns stressed that the technology works and the engineering is doable. The greatest barrier to CCS implementation remains the economics of such projects.

What are the risks of deep-sea underground storage?

David Kearns: There are two reasons why storing carbon under the seabed is safe:

- The CO_2 is stored at a significant depth (2km or more). In the Longship project, it is 3km.
- A lot of work is done to understand the geology of the storage site. A rock with holes in it is preferable. There must also be an impervious rock on top of the place of storage which will prevent the CO_2 from coming back to the surface. This is similar to what you find for natural gas sites.

A lot of CO_2 dissolves into the water but there is no real incentive for it to bubble back out. Moreover, if the rock chemistry is right, the CO_2 will slowly turn into carbonates. If the CO_2 turns into rocks overtime, then the risks diminish.

Jannicke Bjerkas: In the Longship project, the storage space contains a layer of porous stone with a layer of shale above which makes it very stable and prevents the CO_2 from coming back up.

Maria Velkova: In Europe, storage sites containing risks of CO_2 leakage will not be selected. We need to work globally to ensure that the same rigorous appraisal is applied elsewhere in the world.

Which European Fund would be more suited to support the inclusion of CCS technologies in the Waste-to-Energy sector?

Maria Velkova: The Innovation Fund can be suitable and can be combined with other resources to support these developments. But the Innovation Fund can only support up to 60% of the additional capital and operational costs of large-scale projects and up to 60% of the capital costs of small-scale projects. The rest must come from somewhere else. It is also the role of the Member States to support these projects. Given the competition for funding from the Innovation Fund, it will not be able to fulfill the needs of all CCS projects.

Jannicke Bjerkas: It is clear that the first projects of CCS application to Waste-to-Energy will be very costly, including the Longship project. But it is important to look at the value of the measure, not only the cost isolated. It is a cost effective climate measure compared to other climate measures. Ms. Bjerkas is confident that the following projects will see significant cost reductions.

How much energy is used and consumed by the capture plant (specifically in the Longship project)?

Jannicke Bjerkas: No exact numbers available. But steam is being delivered to the capture process and low temperature heat of about 40°C is being reclaimed. The same amount of energy being used for the capture process is reclaimed in the form of low temperature heat.

Do you believe there should be a differentiation between bioenergy produced by Waste-to-Energy combined with CCS and bioenergy produced by cutting down wood directly for this purpose? Should all BECs be treated the same?

David Kearns: It is preferable not to lean on one or the other. Our interest is simply CO_2 and where it ends up. You need to make sure that every bit of CO_2 in the life cycle of the product is accounted for and then everything can be measured on the basis of CO_2 tonnage. There will not be a competition between the two, the world is going to need both conventional BECs and Waste-to-Energy BECs.

Jannicke Bjerkas: It is important to remember that the main purpose of Waste-to-Energy is not the production of energy but the treatment of residual waste which we can't manage otherwise. This was hard to categorise in the Innovation Fund.

Maria Velkova: The Commission always tries to remain technology neutral and tries not to regulate more than what is necessary. Waste treatment is necessary and this biogenic CO_2 will be there and can be captured. Costs will be lower for this type of plant than for plants in which you actually have to increase the costs to produce biomass. The Commission is very insistent on the sustainability of biomass. Biomass must not harm other parts of the environment and that will add further burden to those plants.

We know that the Waste-to-Energy sector is starting to look at CCS application. Are there any specific tools in place that allow to share knowledge and experience to the sector?

Jannicke Bjerkas: A lot of time has been used to focus on sharing information and knowledge and a lot of seminars and webinars have been hosted for this purpose. The Norwegian State has been very specific on this. One of the conditions for their co-funding of the project was that learnings are shared and that the development of CCS technology in the Waste-to-Energy sector is pushed.

The knowledge obtained from the Longship project has been shared in Norway, Scandinavia and Europe.

Maria Velkova: This is also at the heart of the Innovation Fund. The Commission is already planning a knowledge sharing system. This is important as grants will only be given to a certain number of projects. It is feared that the costs will reduce only after the second or third commercialisation of the technology. But they will be reduced if the knowledge is spread and shared to the greatest possible extent.

Of course, there will be a balance as we cannot force innovators to share all of their knowledge. A knowledge sharing event will be organised in 2021 in the context of the Innovation Fund and a knowledge sharing system will be developed as well.

Last remarks by the panelists

David Kearns: The Waste-to-Energy sector has a real opportunity here, in the sense that it is one of the few carbon dioxyde removal opportunities that we have. The industry really needs to grab it with both hands as it will be around in the long-term, even beyond 2050.

Jannicke Bjerkas: I would like to add the importance of the connection to cities infrastructure and cities climate goals, as WtE is often large emission points in cities and CCS on WtE can contribute to substantial emissions reductions enabling the cities or municipalities to reach their climate goals.

Maria Velkova: I hope there are many companies that are getting their projects ready and we are really looking forward to mature projects with significant emissions avoidance from the Waste-to-Energy sector.

CAN WASTE-TO-ENERGY
BECOME CARBON NEGATIVE?

THANK YOU FOR YOUR PARTICIPATION!

For any further information, please write to:

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