7th November 2019, Athens, Greece
ACT Knowledge sharing workshop

Negative Emission in the Waste to Energy Sector: Technologies for CCUS

(NEWEST-CCUS)

newestccus.eu

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NEWEST-CCUS PROJECT PARTNERS

THE UNIVERSITY of EDINBURGH

The University Of Sheffield.

SINTEF

TNO innovation for life

CCSL Carbon Clean Solutions Limited

University of Stuttgart Germany

- 6 partners from 4 countries,
- 3 years, €2.7M total with €2.2M from ACT
- Expert Advisory Group (>15 members) to ensure industrial relevance
- Technology end-users, technology developers, SMEs, trade associations, regulators, policymakers and NGOs

NEWEST-CCUS INDUSTRY PARTNERS

- CEWEP (EU) Confederation of European Waste-to-Energy Plants
- CFF environment (UK) WtE plant owner
- Veolia (UK) WtE plant operator
- CCC (UK) Independent government advisory body
- SEPA (UK) Environmental protection agency - regulator
- SSE (UK) Energy utility
- CCSL (UK) Solvent technology commercial developer
- BIR (NO) WtE plant owner in Bergen
- EGE (NO) WtE plant owner in Olso
- Returkraft (NO) WtE plant owner in Kristiansand
- KRV (DE) WtE plant Operator
- LHOIST (DE) Lime sorbent provider
- REMONDIS (DE) Recycling company
- Steinmüller (DE) WtE engineering
- TWENCE (NL) WtE plant owner

Why Waste to Energy with CCUS?

Waste-to-Energy: Energising your waste

CEWEP Confederation of European Waste-to-Energy Plants

Waste-to-Energy Plants (waste incineration with energy recovery) thermally treat household and similar waste that remains after waste prevention and recycling – generating energy from it.

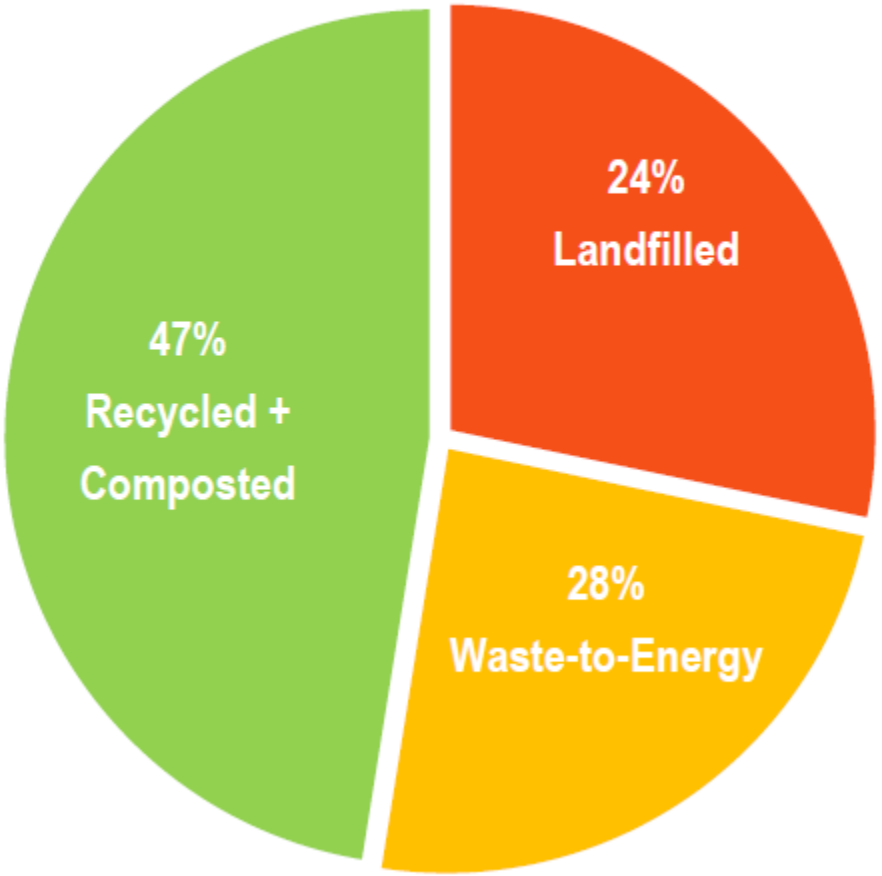
Uddevalla WtE plant, Sweden

CEWEP (2018)

Image courtesy of CEWEP

WASTE IS A VALUABLE RESOURCE

Municipal waste treatment in 2017 in EU28



Waste is a Resource.

However 24% of municipal waste across the EU28 is still landfilled although landfill gases (methane) contribute significantly to global warming.

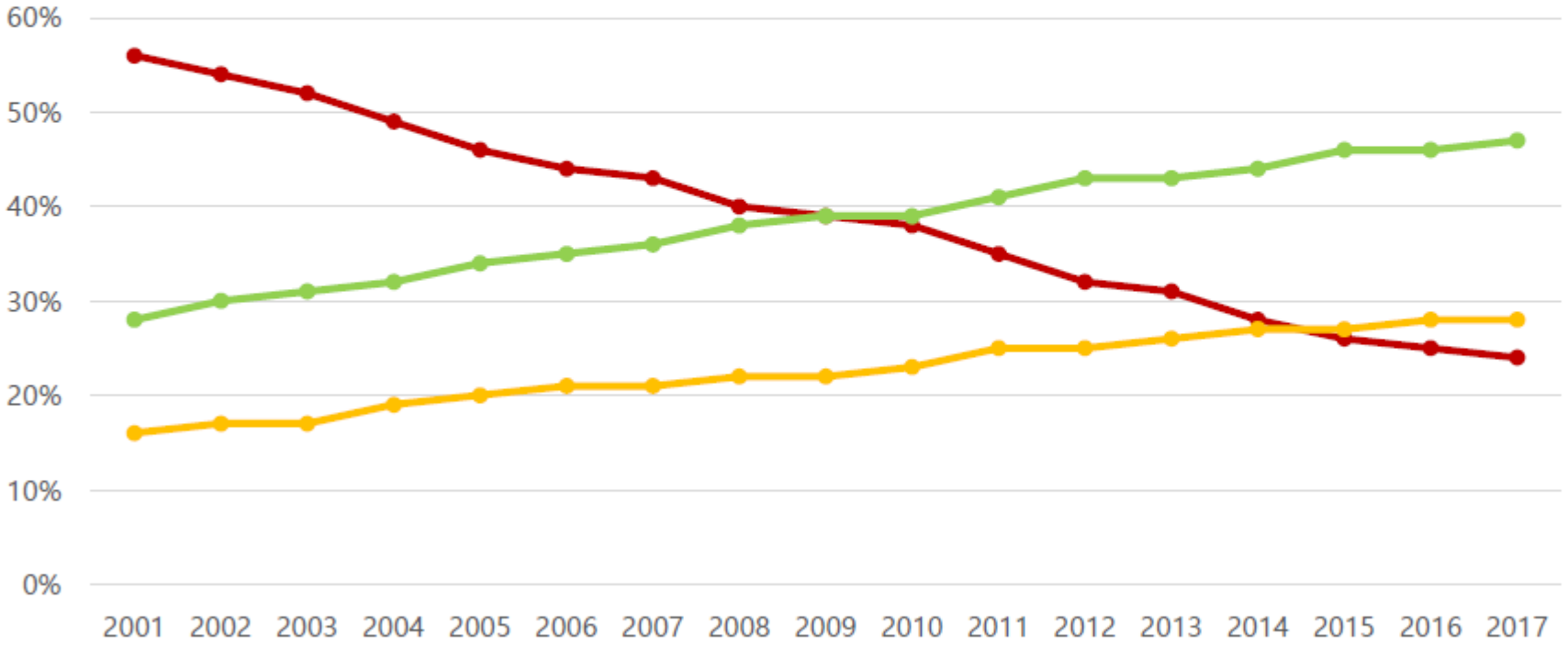
CEWEP (2018)

WASTE TO ENERGY IS GROWING IN EUROPE

Recycling & WtE complementary to divert waste from landfills

EU 28 + Switzerland, Norway and Iceland

Municipal waste treatment trends 2001-2017 EU 28



Legend:

- Landfill -32% points
- Waste-to-Energy +12% points
- Recycling +19% points

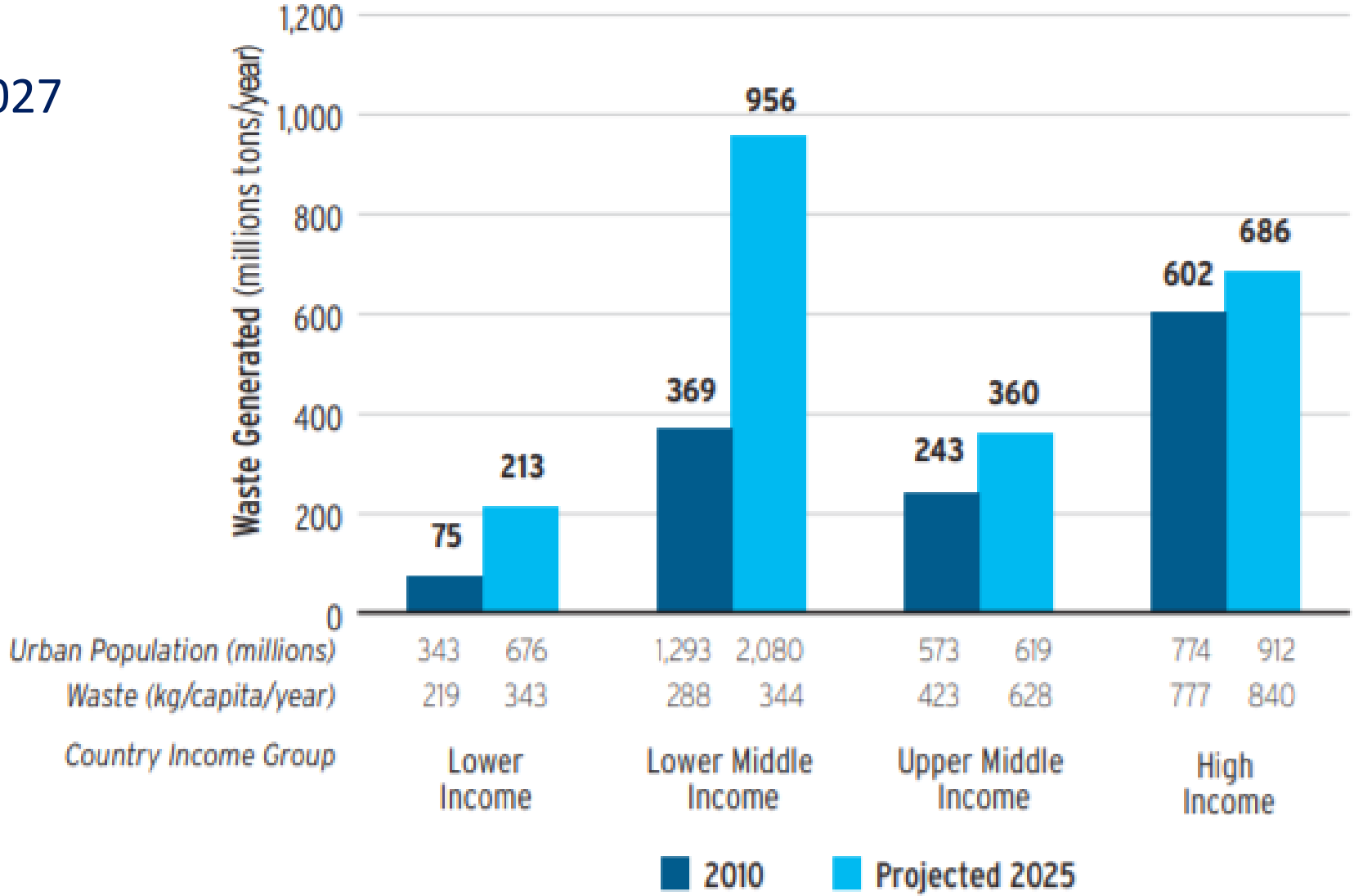
Graph by CEWEP, Source: EUROSTAT 2019

CEWEP (2018)

THE WASTE RESOURCE IS EXPECTED TO GROW GLOBALLY

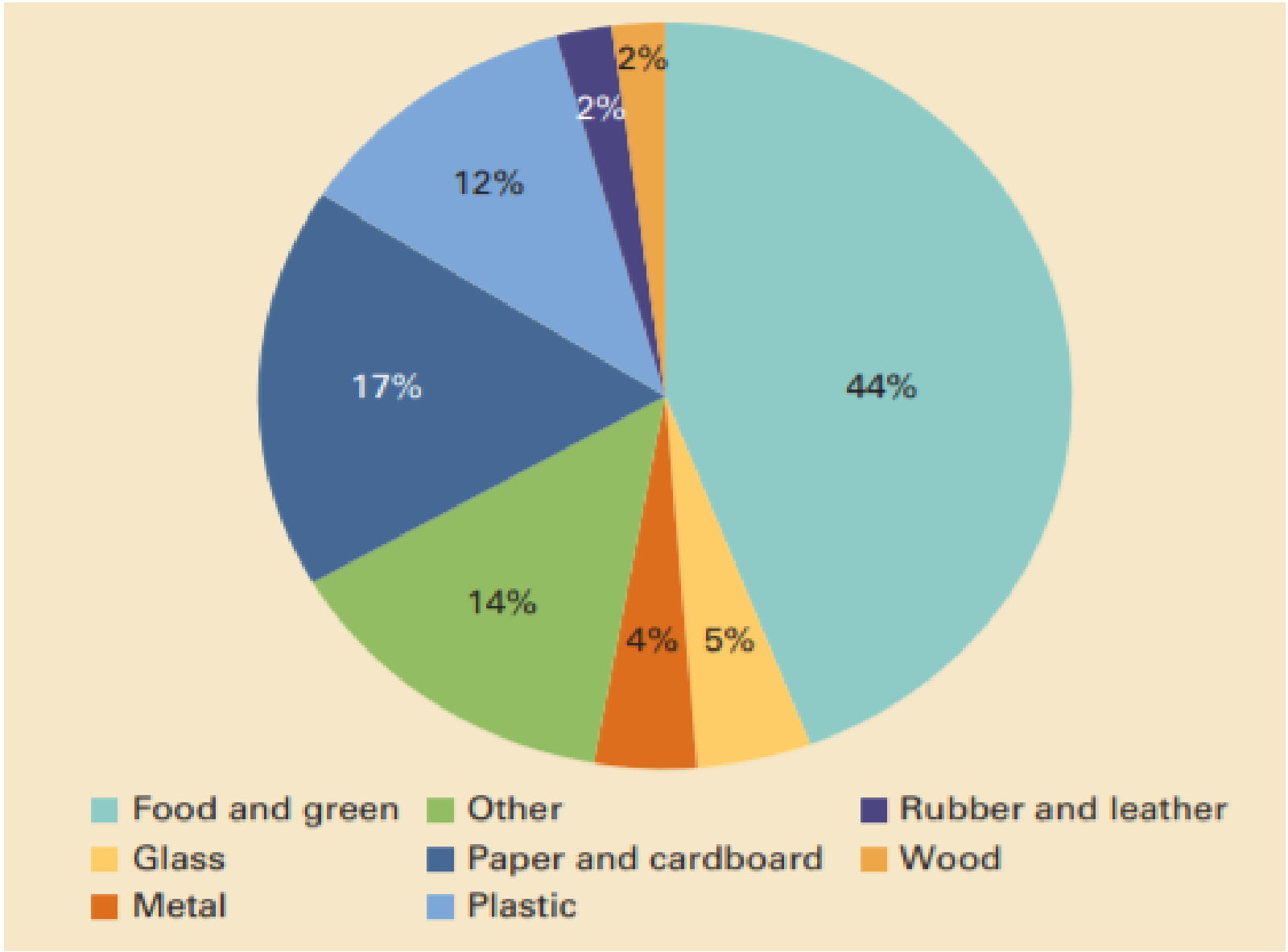
2,700 Waste to Energy plants expected to be operational by 2027

530 million tonnes capacity (Ecoprog, 2018)



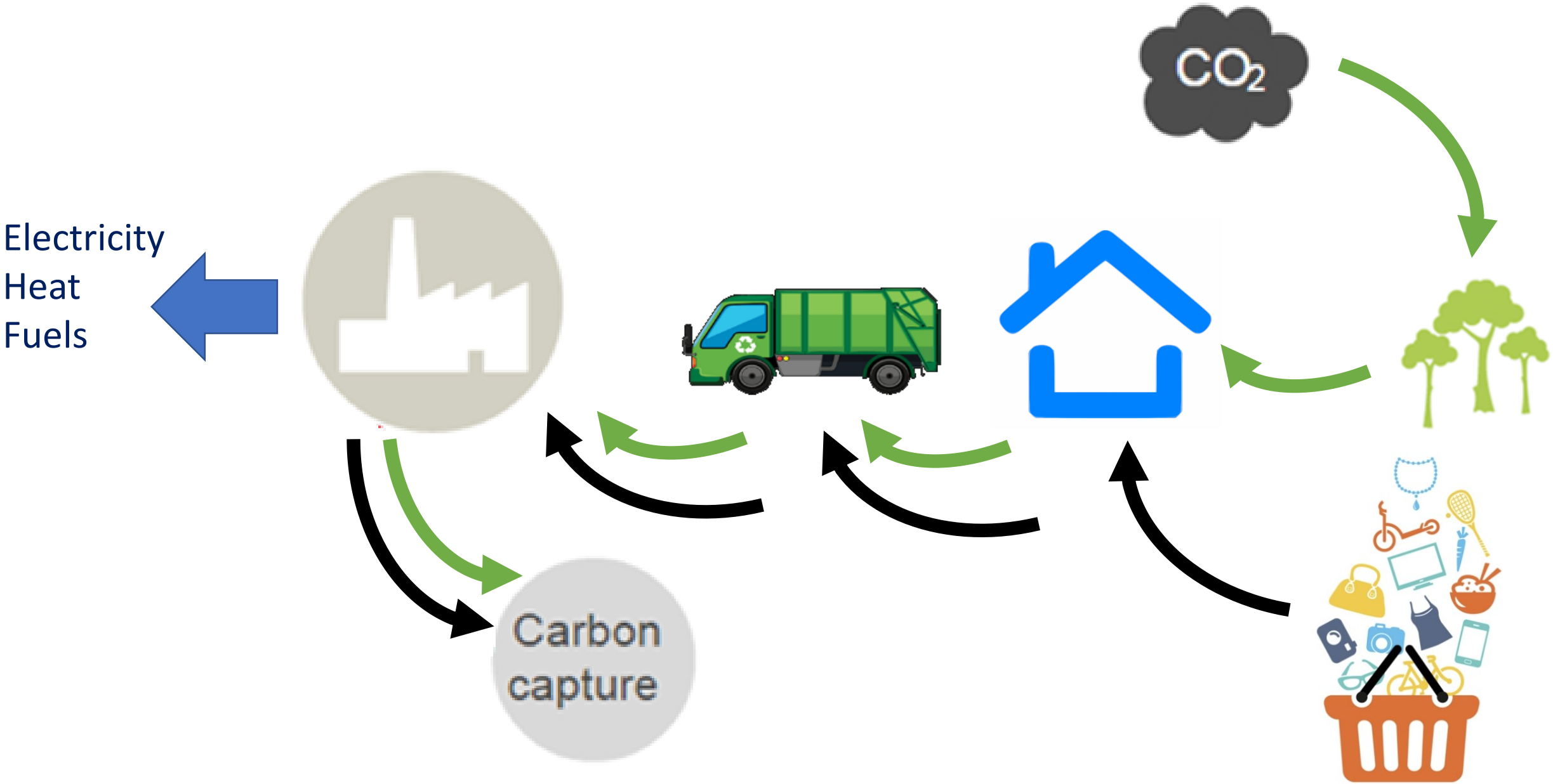
Urban Waste Generation by Income Level and Year, *Hoornweg et al., 2012*

ALMOST HALF OF GLOBAL WASTE IS BIOGENIC CARBON



Global Waste composition
(Kaza et al. 2012)

Biomass Energy with CCS to Waste to Energy with CCS



Why Waste to Energy with CCUS?

- Addressing climate change and sustainable waste management are two increasingly important societal challenges
- CCUS technologies in Waste to Energy (WtE) conversion can create a negative carbon sink over the lifecycle of waste
- Household waste of biogenic origin could become a strategic domestic resource in a net-zero world. Unlike ‘conventional’ biomass/biofuels, waste is available without impacts on food security or land availability.
- European interest in CCUS for WtE is growing as landfill sites are phased out.
- Yet the potential for negative emissions when WtE and CCUS are combined is yet to be fully characterised.

Scientific, technical and commercial challenges

Challenge 1: Waste-derived feedstock is a challenging fuel

Due to the non-homogenous nature and variability of waste, trace metals and combustion aerosols, efficient combustion and management of solvent life for CO_2 capture are yet to be resolved.

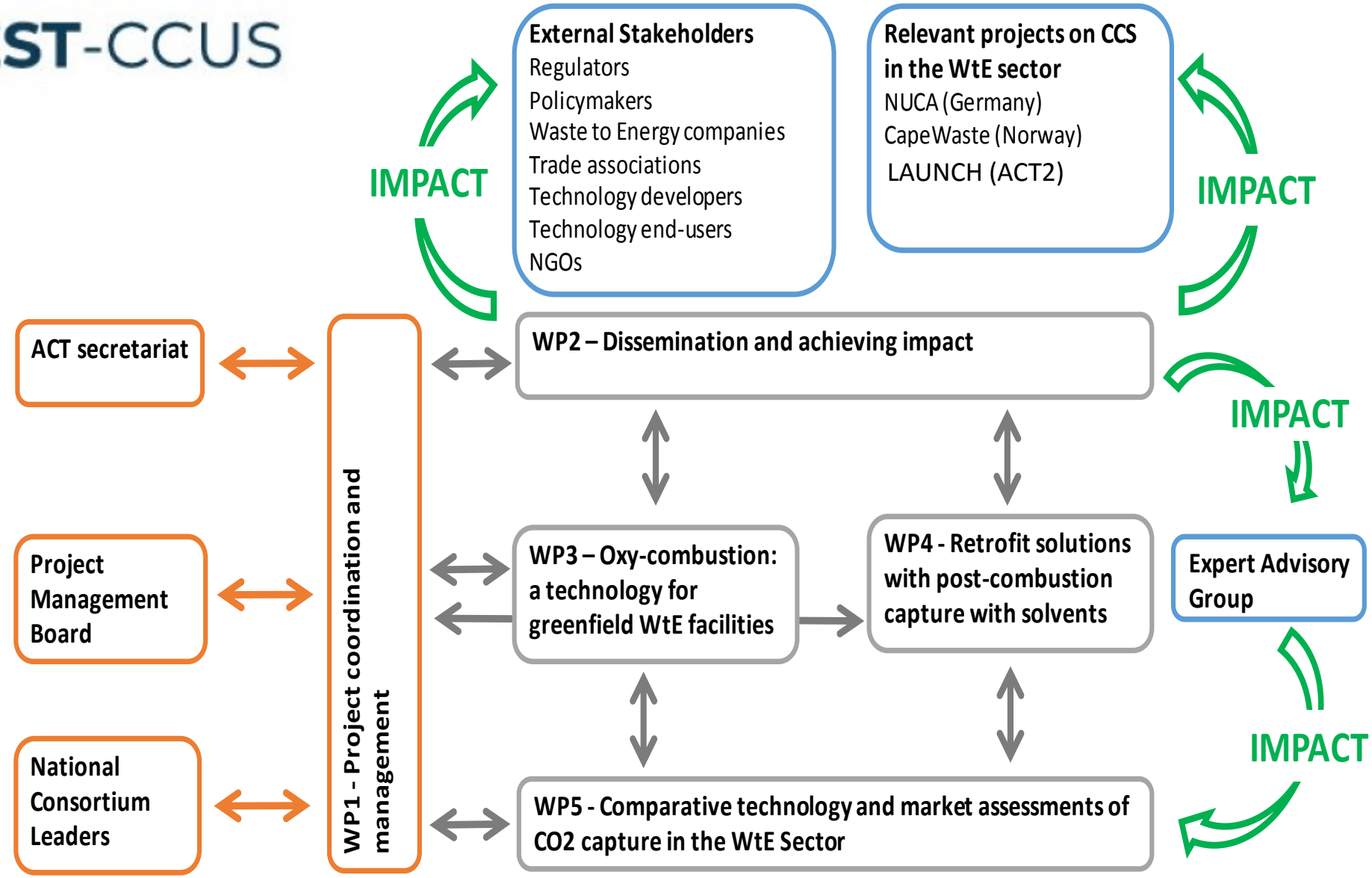
Challenge 2: Deliver a reliable methodology for accounting for negative emissions

- Current methodology is not adequate
- Conventional Life Cycle Assessment (LCA) focusses on impacts rather than impact reductions. Biogenic carbon is typically excluded
- Significant debate on how to account for benefits without double-counting

Challenge 3: Establish a platform for CCUS in the WtE sector

- Lack of knowledge of techno-economics and the economic potential of WtE with CCUS
- Poor understanding of likely environmental impacts/benefits
- Deliver an accessible evidence base for effective policy and regulation

NEWEST-CCUS


External Stakeholders
Regulators
Policymakers
Waste to Energy companies
Trade associations
Technology developers
Technology end-users
NGOs
Relevant projects on CCS in the WtE sector
NUCA (Germany)
CapeWaste (Norway)
LAUNCH (ACT2)
IMPACT
IMPACT
IMPACT
IMPACT
IMPACT
ACT secretariat
Project Management Board
National Consortium Leaders
WP1 - Project coordination and management
WP2 – Dissemination and achieving impact
WP3 – Oxy-combustion: a technology for greenfield WtE facilities
WP4 - Retrofit solutions with post-combustion capture with solvents
WP5 - Comparative technology and market assessments of CO2 capture in the WtE Sector
Expert Advisory Group

What is on the menu?

Oxyfuel 3 ways

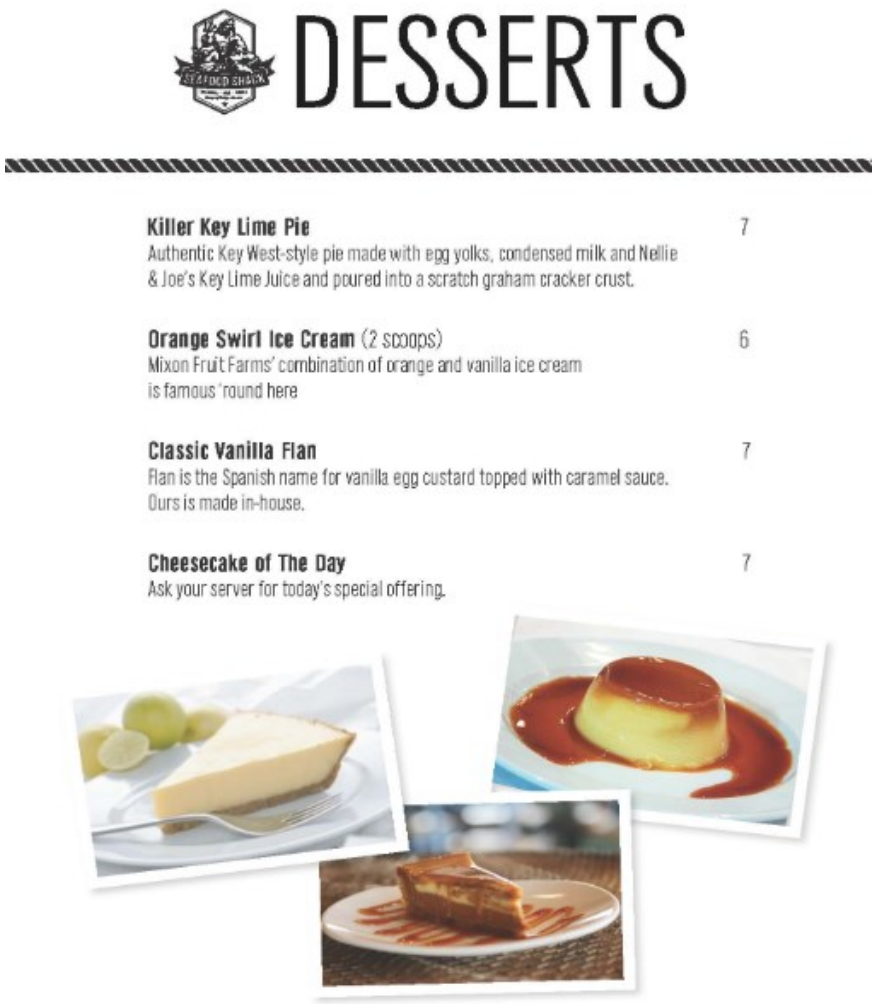
Trio of Solvents
(3 facilities, 4 test campaigns)

The cherry on the cake:
Negative emissions

(all good things with moderation)

WP2: Dissemination & Achieving Impact

What is the menu?



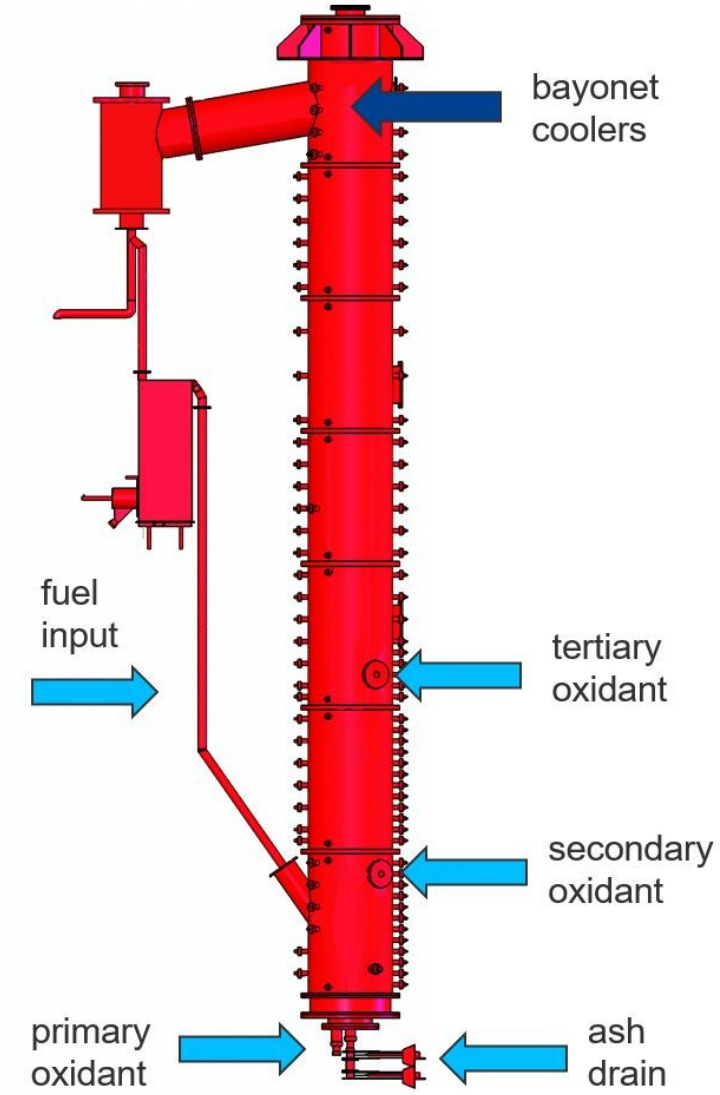
- Led by dissemination experts at SCCS
- Communication Plan
  - ✓ Website: newestccus.eu
  - ✓ social media: Twitter, LinkedIn
  - ✓ technology bulletins
  - ✓ short information videos,
  - ✓ briefings for technical stakeholder groups;
  - ✓ briefings for non-technical stakeholder groups;
  - ✓ researcher vlogs (video blog)

- Dedicated strategy for user engagement
- New Stakeholder engagement
- Webinars
- Interaction with CCS R&D projects in Germany (Nuca) and Norway (CapeWaste)

Oxy-combustion of Solid Recovered Fuel in Circulating Fluidised Beds

IFK Stuttgart, 200kW pilot, modified for Oxyfuel combustion

University of Stuttgart
Germany



The 200 kW_{th} oxy-fuel CFBC at USTUTT

Solid recovered fuel (SRF) is higher calorific value fuel produced from mainly commercial waste including paper, card, wood, textiles and plastic.
Circulating Fluidised Beds achieve higher efficiency with these challenging fuels than conventional grate-fired boilers

Objectives:

- Demonstrate and optimize the technology at TRL6 (200 kWth)
- Improve understanding of the effect of highly reactive trace impurities in combustion gases on CO2 purity
- Assess the impact of the fuel on key process properties (i.e. materials, fouling and corrosion)
- Investigate ash behaviour (e.g. agglomeration tendency)
- Explore how mechanical and chemical properties of SRF affect operational issues

Oxy-combustion of municipal solid waste

Objectives:

- Data of fundamental properties of oxy-combustion of Municipal Solid Waste
- Characterization of the bottom ash
- CFD model of oxy-combustion of Municipal Solid Waste, validated with experimental data, with input on boundary conditions from industrial partner KRV

Facility:

Bench scale Vertical Tube Furnace (VTF), an ECCSEL Research Infrastructure at SINTEF
Bed reactor with thermally thick particles (pellets)
De-volatilisation and slow oxy-combustion experiments with varying O_2 concentration, gas temperature, and heating rate

Hybrid Oxy-combustion in WtE plans

Objective:

Better performance and control of the incineration process, by better furnace zone temperature control.

Process modelling of hybrid oxy-combustion concepts

- Evaluate the concept of CO2 recycling via membranes (similarly as in oxy-fuel combustion)
- Evaluate the concept of oxygen enrichment (partial oxy-fuel)

Pilot scale testing at 1 tCO_2/day facilities

The University Of Sheffield.

Carbon Clean Solutions Limited

Objective: Understand the effect of trace metals and combustion aerosols on CO_2 capture solvents

Facility:

- Pilot-scale Advanced CO_2 Capture Technology (PACT) facilities
- 1 t CO_2 /day solvent pilot plant connected to dedicated waste boiler and to state-of-the-art aerosol and particle measurements

Novelty

- Understand release profiles of entrained aerosols
- Measure emissions of particulate matter, specifically sub-micron particles (PM1) in terms of particle size distribution and particle concentration
- Quantify their impacts on operational performance for

(i) a generic amine, aqueous 30%wt MEA

(ii) a proprietary solvent from CCSL

Pilot scale testing at 10 tCO_2/day facilities

Facility:

10 tCO_2/day solvent pilot plant connected to commercial WtE plant

Objective:

Quantify impacts of the fuel on the operational performance of a proprietary solvent from CCSL

Twence pilot facility, Courtesy of CEWEP

3rd generation solvent technology

‘Breakthrough’ promoted ammonia-based solvent, a.k.a. STAR
Active components are resistant to degradation -> suitable for challenging fuels

<u>Objectives:</u>

- Demonstrate the performance of STAR with a 200 hour test campaign on a test facility, with artificial flue gas mixture representative of WtE flue gas CO2 concentration.
- Determine optimum solvent formulation in terms of suppression of ammonia vapour pressure and enhancement of CO2 absorption kinetics.

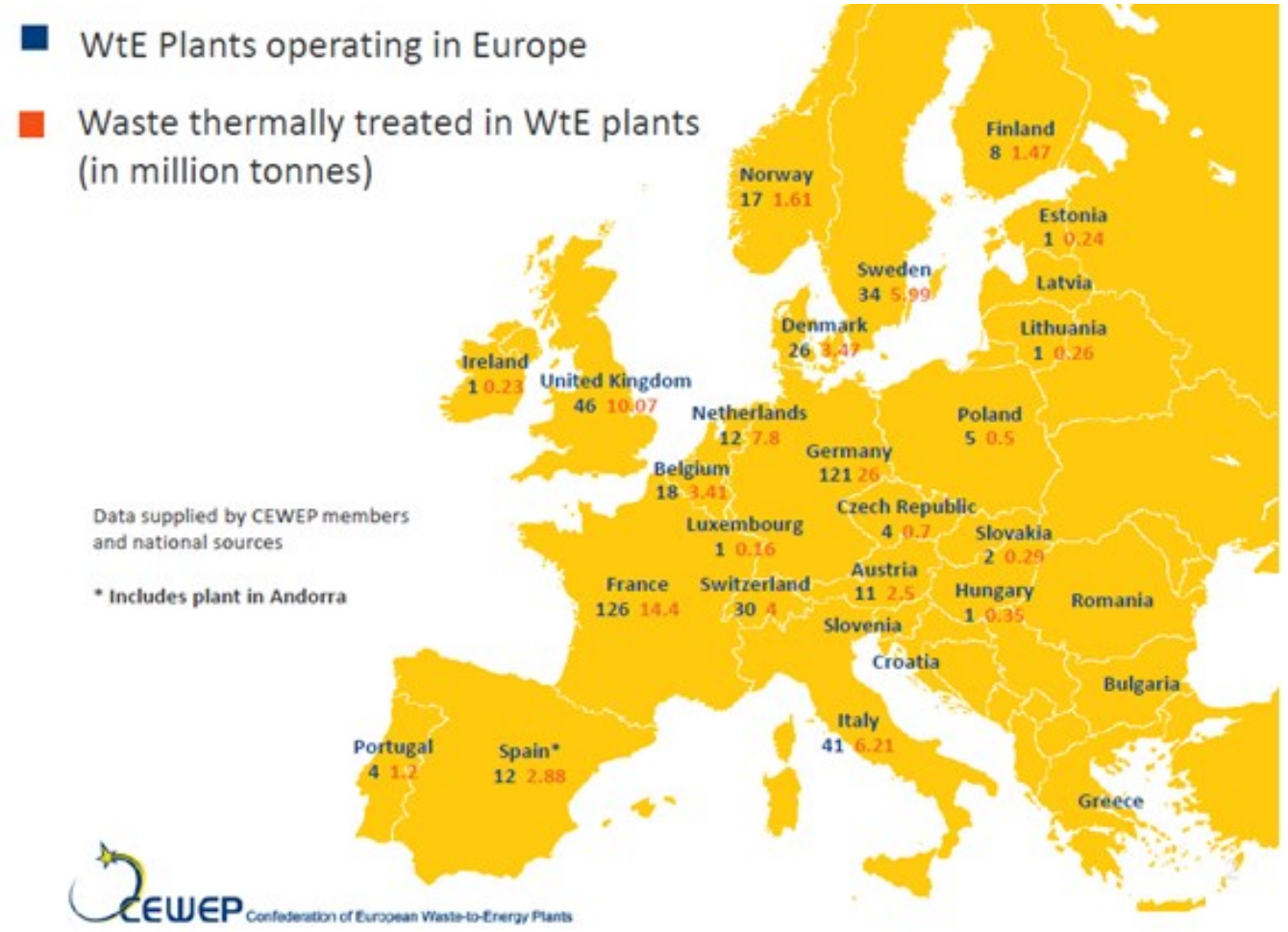
Larger test rig for operating TNO’s STAR solvent

WP5 Comparative technology and Market assessment

THE UNIVERSITY of EDINBURGH

with contribution from all partners

- Assessment of the potential size of the European WtE CCUS market
- Performance evaluation of selected technologies
- Techno-economic assessment
- Life cycle environmental impact assessment of scenarios
- Evaluation of the potential cumulative net atmospheric CO_2 removal of WtE with CCUS in Europe



courtesy of CEWEP

Acknowledgements

ERA-NET ACT programme

The project is funded by BEIS (UK), RVO (NL), Fz-Jülich (Germany) and RCN (Norway) under the ACT Programme Grant Agreement No 691712

Department for Business, Energy & Industrial Strategy

Netherlands Enterprise Agency

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

The Research Council of Norway

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Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank (2018) What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050. Urban Development;. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/30317 License: CC BY 3.0 IGO

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