A Spotlight Towards Technological Aspects of WTE Plants

Bettina Kamuk, Global Market Director,
Ramboll Energy from Waste

RAMBOLL

AGENDA

Brief Introduction of Ramboll

01

WtE Market Worldwide

02

WTE in a circular perspective (ARC)

03

Developments in WTE technologies

04

Conclusion

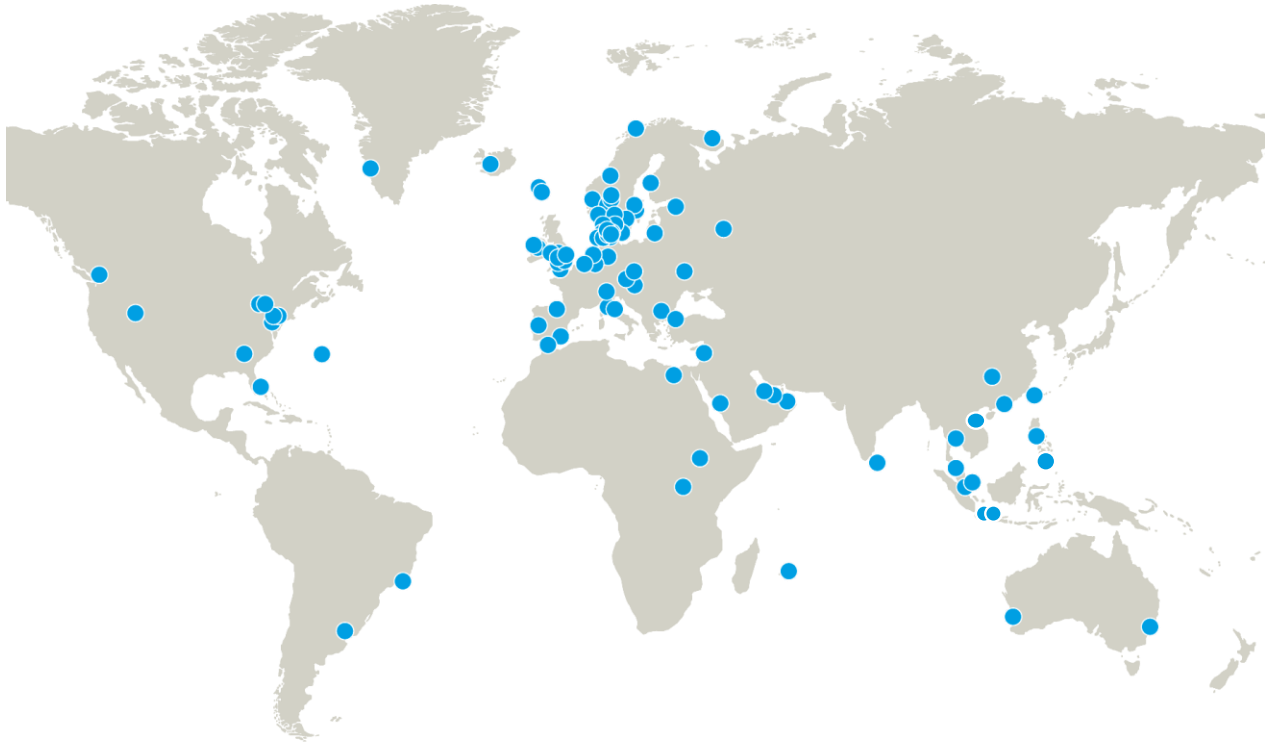
05

RAMBØLL

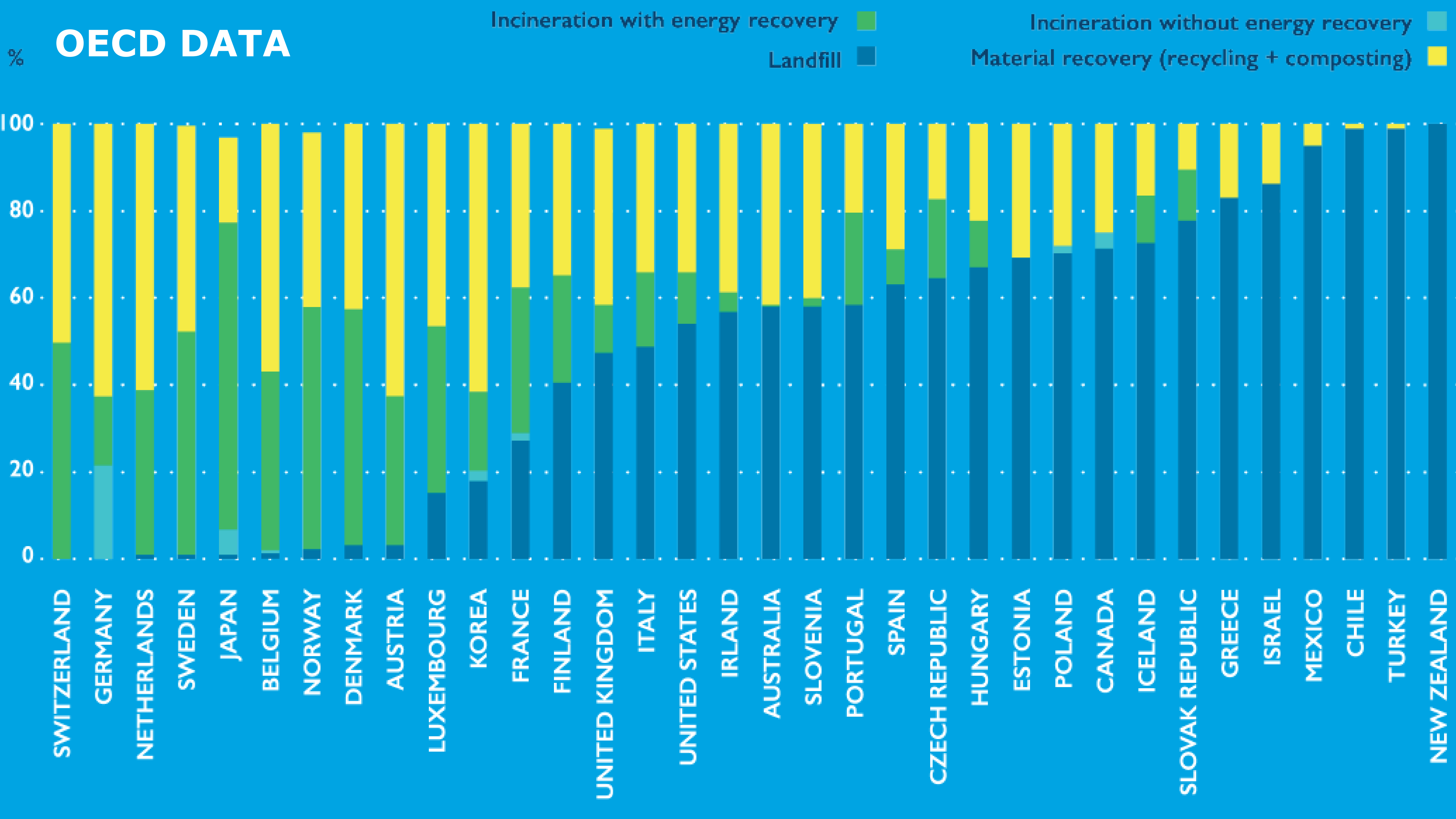
RAMBOLL IN BRIEF

- Founded 1945 in Denmark. Today +16,000 employees in 35 countries
- Globally leading WTE consultant with 150+ WtE reference plants Worldwide
- WtE competence offices in Copenhagen, Stockholm, Oxford, Zurich, Perth and Singapore
- Supports developers, investors, utilities, lenders, etc. in developing and realisation of Waste-to-Energy projects
- Services include waste analysis, technology assessment, feasibility/due diligence, permitting, procurement, design review, contract management and site management for EPC or EPCM projects

Ramboll Waste-to-Energy References

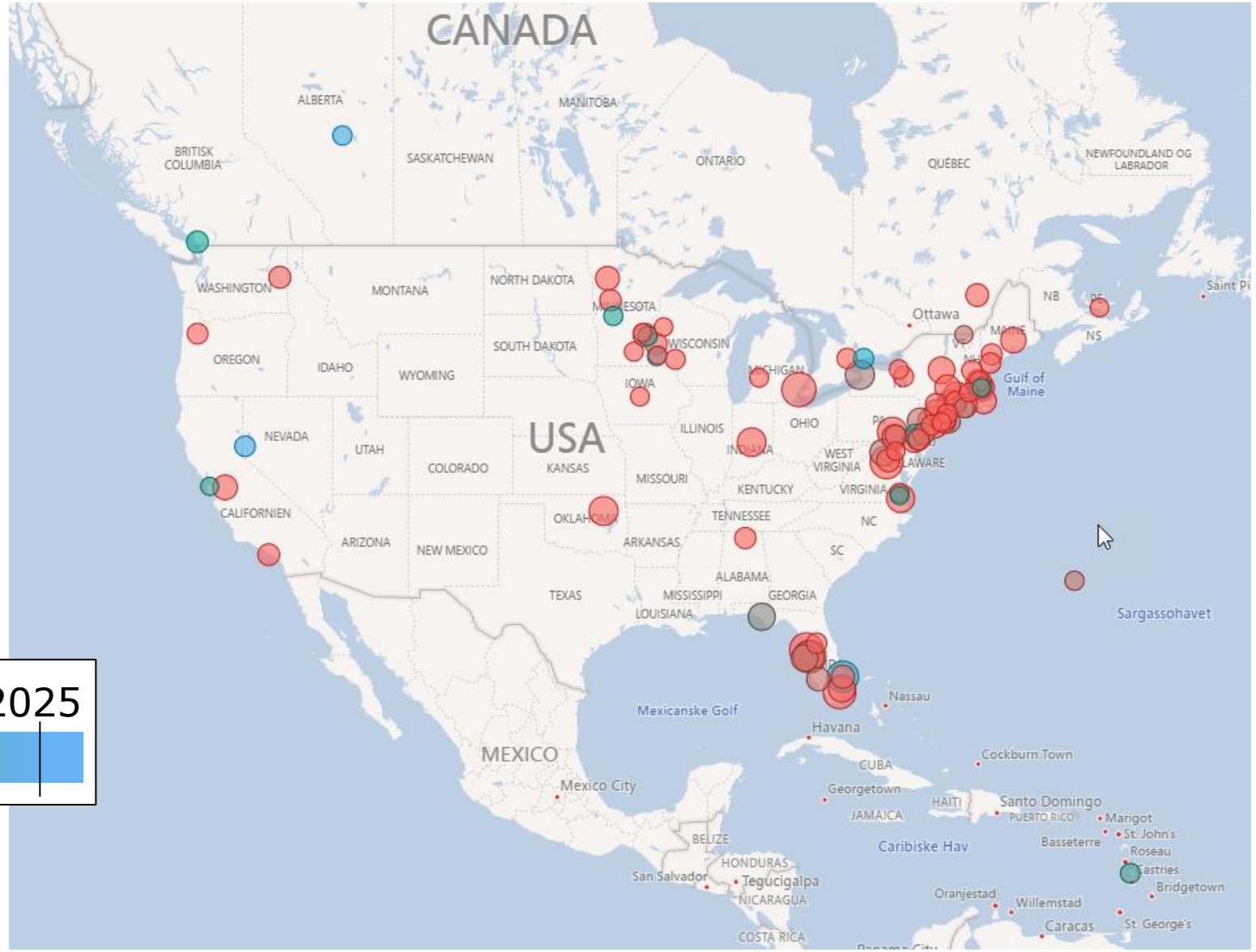


RAMBØLL



OECD DATA
%
Incineration with energy recovery
Landfill
Incineration without energy recovery
Material recovery (recycling + composting)
100
80
60
40
20
0
SWITZERLAND
GERMANY
NETHERLANDS
SWEDEN
JAPAN
BELGIUM
NORWAY
DENMARK
AUSTRIA
LUXEMBOURG
KOREA
FRANCE
FINLAND
UNITED KINGDOM
ITALY
UNITED STATES
IRLAND
AUSTRALIA
SLOVENIA
PORTUGAL
SPAIN
CZECH REPUBLIC
HUNGARY
ESTONIA
POLAND
CANADA
ICELAND
SLOVAK REPUBLIC
GREECE
ISRAEL
MEXICO
CHILE
TURKEY
NEW ZEALAND

WTE MARKET WORLDWIDE - PLANTS IN OPERATION/ERECTION NORTH AMERICA

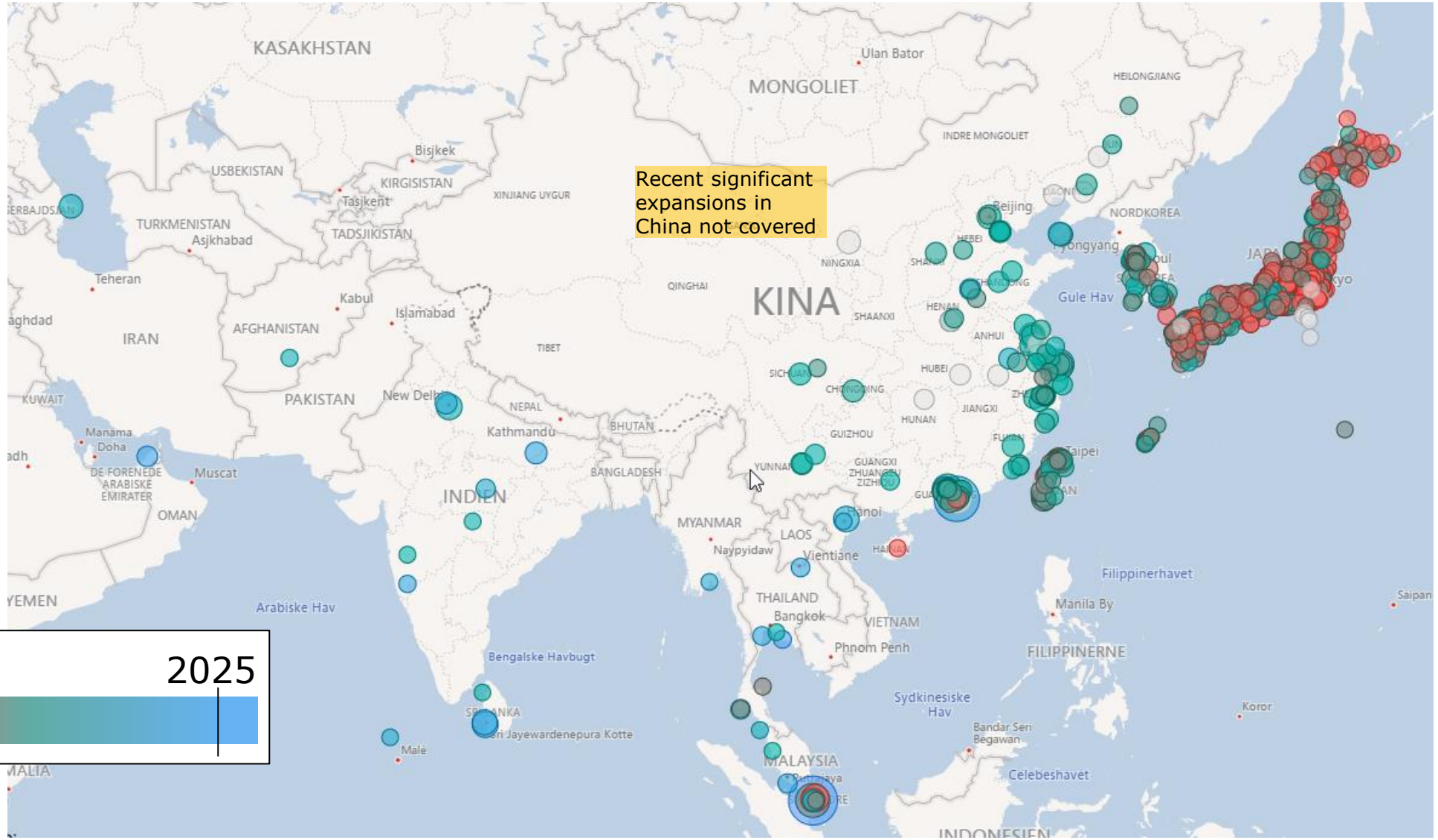


AMERICA - WTE

- USA/Canada: has WTE facilities but few new plants, rely on landfilling, lack regulatory framework conditions and political champignon ship, too much discussion about alternative thermal technologies
- South- and Central America: interest but immature waste management systems and lack of regulatory framework conditions

Image by SWA

WTE PLANTS IN OPERATION – MIDDLE EAST, ASIA AND AFRICA



RAMBØLL

MIDDLE EAST - WTE

- Except Qatar not much WTE capacity in the Middle East – but will come …
- Many countries are in the planning stage for establishing WTE (Israel, Sharjah, Dubai, Abu Dhabi, Saudi Arabia, Kuwait, Bahrain, Oman, ….)
- The driver is renewable energy and sustainable waste management
- Challenged because of no regulatory drivers and because landfilling is cheaper
- In some countries the citizens do not pay for waste treatment

RAMBØLL

ASIA/SOUTH EAST ASIA - WTE

- Singapore: WTE is an important part of the waste management system (IWMF 2,6000,000 tpa capacity)
- Japan: WTE is an integrated part of waste management (many, small plants, low energy efficiency)
- China: Politically decided to divert from landfill to WTE. Have established many WTE facilities (100+), mainly Chinese technology
- Thailand and Malaysia have WTE and more to come but lack political champignonship
- Vietnam, Indonesia and the Philippines (maybe Cambodia) are implementing WTE in near future
- India: Have some few WTE plants but lack structural framework conditions
- Generally challenged due to lacking regulatory framework and due to costs

RAMBØLL

AUSTRALIA - WTE

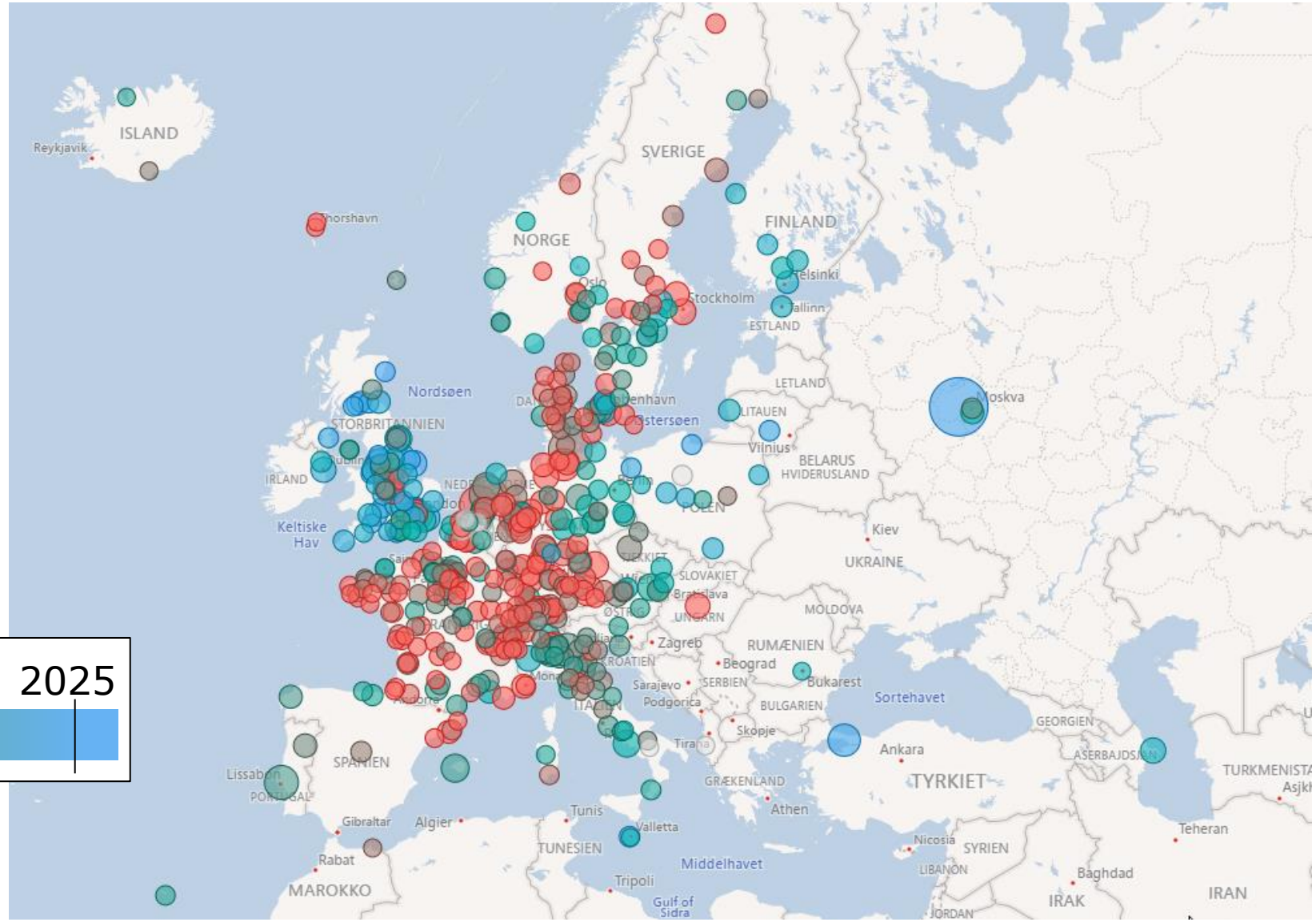
- Acceptance of WTE has changed dramatically over the last few years
- Currently around 4-5 WTE plants are in implementation/being discussed
- The driver is high landfill tax to encourage sustainable waste management
- The Chinese Green Fence has encouraged own solutions

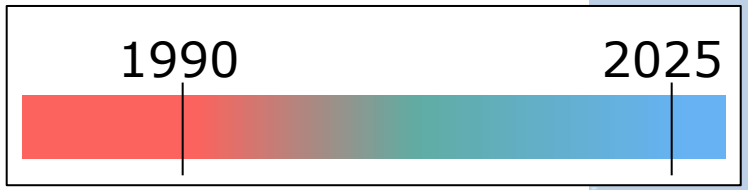
RAMBØLL

AFRICA WTE

- Addis Ababa WTE facility (400,000 tpa)
- A lot of interest – but immature waste management sector and low gate fees
- Large bio fraction
- May become technically and financially feasible in some African countries

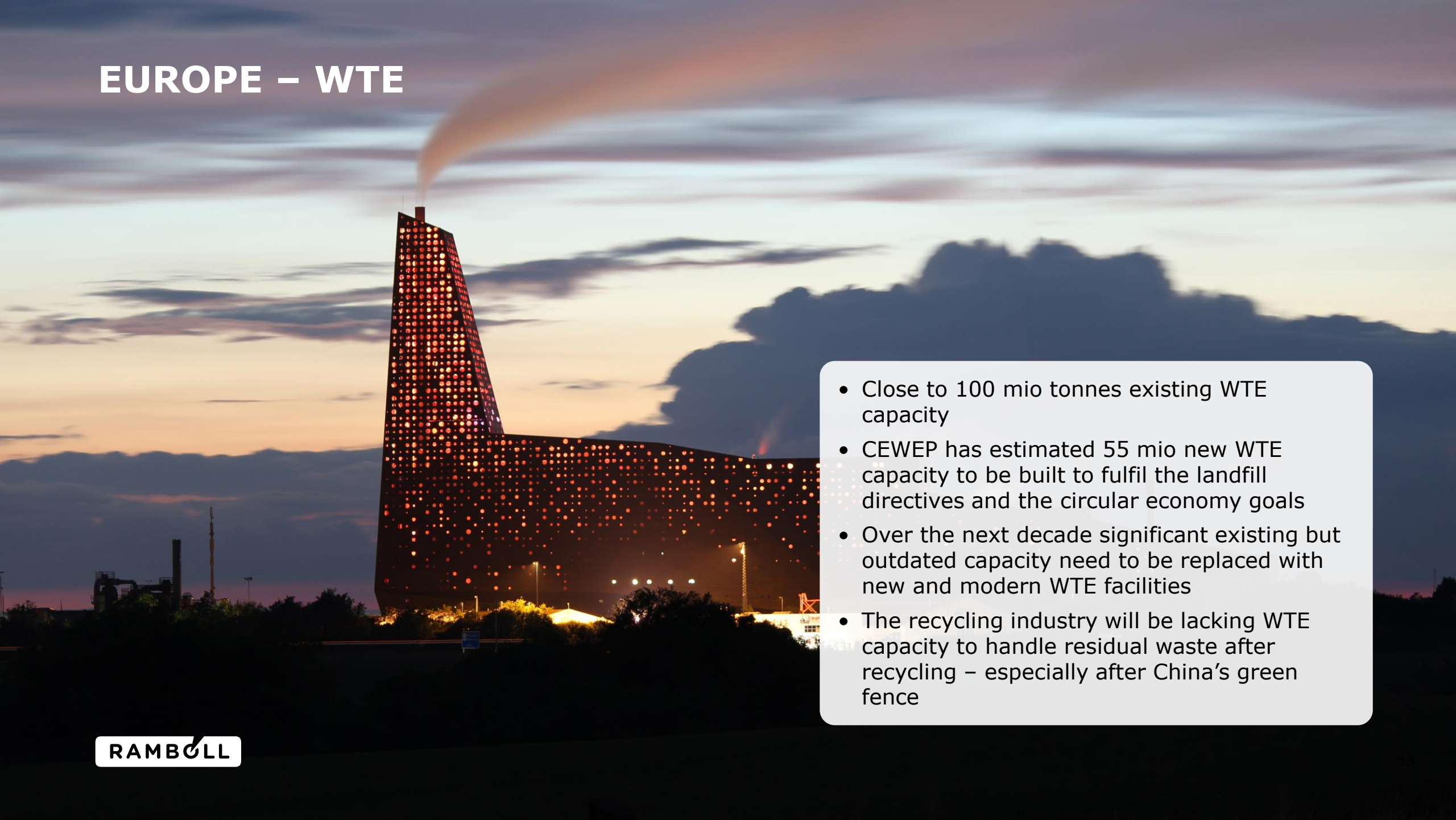
WTE MARKET WORLDWIDE - PLANTS IN OPERATION/ERECTION EUROPE





RAMBØLL

EUROPE – WTE



- Close to 100 mio tonnes existing WTE capacity
- CEWEP has estimated 55 mio new WTE capacity to be built to fulfil the landfill directives and the circular economy goals
- Over the next decade significant existing but outdated capacity need to be replaced with new and modern WTE facilities
- The recycling industry will be lacking WTE capacity to handle residual waste after recycling – especially after China's green fence

RAMBØLL

CIRCULAR ECONOMY – A DRIVER FOR WTE

- Energy recovery (WTE) goes hand in hand with recycling
- The circular economy relies on energy as much as it does on material feedstock
- Circular flows will always have a residual waste stream either due to market conditions, technologies available, social barriers or the need for sanitizing
- The residual not recycled waste stream is an important energy source and an important contributor in saving fossil fuels and reducing climate impact

ISWA task force on resource management – circular economy

RAMBØLL


WASTE IS NOT A WASTE
=
+
1 TON WASTE
= 2 MWh DISTRICT HEATING
+ 0.67 MWh ELECTRICITY
ELECTRICITY FOR 550,000 CITIZENS, HEAT FOR 140,000 HOUSEHOLDS
400,000+ TONS OF WASTE/YEAR
RAMBØLL
Image by SWA

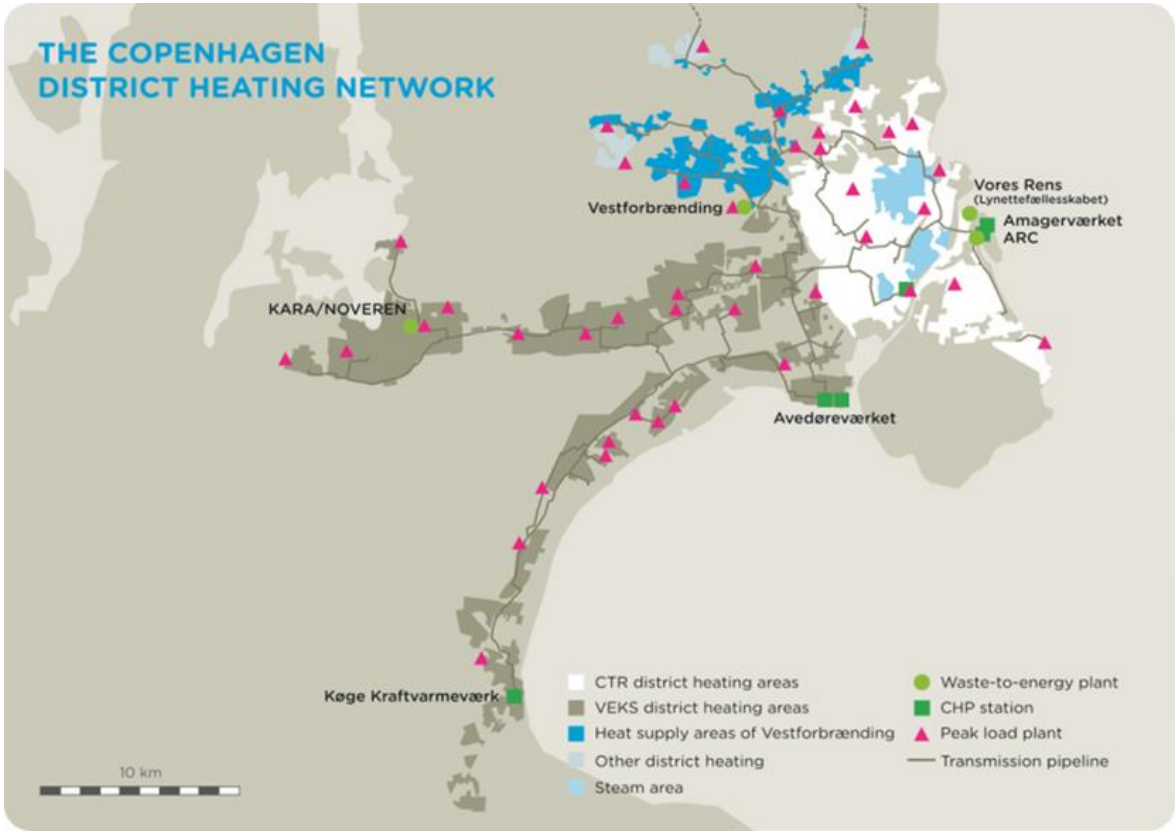
AMAGER BAKKE, COPENHAGEN, DENMARK

- Capacity: 2 x 280,000 tonnes of waste annually
- Energy output: 400,000 MWh electricity and 1,000,000 MWh heat per year
- Commissioned: 2018

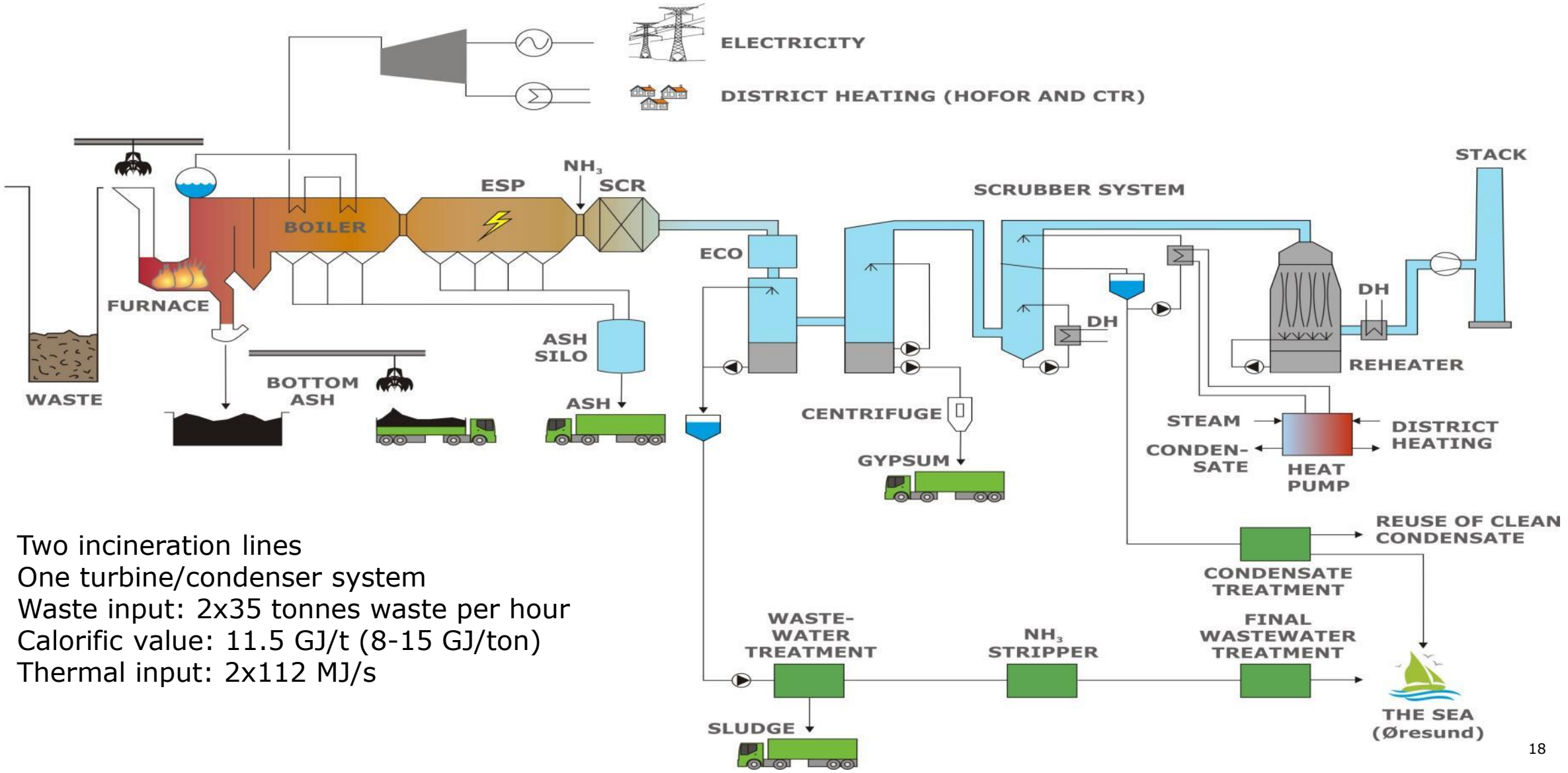
RAMBØLL

FRAMEWORK DECISIONS BY THE CITY

- An important contribution to reaching climate goals for Copenhagen City
- Can offer very high energy efficiency and high potentials for material recycling and recovery (metal)
- Can offer a high environmental performance
- Shall be open to public and offer an recreational area for the society
- Shall become a beacon for the city of Copenhagen



ARC - OVERALL TREATMENT PROCESS



Two incineration lines
One turbine/condenser system
Waste input: 2x35 tonnes waste per hour
Calorific value: 11.5 GJ/t (8-15 GJ/ton)
Thermal input: 2x112 MJ/s

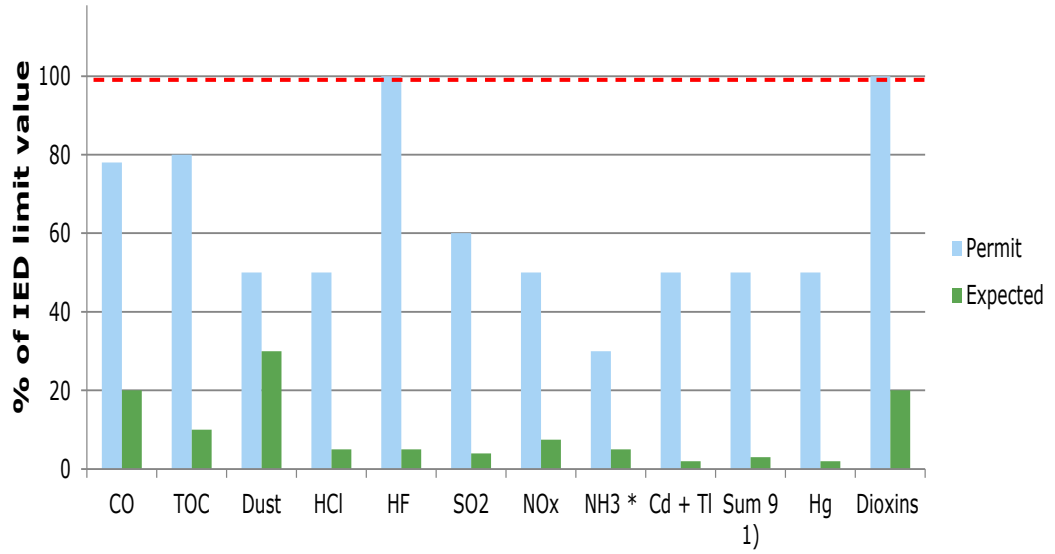
BAR-RISING ENVIRONMENTAL PERFORMANCE

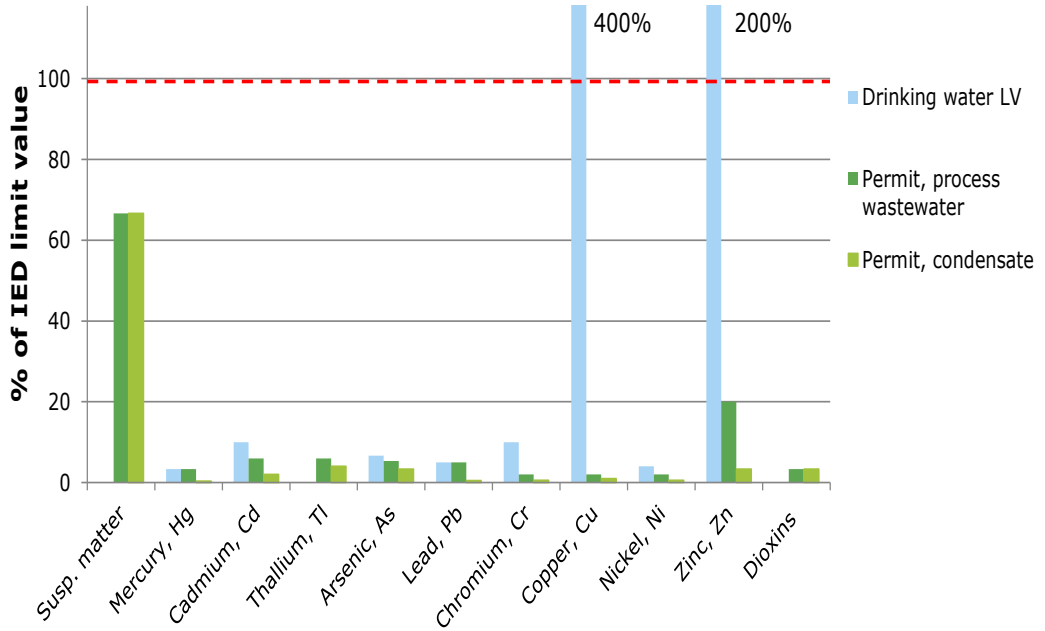
Air emission

- ✓ Permit has 50% of EU-IED requirements for many parameters
- ✓ Expected emissions much lower

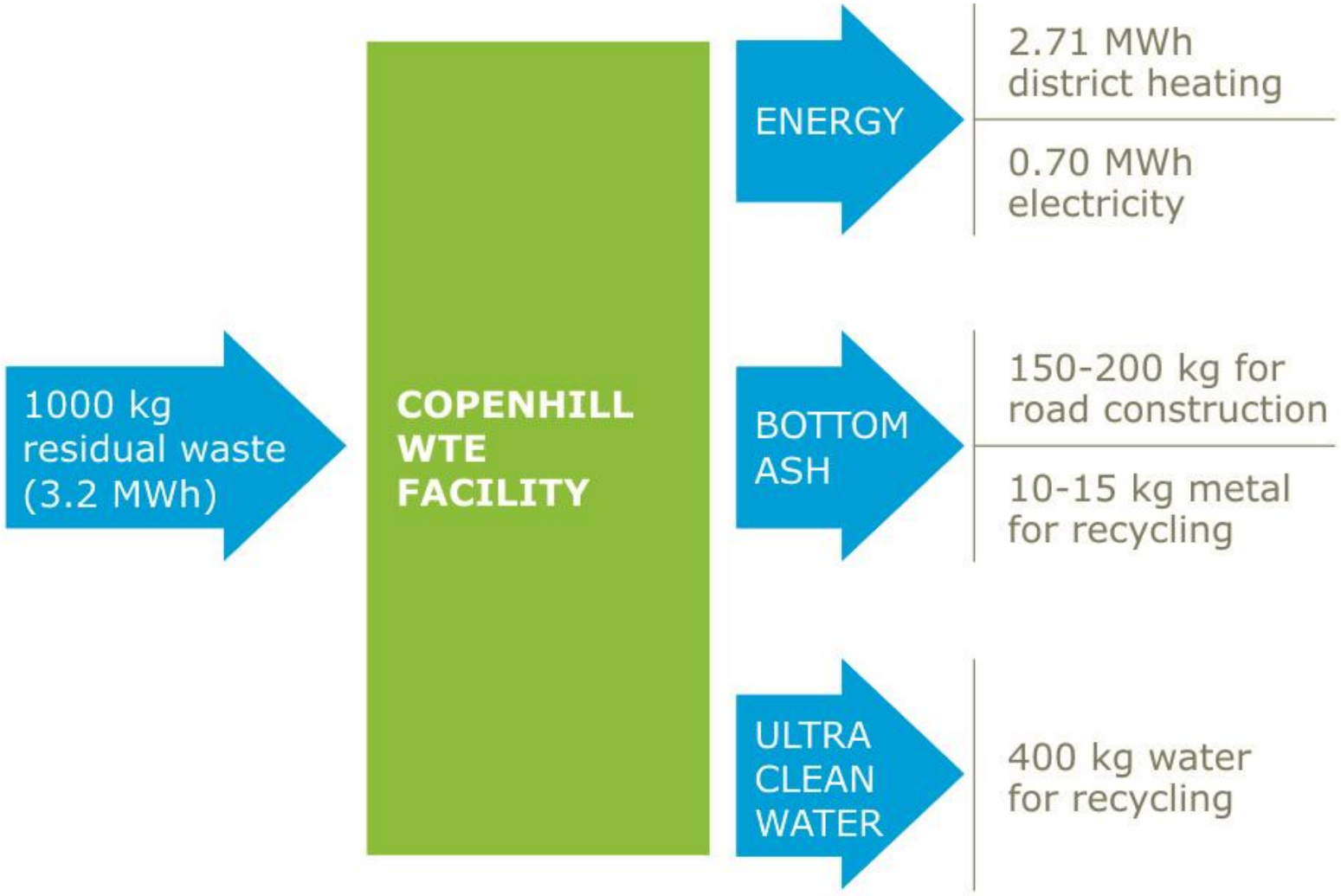
Cleaned waste water discharge

- ✓ Permit has requirements much lower than the EU-IED requirements
- ✓ Permit has requirements lower than limits for drinking water





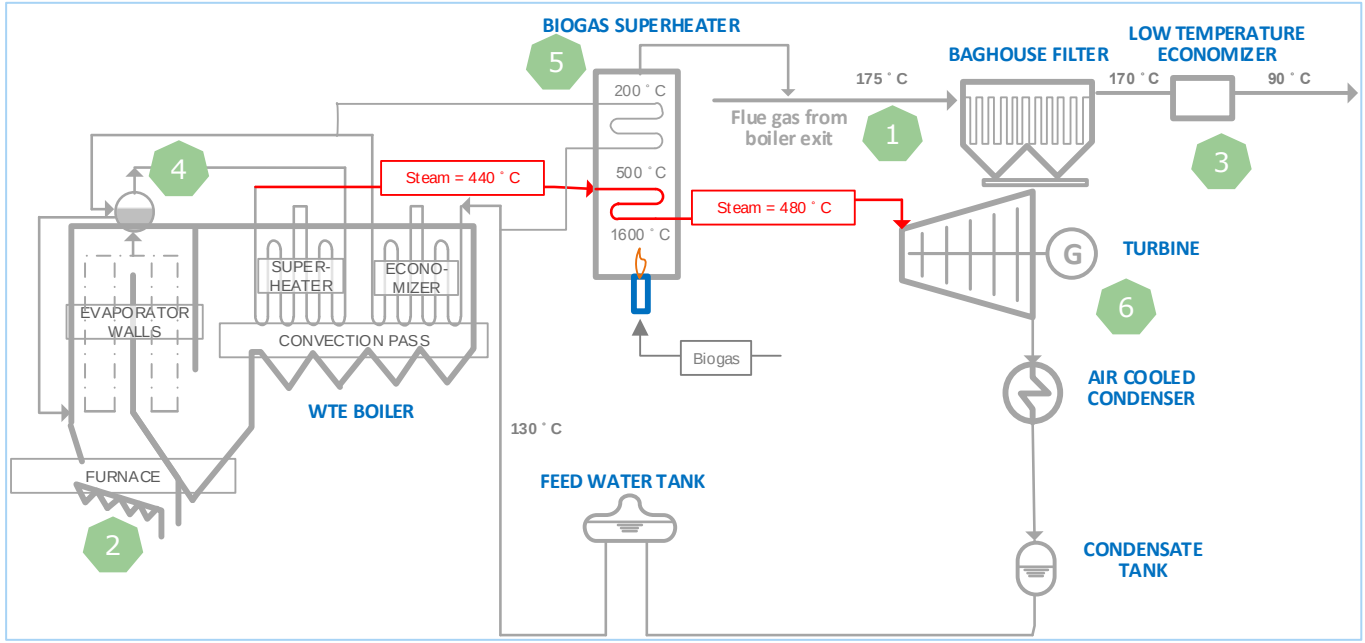
HIGH ENERGY AND MATERIAL RECOVERY



RAMBØLL

MAXIMISE ENERGY PRODUCTION

- Improve boiler efficiency (steam production)
  - Reduce boiler exit temperature 1
  - Reduce combustion air ratio 2
  - Low temperature economizer 3
- Increase turbine efficiency
  - Increase steam parameters 4
    - 400°C/40 bar to say 440°C/60 bar with optimized superheater configuration and increased Inconel cladding of 1st/2nd pass
  - External superheater, if biogas is available 5
  - Reduce turbine condenser pressure (and buy high quality turbine, designed for higher wetness in the steam exhaust) 6



MAXIMISE METAL RECOVERY

- Highly efficient metal recovery is possible from WTE ash (as all combustible material is utilized, which allows easy access to the metal fractions within composite materials)
- Possible to sieve WTE ash fraction into a number of different size fractions (with the finest fractions down to <1mm) and sorting by different methods:
  - Magnet (Ferrous)
  - Addy current (Non-ferrous)
  - Sensor (stainless steel)
- High revenue in the finest fraction (precious metals from e.g. WEEE)

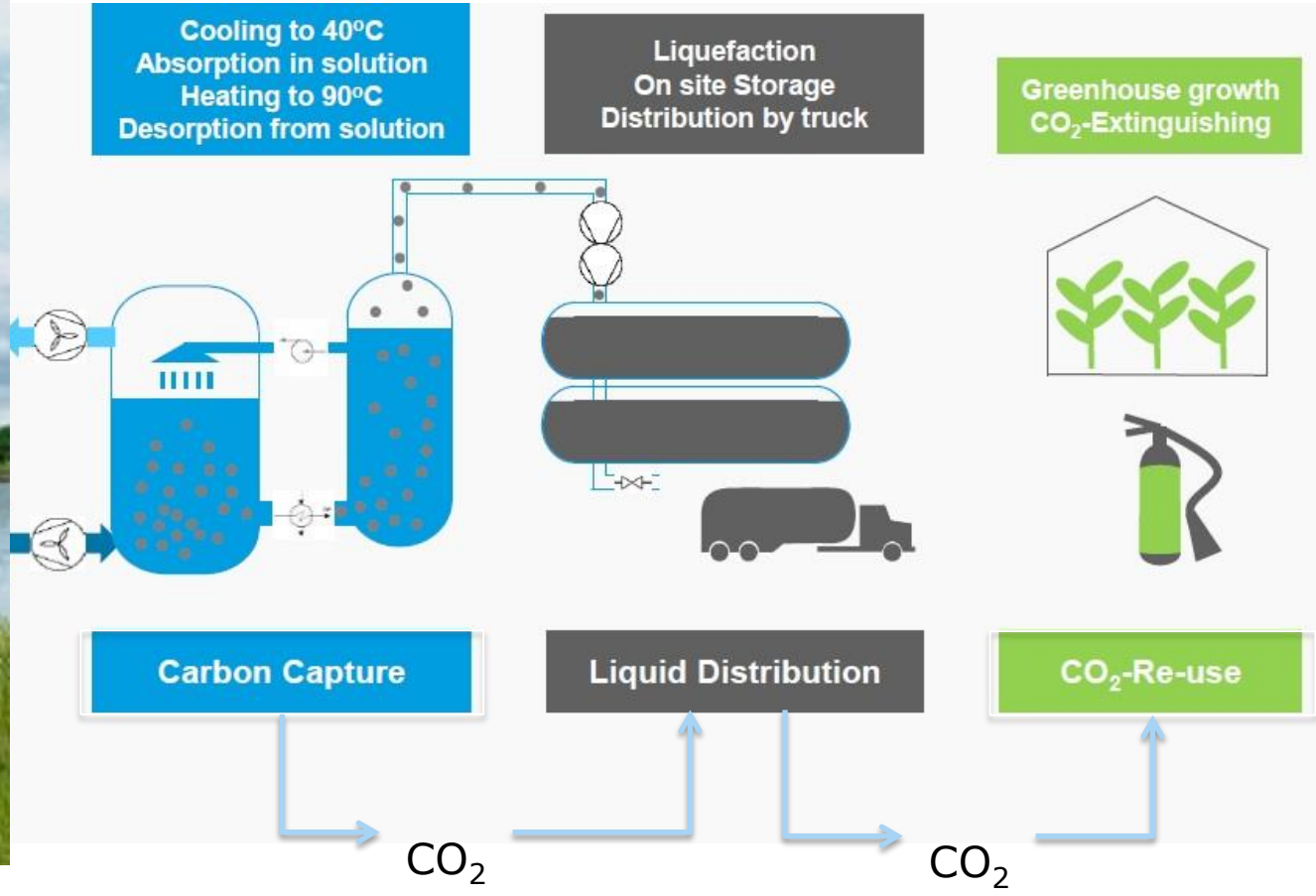
COPENHILL – SKIING AND EVENTPARK

RAMBØLL

PICTURES FROM YESTERDAY

RAMBØLL

INNOVATIVE DEVELOPMENT - CARBON CAPTURE AND USAGE



RAMBØLL

Development of a WtE plant

Primary Issues when developing bankable WtE Projects:

- Regulatory Framework
- Land securement
- Waste Supply Agreement (WSA)
- Power Purchase Agreement (PPA)
- Technology Choice

→ **Business Case**

Financing Issues – Bankability/De-risking of WtE Projects

Waste

- Waste amounts/composition – are waste amounts guaranteed, is the minimum calorific value of the waste guaranteed ?
- What measures are foreseen, if the waste gurantees are not met ?
- How to mitigate (de-risk) if guarantees are not provided ?
  - Sensitivity analysis
  - Waste analysis and prognosis
- Penalties if facility is not able to receive waste ?

Power Sales

- Guarantees for FiT/power price ?
- Obligations, e.g. time frame to achieve subsidies, minimum performance
- Force Majeure issues, e.g. grid availability
- Currency risks
- Inflation compensation
- Security for payment
- Minimum performance requirements and penalties ?

Gate Fee

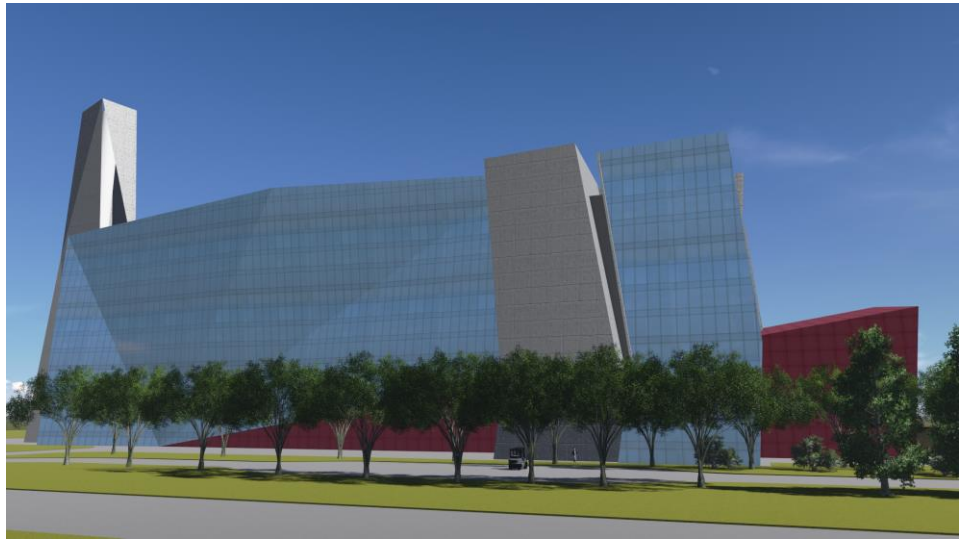
- Security for payment
- Obligations to get subsidies , if any
- Security for delivery
- Currency risks
- Inflation compensation

Technology

- Well-proven
- Risks of budget overrun
- Risk of delays
- Performance
- Availability
- Local expertise and workforce

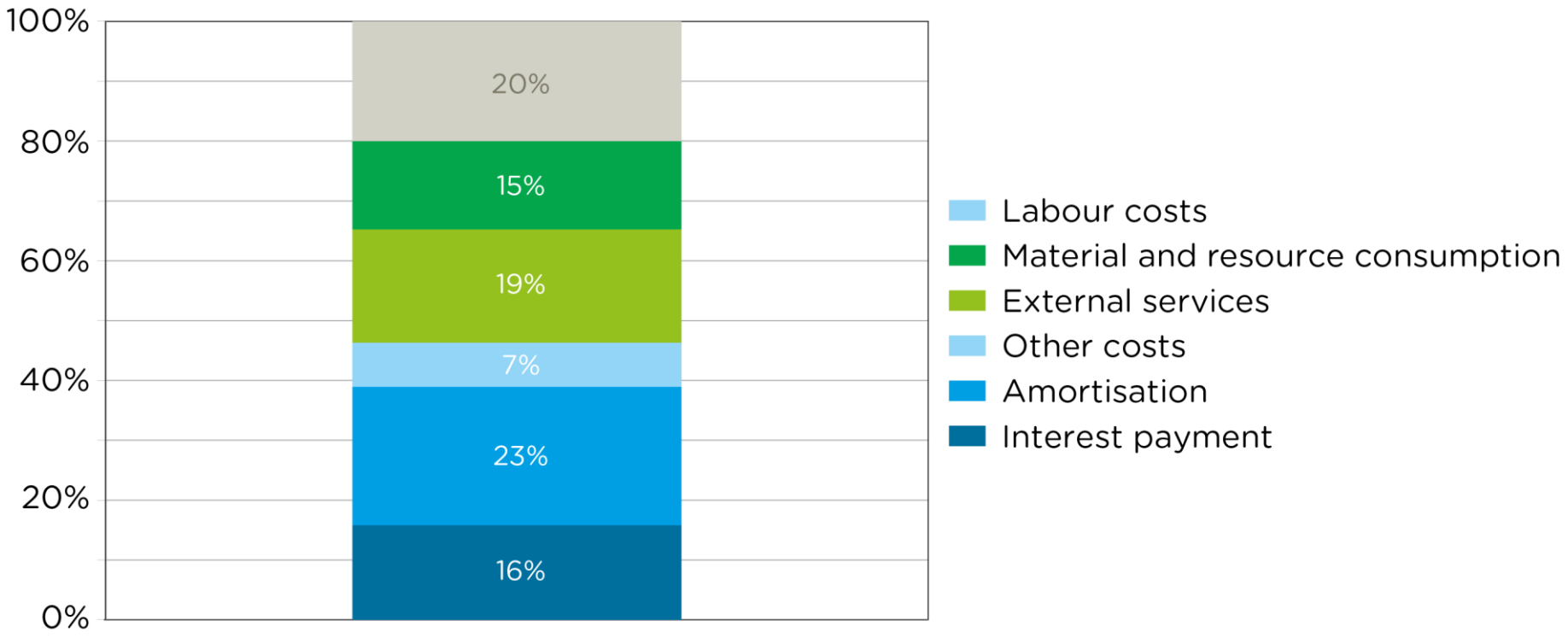
HOW MUCH DOES IT COST?

- CAPEX
  - Size
  - Design/Technology
  - Options for cheap sourcing/local price level
- OPEX
  - Technology
  - Local price level
- Sale of energy
  - Market and price level
- Funding cost
  - Equity/Loans and interest level

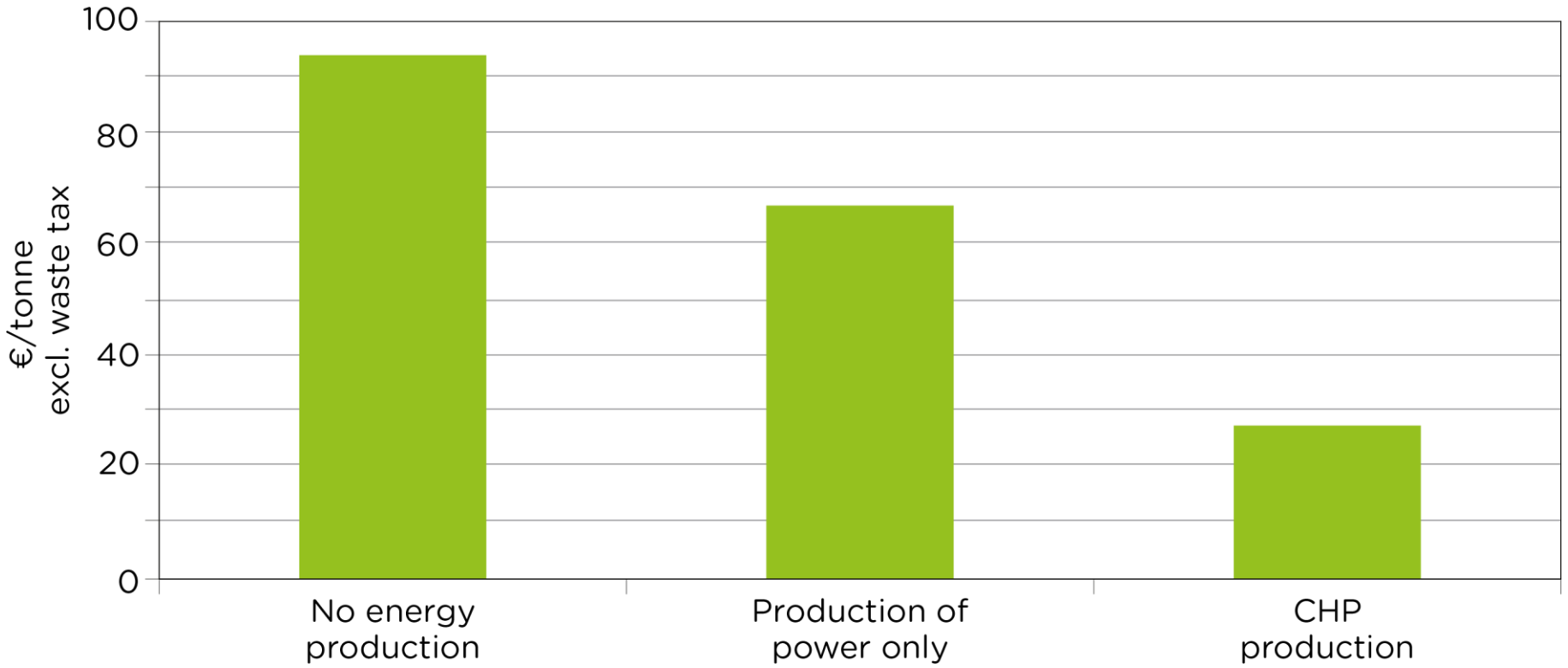


RAMBØLL

TYPICAL DISTRIBUTION OF INCINERATION COSTS, DK



TYPICAL TREATMENT COSTS WITH AND WITHOUT ENERGY RECOVERY, DK



THERMAL TECHNOLOGIES - SHORT SUMMARY

PARAMETER	ADVANCED MOVING GRATE	THERMAL GASIFICATION	PLASMA GASIFICATION	PYROLYSIS
Number of plants in operation	>1,500	Unclear when MSW only (but few)	Unclear when MSW only (but few)	Unclear when MSW only (but few)
Reported annual availability	≥8,000 h/y	<5,500 h/y, but limited data available	Insufficient data available	Insufficient data available
Pre-treatment required for MSW	No	Yes	Yes	Yes
Net electricity production (incl. pre-treatment)	500-650 kWh/t	Limited data available 0-250 kWh/t	Limited data available <100 kWh/t	Insufficient data available
Tipping fee per ton of waste	30-100 USD/t depending on opportunity for sale of energy	Limited data available, according to information from Japan and Italy approx. 300-500 USD/t	Limited data available info shows that > 80-100 USD/t (+100 USD/MWh) is not sufficient to achieve a bankable business case	Limited data available
Operational track records	Numerous plants records publicly available. Bankable projects	Full scale plants shut down (Karlsruhe, Rome…). Bankable?	Full scale plants shut down (Teeside, Ottawa…). Bankable?	Full scale plants shut down (Italy..). Risks for explosion. Bankable?

RAMBØLL

WTE IS PART OF THE SUSTAINABLE AGENDA

- Circular flows will always have a residual waste stream either due to market conditions, technologies available, social barriers or the need for sanitizing
- The residual not recycled waste stream is an important energy source and an important contributor in saving fossil fuels and reducing climate impact
- WTE is an important contributor to the UN sustainable development goals

RAMBØLL

THANK YOU FOR YOUR ATTENTION

Bettina Kamuk
Global Market Director, Ramboll Energy from Waste
bkc@ramboll.com
+45 51618626