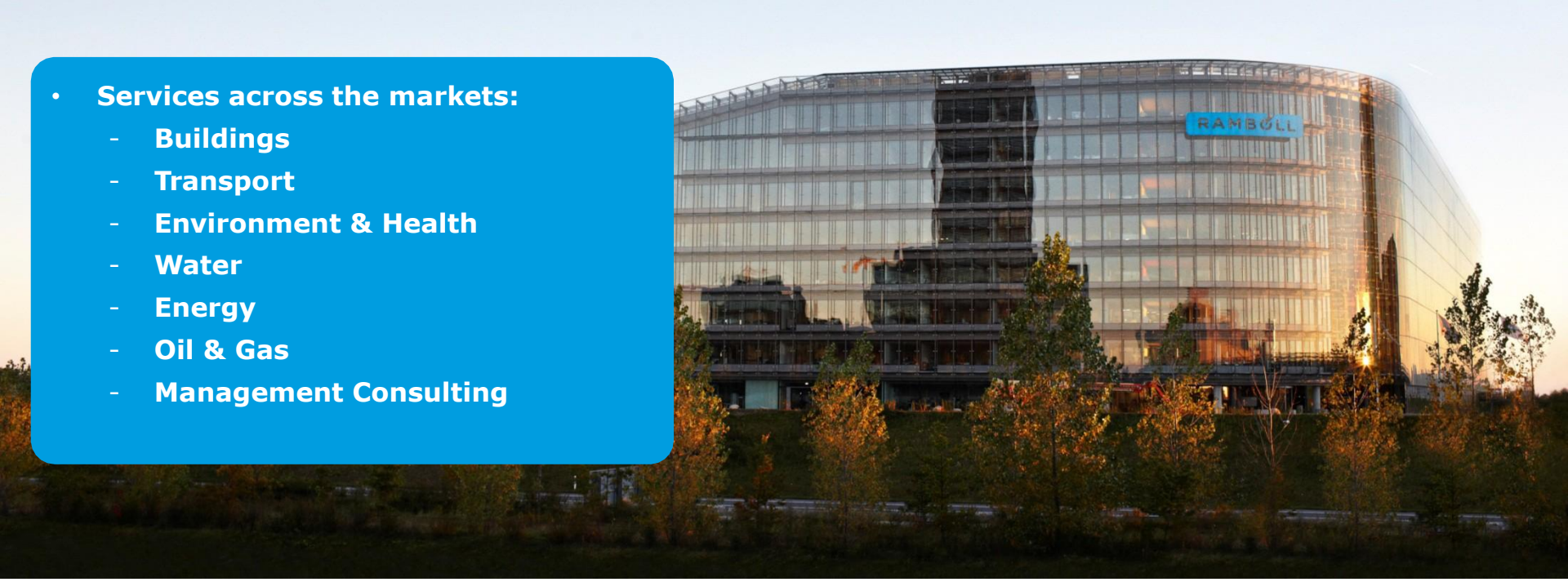
Danish experience with MSW management

Klaus Fafner, Ramboll

IX International Investment Business Forum
Renewable Energy and Energy Efficient
Modernization of Industry

November 2017

- **Services across the markets:**
  - **Buildings**
  - **Transport**
  - **Environment & Health**
  - **Water**
  - **Energy**
  - **Oil & Gas**
  - **Management Consulting**



Ramboll in brief

- Independent engineering and design consultancy and provider of management consultancy
- Founded 1945 in Denmark
- Over 13,000 experts
- Over 300 offices in 35 countries
- Significant presence in the Nordics, North America, the UK, Continental Europe, Middle East, Asia, Australia, South America and Sub-Saharan Africa

- EUR 1.1 billion revenue
- Owned by Ramboll Foundation
- Ramboll Energy - **World leaders in low carbon, district energy infrastructure and waste to energy**
- At the forefront of developments in Danish district heating sector for over 40 years

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AGENDA

1. The Danish Approach as regards Municipal Solid Waste Management
2. Waste Strategy
3. Impact of Strategy on District Heating
4. Challenges for Energy Recovery Facilities

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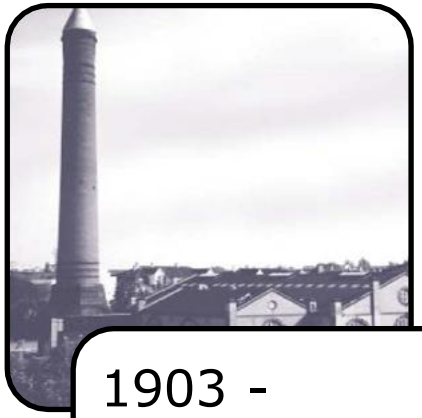
115 YEARS OF WASTE INCINERATION IN DENMARK



1903 - Frederiksberg

- First waste incineration plant with CHP

Today

- Extensive waste incineration

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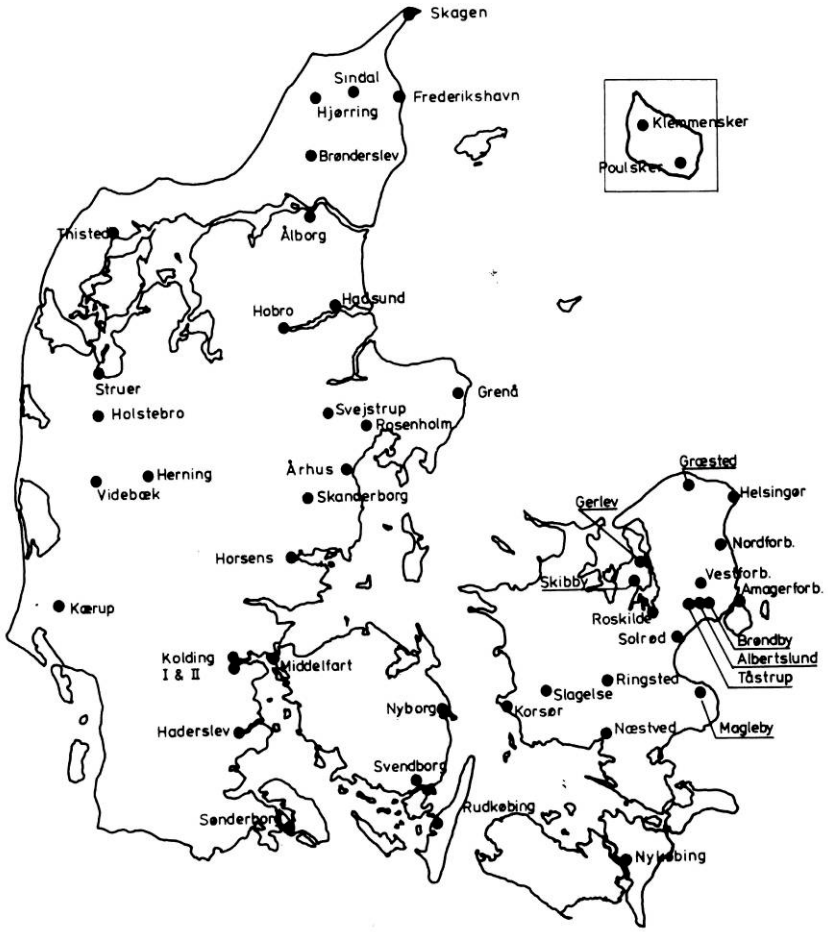
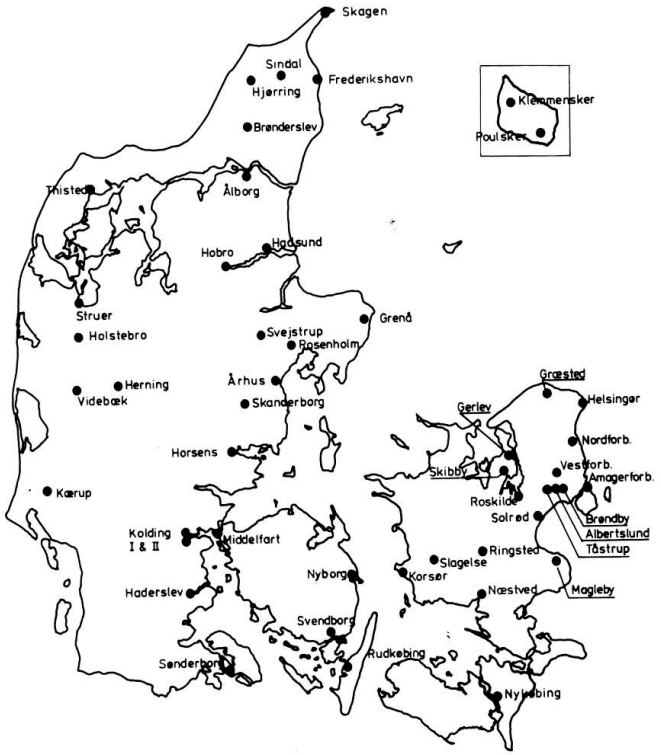
115 YEARS OF WASTE INCINERATION IN DENMARK - HIGHLIGHTS

- Waste-to-Energy facilities are public utilities owned by the municipalities a are based on Not for Profit principles
- New energy policy in 1990:
  - Heat primarily to be produced in CHP: Combined Heat and Power plants
  - Existing plants to be converted to CHP
- 1997: Ban on landfilling of combustible waste
- Today waste is regarded a useful fuel for CHP production - for waste that cannot be recycled or reused
  - More than 20% of all district heating i from waste incineration
  - 5% of electricity is from waste incineration



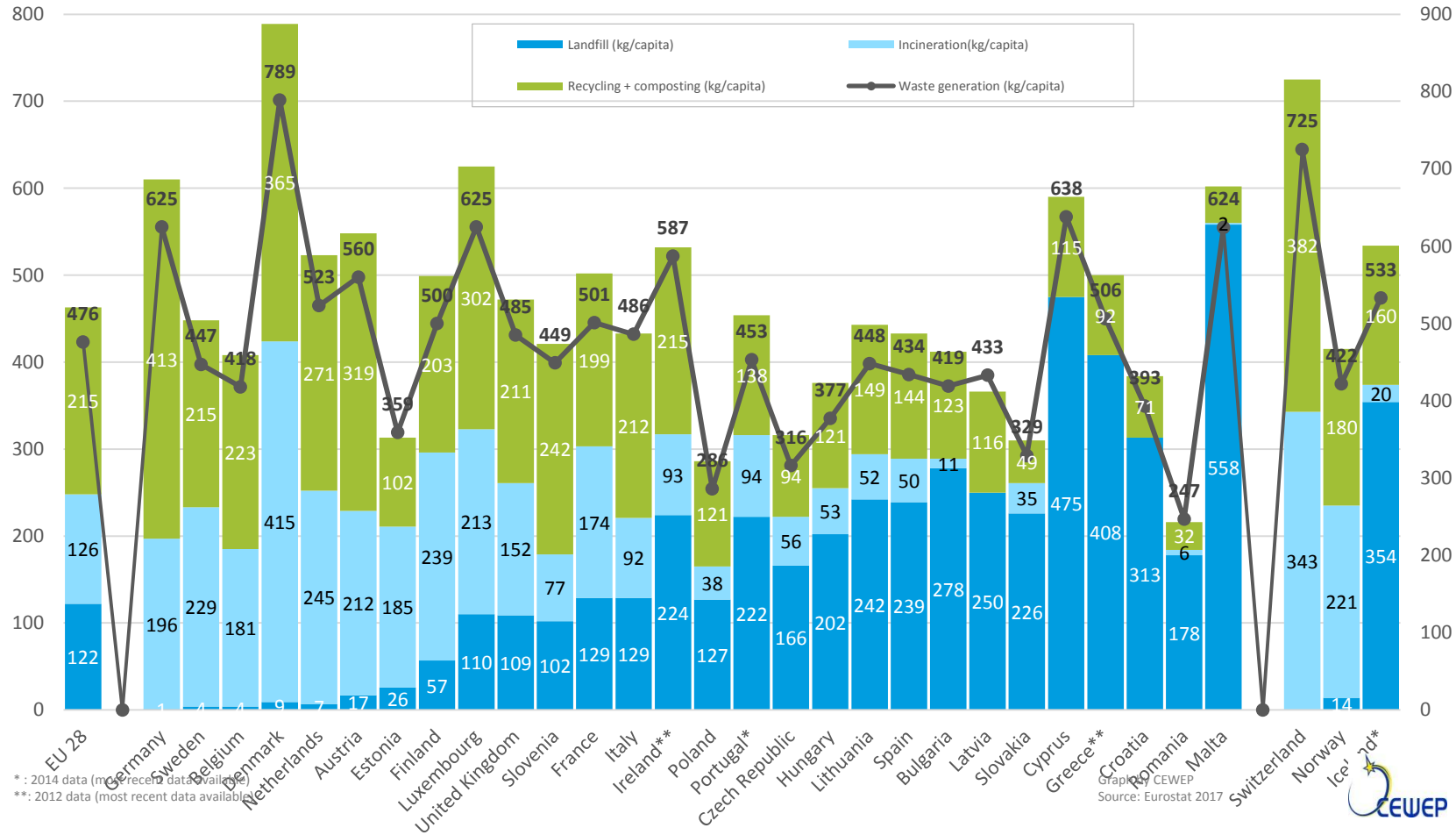
THE DANISH APPROACH: MAIN FOCUS ON WASTE INCINERATION

- Waste incineration makes a significant contribution to reduction of CO2 emissions.
- Waste incineration minimize the landfilling of waste. Just 6% of Denmark´s waste ends up in a landfill.
- Danish waste incineration plants are the cleanest and most efficient in the world, generating approx. 2 MWh heat and 2/3 MWh electricity from every ton of waste incinerated.
- A new strategic approach to waste is to encourage recycling over incineration. By 2022, 50% more household waste will be recycled instead of incinerated.



MUNICIPAL WASTE TREATMENT IN 2015

EU 28 + SWITZERLAND, NORWAY AND ICELAND



* : 2014 data (most recent data available)
**: 2012 data (most recent data available)

Graphic by CEWEP
Source: Eurostat 2017

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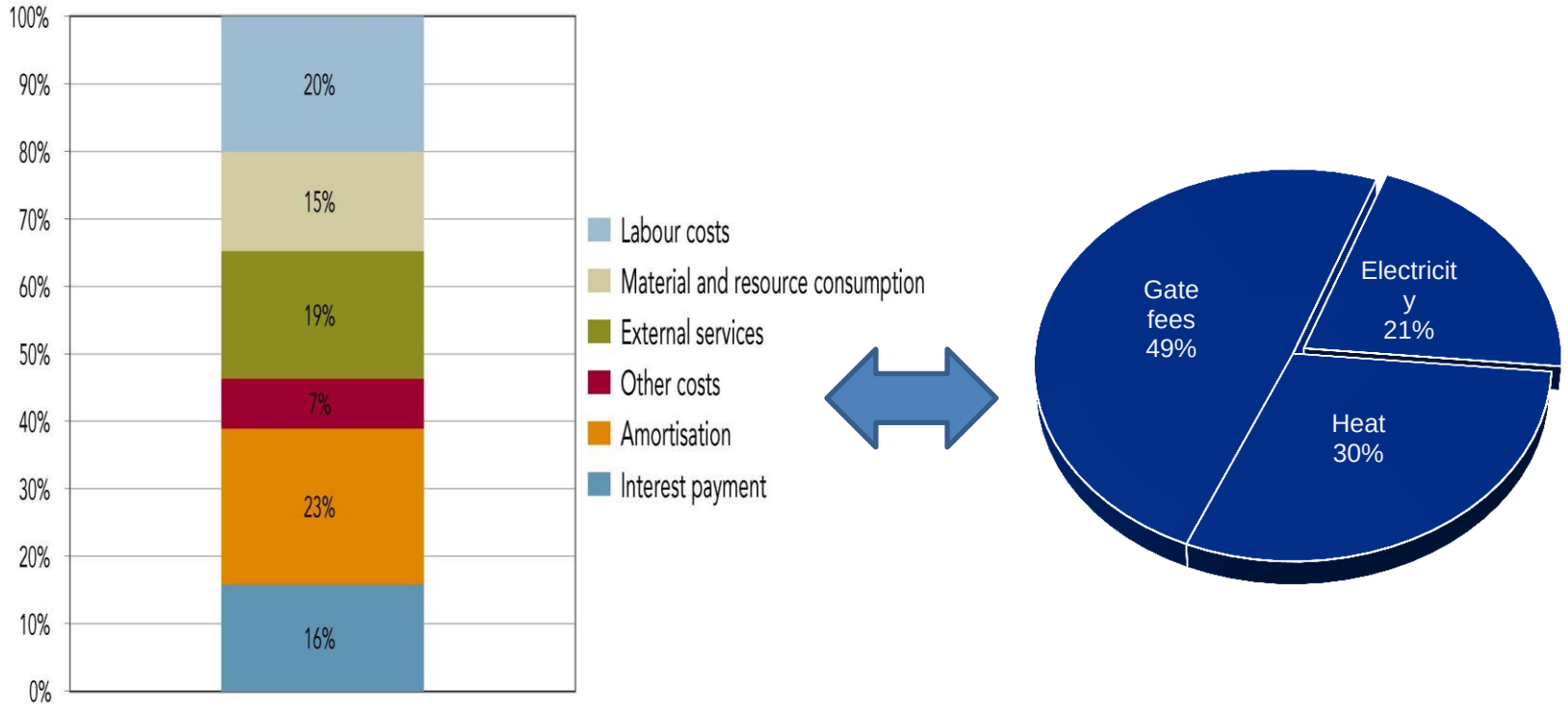
TYPICAL DISTRIBUTION OF INCINERATION COSTS and income



AMAGER BAKKE, COPENHAGEN, DENMARK

- Green-field WtE facility
- Capacity: 2 x 280,000 tonnes of waste annually
- Energy output: 400,000 MWh electricity and 1,000,000 MWh heat per year
- From project analysis and planning to take over
- Owners Engineer on M&E, site management
- Commissioning: 2016

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KARA/NOVEREN, ROSKILDE, DENMARK

- New waste-to-energy unit
- 200,000 tpa
- From project analysis and planning to take over
- Owners Engineer on M&E
- Commissioning: 2013

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I/S NORDFORBRÆNDING, DENMARK

- New unit for waste-to-energy facility
- 96,000 Tpa
- From project planning to take over
- M&E advisor and Owners Engineer
- Commissioning: 2016

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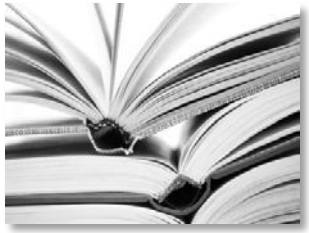
TIMELINE OF REGULATION AND STRATEGIES

Energy crisis

Responsibility for Communal Waste switches to Municipalities

1970

- Hazardous waste
- Environmental regulation of landfills



1990

- Recycling of paper and glass
- Tax on landfill and incineration
- Regulation of commercial waste

1997

- Recycling stations
- EU Landfill ban

2006

- Electronically waste (EU producer responsibility)
- Packaging waste (EU regulation demand)

2014

- EU Roadmap and resource plan
- Planning a future without waste in Denmark

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ROADMAP TO A RESOURCE EFFICIENT EUROPE FROM 2011:

Denmark became member of EU in 1973

EU MILESTONES BY 2020:

- Waste is managed as a resource
- Waste generated per capita is in absolute decline
- Waste legislation is fully implemented
- Energy recovery (by waste-to-energy) is limited to non recyclable materials
- Landfilling is virtually eliminated
- High quality recycling is ensured

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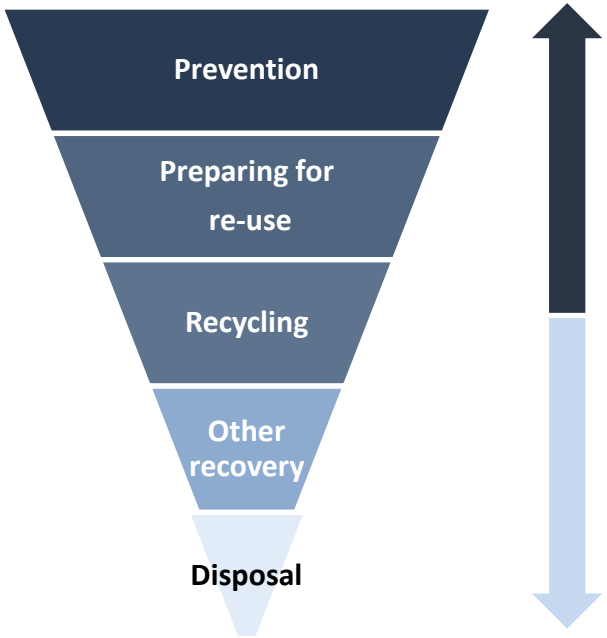
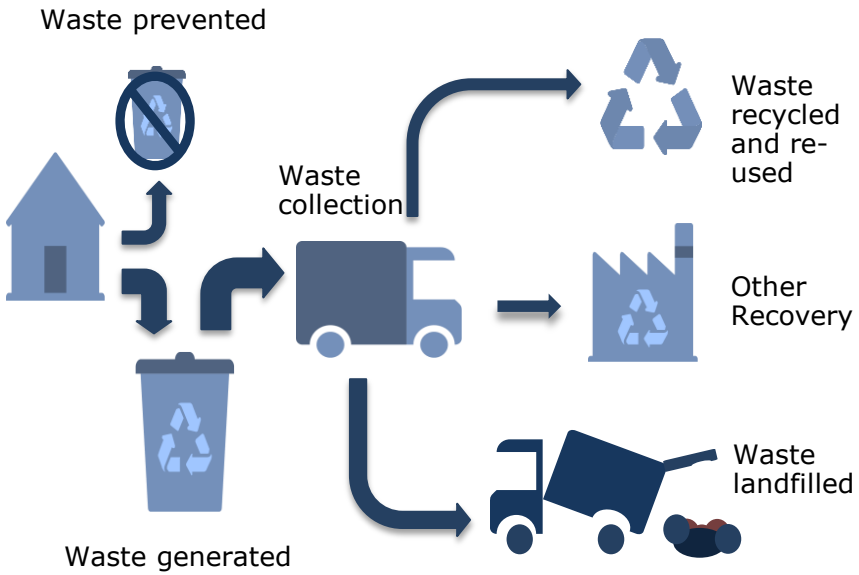
THE STRATEGIC WASTE HIERARCHY



Most favoured option

Least favoured option



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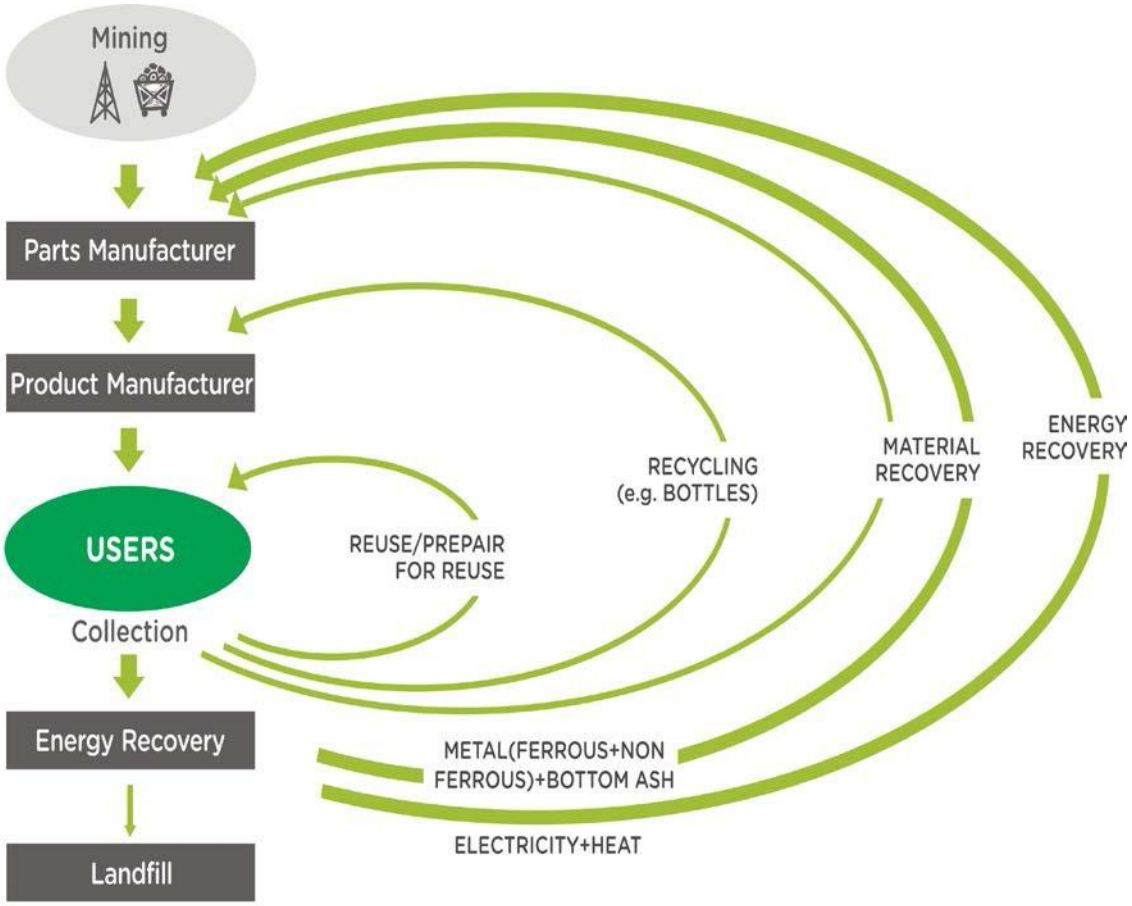
CIRCULAR ECONOMY AND WASTE HIERARCHY



Energy Recovery Facilities

- ERF important measure to ensure energy recovery from "last cascade" of recycling
- ERF important measure to ensure a safe sink for polluted materials
- ERF can ensure recovery of the small metal fractions

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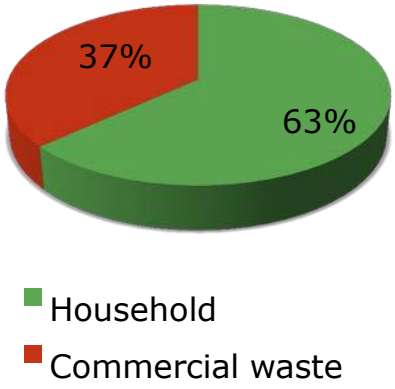
WASTE HIERARCHY AND COST INCENTIVES

RECYCLING

- Pre-sorting and recycling
- "Free" entrance for households
- Gate fee for companies: 20- 60 €/visit
- 20-30 waste types

WASTE TO ENERGY

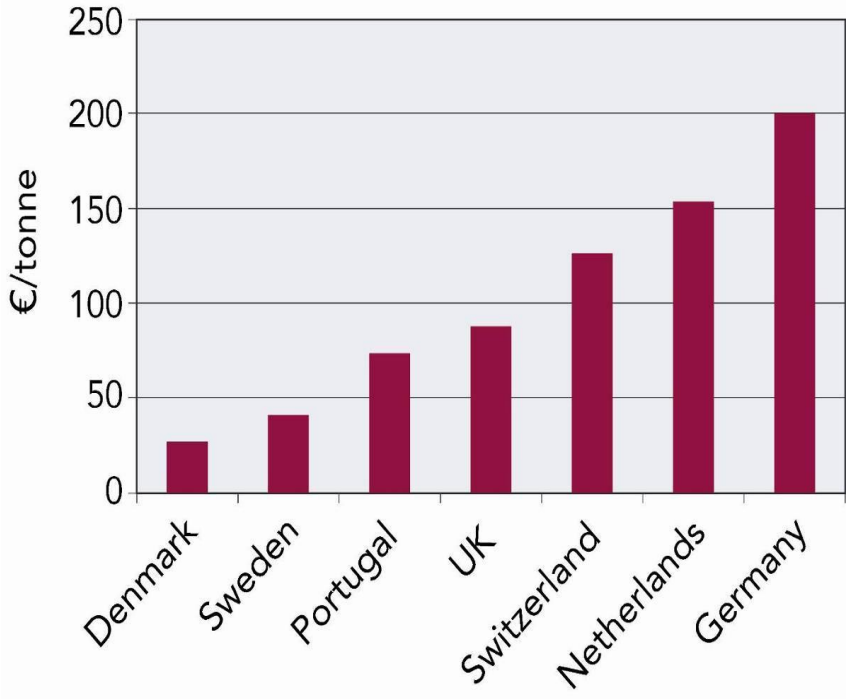
Average fee 2011	$/ ton
Fee	42
Tax	39
Gate fee	81

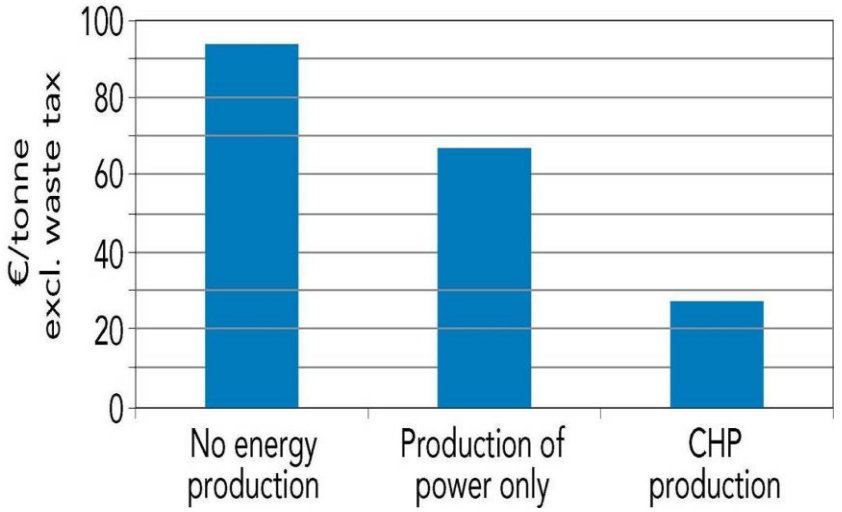


LANDFILL

Average fee 2011	$/ ton
Fee	65
Tax	85
Gate fee	150

GATE FEES IN EUROPE





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WASTE INCINERATION AND DISTRICT HEATING IN DENMARK

Main DH systems Denmark 2010	Systems	Average peak MW	Produced heat GWh	Waste CHP GWh	Biomass heat GWh	Biomass CHP GWh	Surplus heat GWh	Solar heat GWh	Geo-thermal GWh	Fossil CHP GWh	Fossil heat GWh
Greater Copenhagen	1	3.386	9.481	2.223	43	1.218	0	0	161	5.682	154
Aarhus DH	1	1.063	3.083	577	97	28	53	0	0	2.318	10
Aalborg	1	587	1.761	307	0	0	446	0	0	1.000	7
TVIS	1	579	1.737	187	2	0	331	0	0	969	248
PP extraction	11	143	4.708	1.079	179	0	25	0	0	**3.373**	52
Waste + Biomass SC	18	57	3.062	**1.785**	201	**690**	12	0	7	202	164
Waste + Gas CC	8	52	1.240	**530**	89	9	0	0	0	**488**	122
Gas SC/CC	224	8	5.812	156	178	19	9	10	0	**4.633**	806
Bioenergy etc.	112	8	2.898	120	**2.428**	**115**	87	17	0	0	132
Sum	377		33.781	6.965	3.218	2.079	961	27	169	18.667	1.696
Share			*100%*	*21%*	*10%*	*6%*	*3%*	*0%*	*0%*	*55%*	*5%*

COPEHAGEN – THE BIGGEST DISTRICT HEATING SYSTEM WITH ENERGY FROM WASTE

Facts

160 km pipe mains

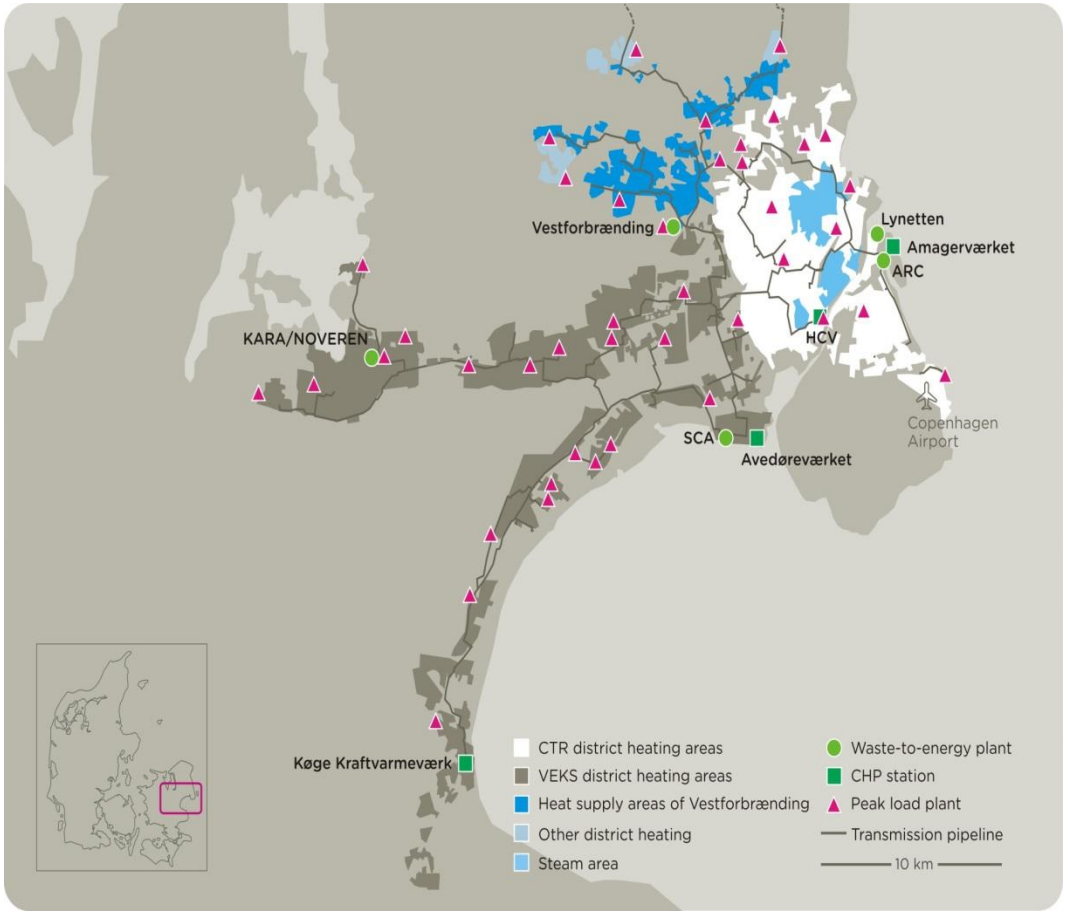
30.000 TJ/a heat sold

60 mill. M2 floor area heated

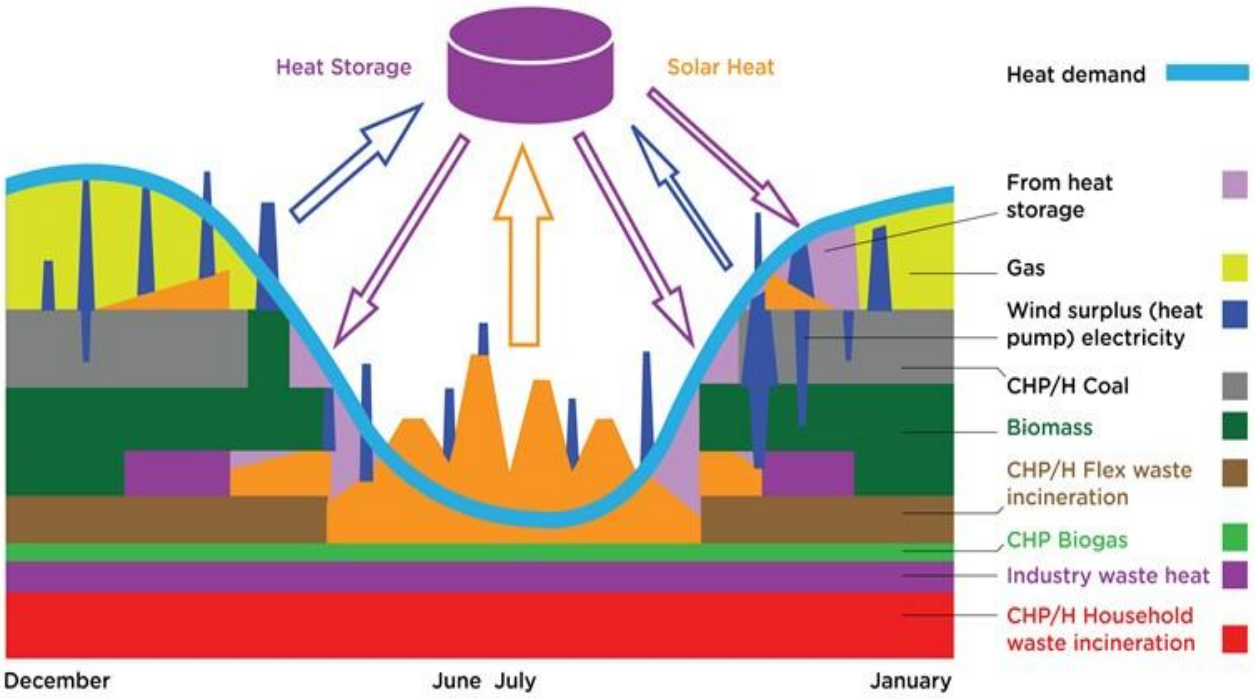
110 kg CO2 /MWh

25 % Waste-to-Energy

97 % CHP production mode



WASTE-TO-ENERGY AND DISTRICT HEATING AN ELEMENT OF SMART ENERGY SYSTEMS



Balancing supply and demand

Merit order of production to minimise cost and carbon emissions

Energy and price forecasting to avoiding spilling and to maximise value of within the power market (NORDPOOL)

Capturing, storing and dispatching “free heat”

Minimising heat losses though continuous optimisation

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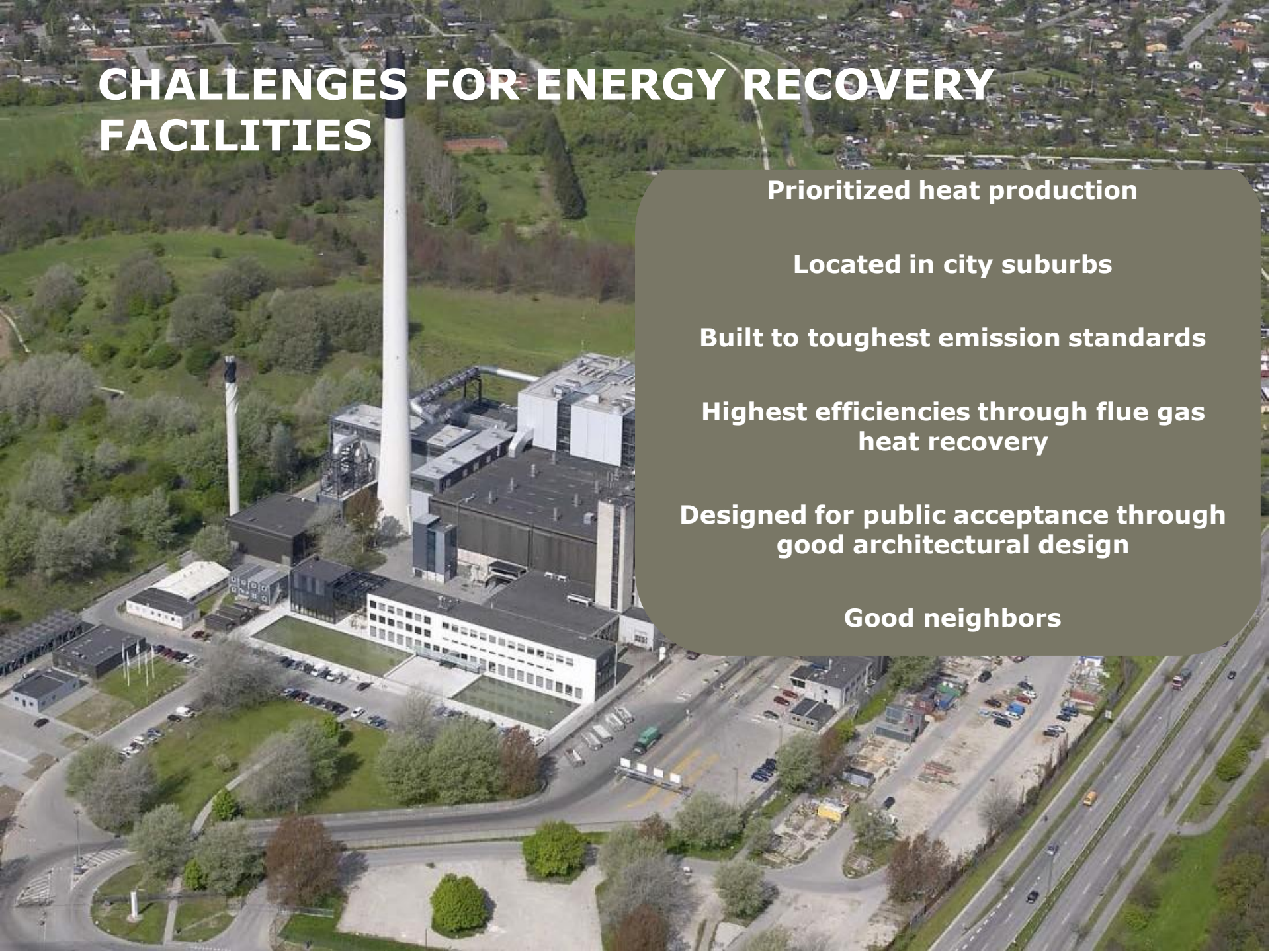
CHALLENGES FOR ENERGY RECOVERY FACILITIES



Prioritized heat production

Located in city suburbs

Built to toughest emission standards

Highest efficiencies through flue gas heat recovery

Designed for public acceptance through good architectural design

Good neighbors

CHALLENGES FOR ENERGY RECOVERY FACILITIES

- Commercial and Financial Environment
  - High investment costs and long development timescales
  - Risk reward profile deters private sector and 3rd party investors
  - Immature supply chain drives up costs
  - Complex stakeholder arrangements

- Policy environment
  - No direct support for heat networks
  - Policy instability at national level
  - Local planning policy - insufficient leverage

- Technical challenges
  - Retrofitting costs (building temperatures and heating systems)
  - Development density
  - Existing utilities and grid connection
  - Supply chain lacks capacity and knowhow

- Capacity and appetite to deliver
  - Internal resources, funds, relevant skills
  - Access to finance
  - Appetite for risk

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FINAL CONCLUSION:
MAIN BENEFITS OF EFFICIENT WASTE MANAGEMENT

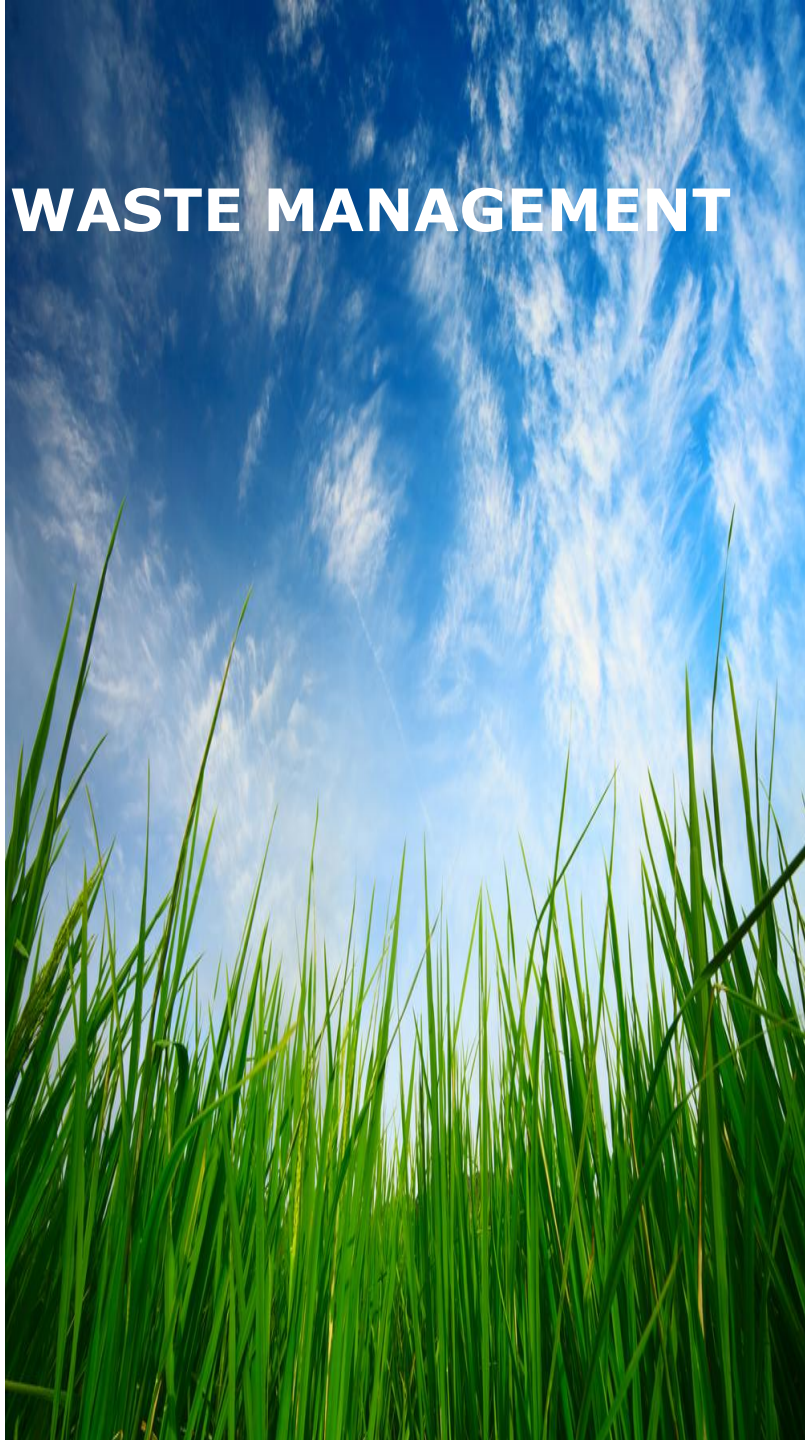
Provide a clear indication of **Government policy** which will shape the actions of local self-government units and give confidence in relation to investment

Relieving the pressure on the extraction of **raw materials** through the reuse of products and the recycling of paper, glass, plastic etc

A reduction of **greenhouse gas emissions** (e.g. through increasing diversion of biodegradable waste to landfill and managing LFG by flaring or utilization);

An increase in **job opportunities** in the waste sector and recycling sector;

An enhanced environment and a **cleaner and safer place to live**, through the prevention of pollution to ground, water and air, and reduced litter by the provision of safe landfills operated to best international practice.



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THANK YOU FOR YOUR ATTENTION!

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