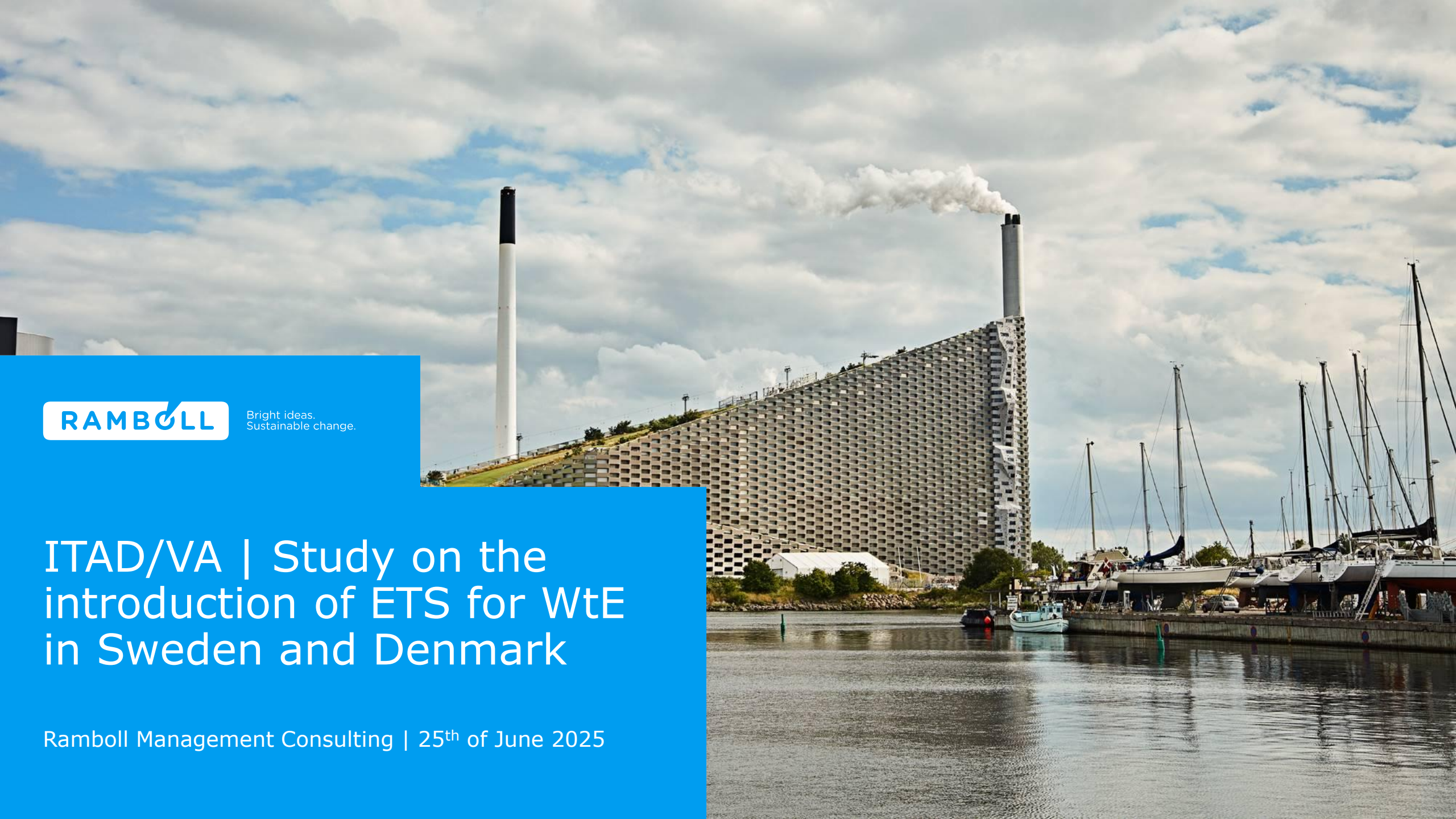

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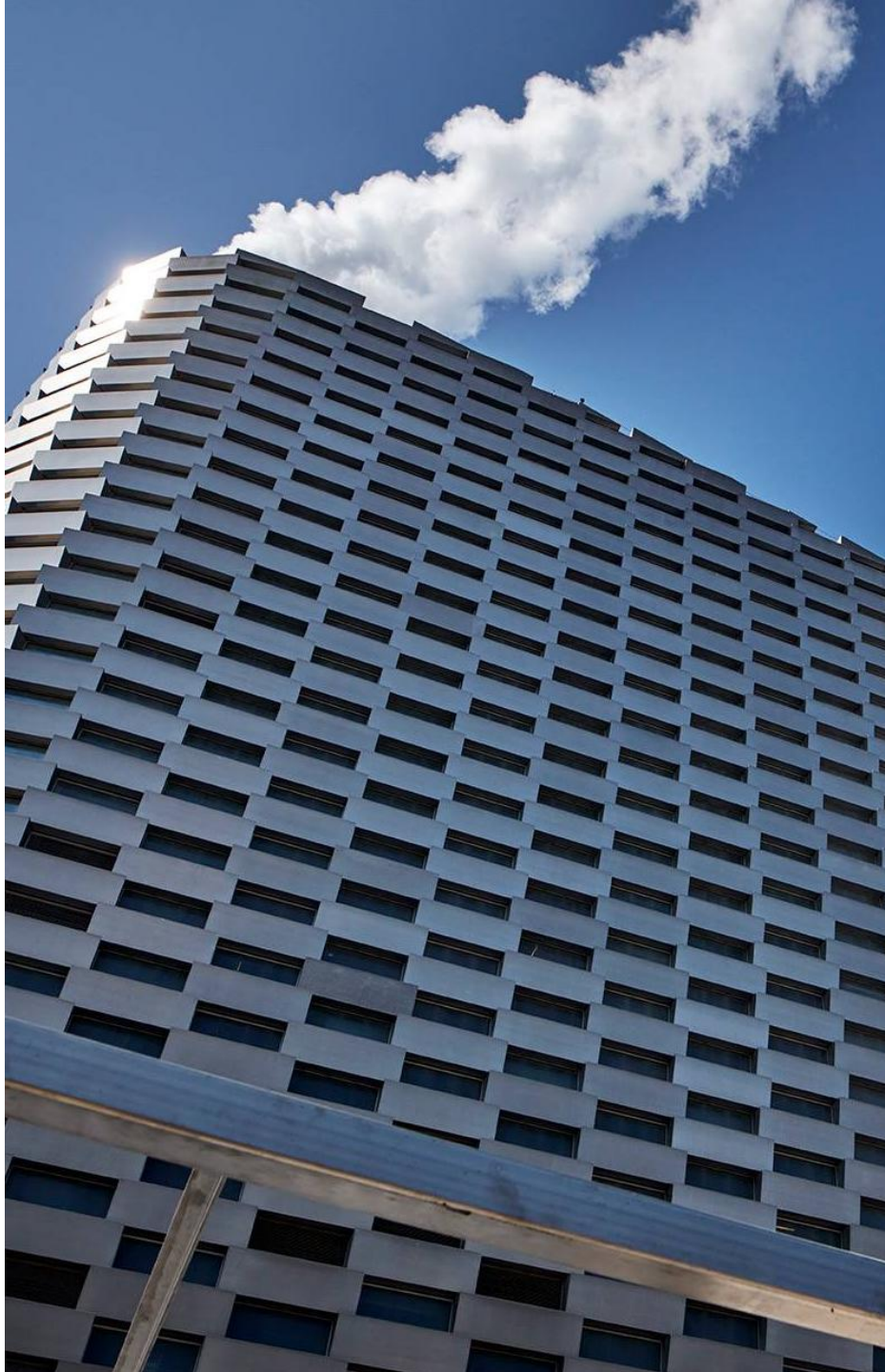
Sustainable change.

# ITAD/VA | Study on the introduction of ETS for WtE in Sweden and Denmark

Ramboll Management Consulting | 25th of June 2025

# Contents





# Executive Summary: Market Study on ETS in Waste-to-Energy (WtE) in Sweden and Denmark

## 1. Waste Volumes & WtE Capacities

- Denmark: Approximately 12 million tonnes of waste per year total, with 22 % incinerated in 26 WtE plants (total WtE capacity: 4.5 Mt). A significant reduction in capacity is expected, and by around 2030, domestic capacity will likely fall short, requiring strategic export planning.
- Sweden: Approximately 22.6 million tonnes of waste, with about 30 % thermally treated in 35 dedicated WtE plants. Technical capacity remains stable at approx. 7 Mt. Excess capacity is filled by imports, primarily from Norway and the UK.

## 2. Energy Output & Economic Aspects

- Heat is the dominant energy output from WtE plants in both countries and is seen as a socially relevant strategic asset for the energy system:
  - Denmark: The contribution to the national district heating system is increasing steadily.
  - Sweden: Heat production remains steady but slightly declined from 2022 to 2023.
- Revenue composition: In Denmark, net revenues from heat sales account for the majority of WtE income. Electricity revenues remain marginal but volatile (e.g., spike in 2022 due to the Ukraine war).

## 3. EU ETS & National $CO_2$ Pricing

- Both countries include WtE in their national ETS schemes, with the following distinctions:
  - Denmark additionally applies a CO2 tax (2024: €26/t, 2025: €111/t) and a GHG emissions tax (from 2025: €11/t $CO_2e$).
  - Sweden does not apply a national CO2 tax to WtE plants covered by ETS. Its carbon tax only applies to non-ETS sectors.
- Despite increasing ETS prices, fossil CO2 emissions from WtE plants have remained largely stable in both countries – pricing alone has not driven emission reductions so far.

## 4. Monitoring & Reporting

- Monitoring follows the EU Monitoring and Reporting Regulation (MRR) but may not necessarily be congruent with the European requirements:
  - Denmark: Prefers direct measurement (e.g., C14 testing) or the BIOMA calculation model.
  - Sweden: Large facilities measure directly; smaller ones apply standardized emission factors.

## 5. Free Allocation of Emission Allowances

- In both countries, 26–31 % of emission allowances were granted free of charge in 2022, but this share is set to decline to 0 % by 2030.
- Implication: Increasing compliance costs for WtE operators - especially critical under high ETS price scenarios.



Source: Ramboll experts,

# Key Takeaways

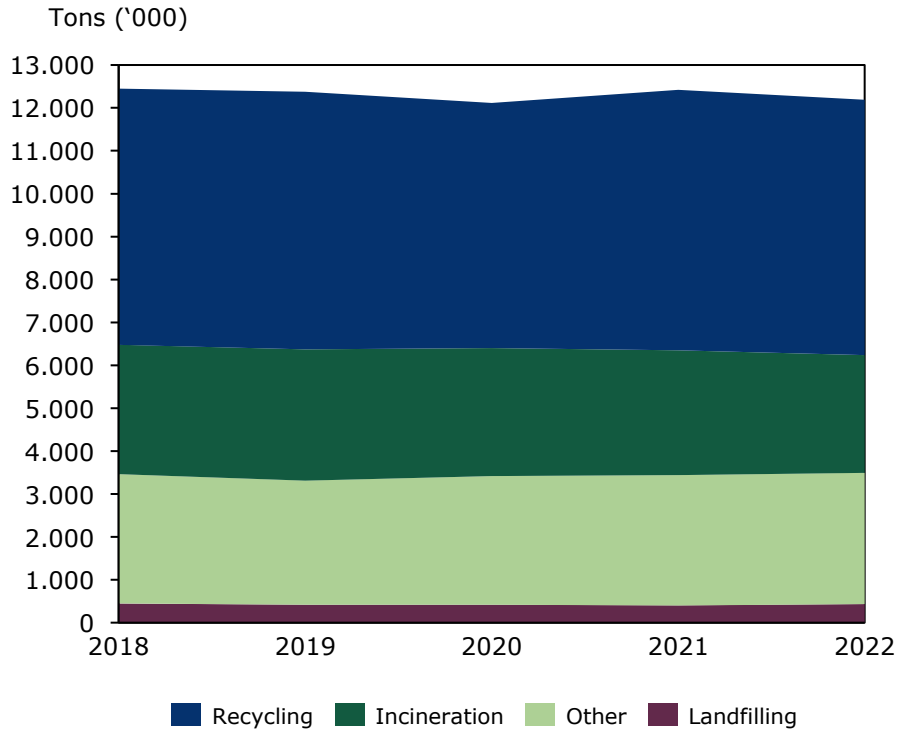
- Heat generation is key to WtE business models in Denmark and Sweden and both countries see WtE as a socially relevant strategic asset for the energy system.
- ETS pricing / CO2-taxation has had little effect so far on CO2 emission reduction in the WtE sector.
- Denmark pursues a far more aggressive CO2 pricing approach than Sweden via its green tax reform.
- Free allocation of allowances currently plays an important economic role but is being phased out—cost pressure on WtE operators is growing in the near future when this competitive advantage fades.
- The national methods of measuring CO2 is not necessarily congruent with the European requirements, and it is possible that customization in European regulations is required if WtE falls within the European EU-ETS system.
- Import dependency remains a strategic factor (DK: future exporter; SE: reliant on waste imports).

# 02 | Brief overview of waste markets

# Total waste volumes in Denmark average at ~12 million tons, of which around 22% are incinerated

**Waste volumes and incineration in Denmark** | 22% of Denmark's 12.2 million tons of waste were incinerated across 26 plants in 2022.

## Generated waste (excl. soil) by treatment type[1]




## Incineration in Denmark[2]

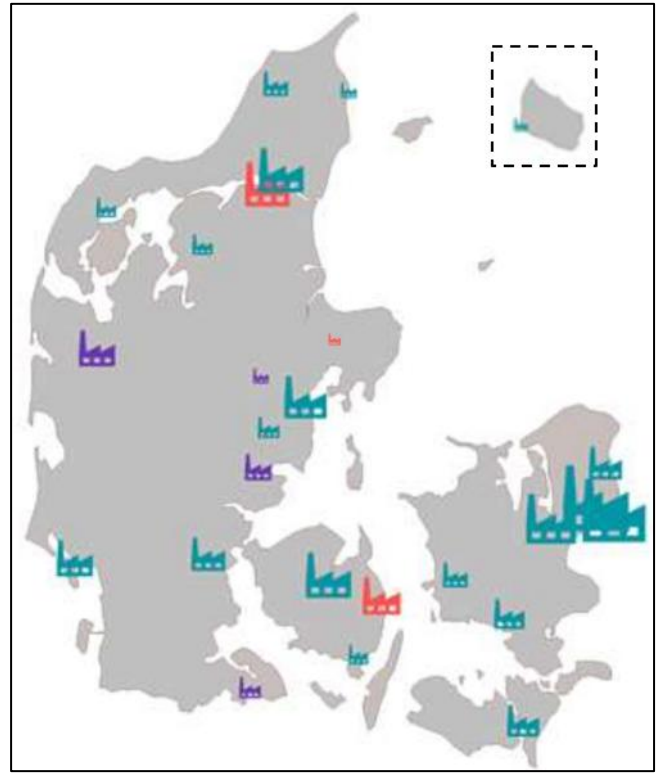
In Denmark, there are 26 incineration plants with a total capacity of 4.5 million tons. Most plants are CHP-Plants while 5 are solely heat plants.

There are three main plant types:

**Dedicated** plants (19) incinerating household and industrial waste energy production

**Multi-fired** plants (4) incinerating household and industrial waste as well as biomass and/or natural gas

**Special** plants (3) primarily incinerating toxic waste



**Incineration plants by type and capacity**



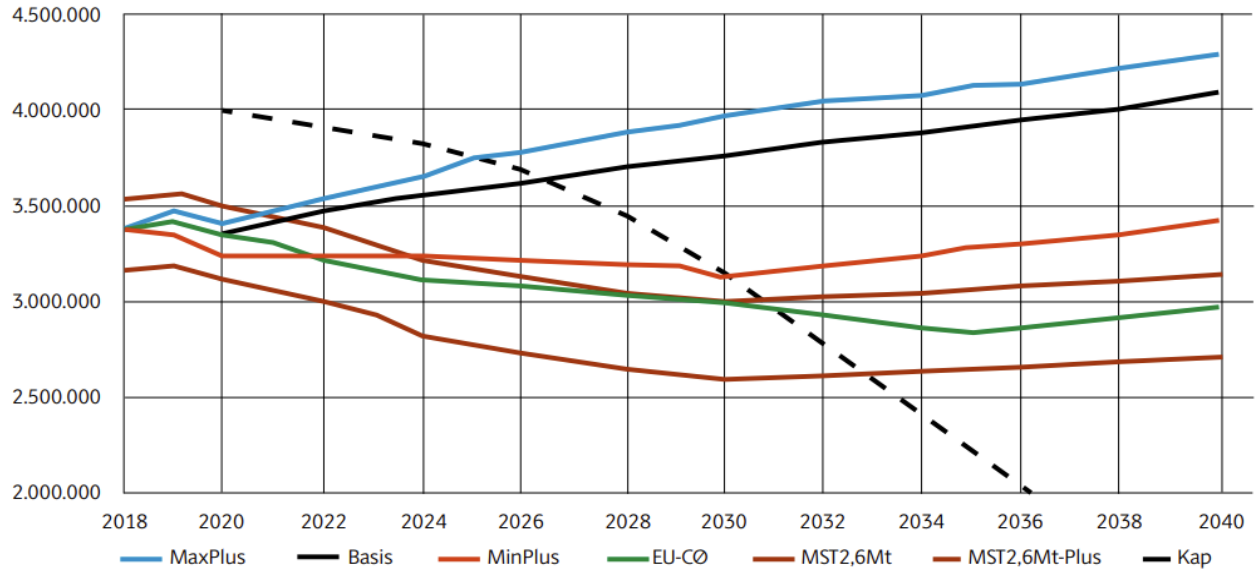
Source: (1) The Danish Environmental Protection Agency (2022): Affaldsstatistik 2022; (2) Source: The Danish Energy Agency (2021): Beate 2021

# Denmark's Waste-to-Energy capacity is projected to decline significantly in the coming years due to political ambitions

**Development of capacity and amount of waste in Denmark** | Denmark's WtE capacity is projected to decline significantly in the coming years. Around 2030, domestic capacity will likely be insufficient to manage national waste volumes, requiring strategic planning for export solution, potentially leveraging existing international waste trade agreements to secure export routes.

## Waste incineration forecasts for Denmark (tonnes/year)[1]

It is projected that there will be an equilibrium between waste volumes and capacity between 2026-2033, dependent on the waste prognosis.




## Import of waste for incineration to waste incineration plants excluding specialised plants[2]

Germany has been the primary country from which Denmark imports the largest share of waste. Overall, Denmark's waste **imports have fluctuated in recent years, with a downward trend in the most recent period.**

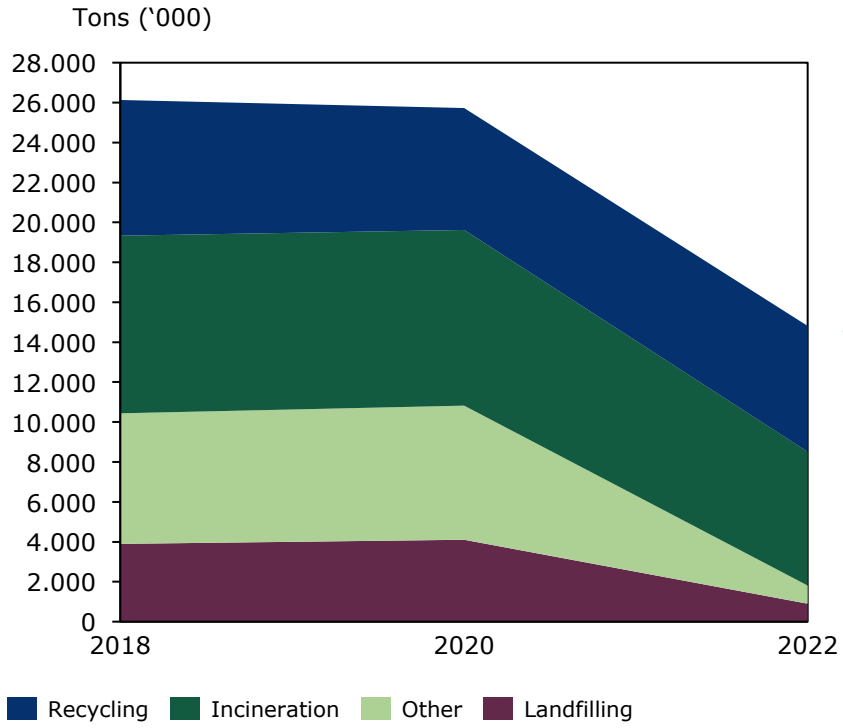
| Import of waste suitable for incineration ('000 tonnes)[2] | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| Germany | 148 | 165 | 173 | 187 | 108 |
| United Kingdom | 139 | 163 | 85 | 90 | 114 |
| Ireland | 0 | 44 | 81 | 47 | 36 |
| Norway | 5 | 0 | 0 | 14 | 0 |
| Sweden | 0 | 0 | 0 | 0 | 0 |
| Italy | 0 | 9 | 38 | 44 | 90 |
| Iceland | 0 | 0 | 16 | 0 | 10 |
| **Total** | **292** | **380** | **393** | **382** | **358** |

Source: (1) Source: The Danish Local Government Association (2020): *KL's plan for at tilpasse kapacitet for affaldsenergi frem mod 2030; (2)* Source: The Danish Environmental Protection Agency (2022): *Affaldsstatistik 2022*

# Total waste volumes in Sweden average at ~22.6 million tons, of which around 30% are incinerated

**Waste volumes and incineration in Sweden** | In 2022, Sweden generated 22.6 million tons of waste from which 6.7 million tons were incinerated across 35 WtE plants.

## Generated waste (ex. mineral waste) by treatment type[1]




The total amount of waste in 2022 was **22.6 million tons**. However, in 2022 a new data collection method was introduced, causing a break in the time series. Year-on-year comparisons are therefore not meaningful. Additionally, some data have been excluded due to confidentiality.

## Incineration in Sweden[2]

Sweden has a total of 74 plants that incinerate waste.[3]

Differentiation between:

- **WtE plants** (Avfallsanläggningar)
- **Co-incineration plants** (Samförbränningsanläggningar) that also burn hazardous waste, as well as other products (e.g. fuels)

The 35 Waste-to-Energy plants (Avfall Sverige) have incinerated 6.655 million tons of waste in 2023.


**Incineration plants**

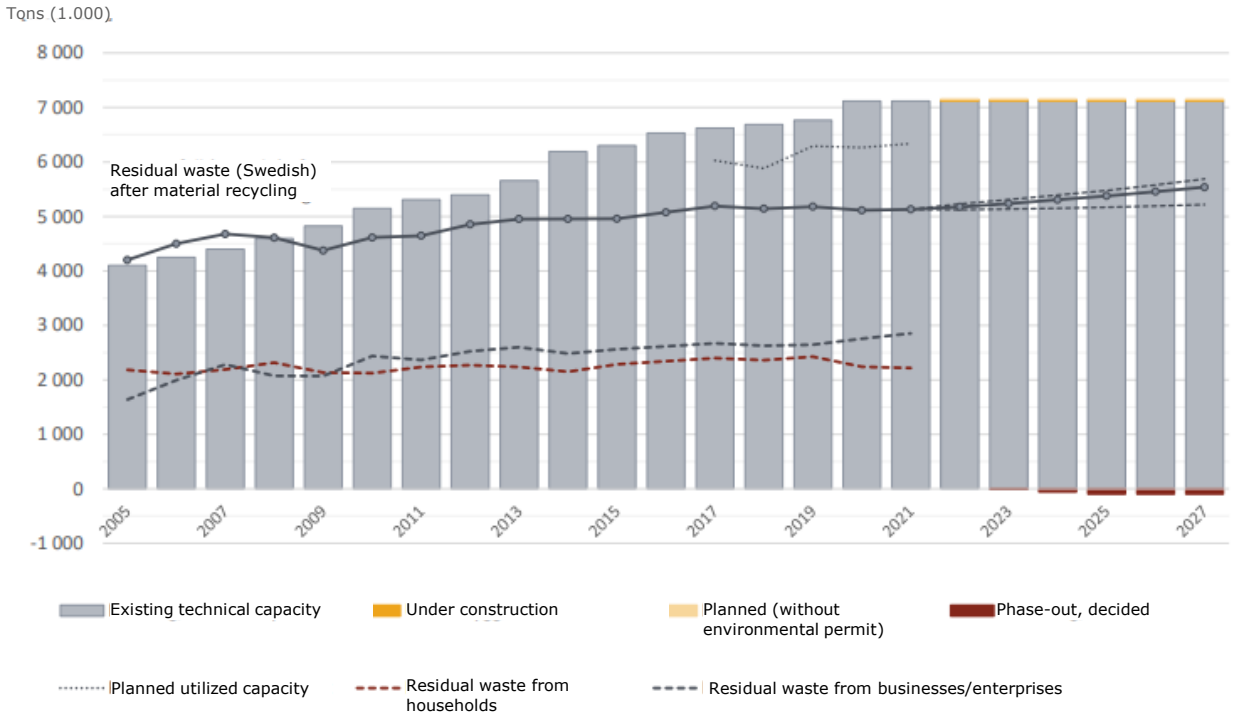


Source: (1) SCB; (2) Avfall Sverige – Swedish Waste Management; (3) Sweco for Naturvardsverket

# Technical waste incineration capacity in Sweden is expected to remain at approx. 7 million tons

**Development of capacity and amount of waste in Sweden** | In 2023, Swedish waste incineration plants had an excess capacity of approx. 2.2 million tons, covered by imports, primarily from Norway, to optimize energy recovery and utilize available incineration infrastructure.

## Waste incineration forecasts for Sweden (tonnes/year)[1]




## Import of waste incineration plants[2]

A majority of imported waste is used for incineration.

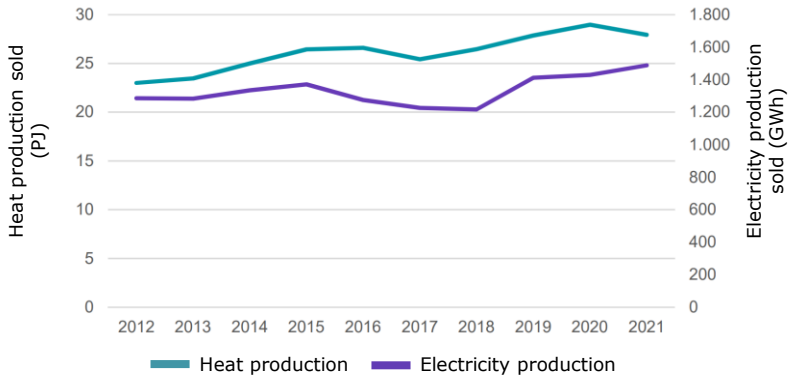
| Import of waste ('000 tonnes) | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| Norway | 1,364 | 1,341 | 1,364 | 1,472 | 1,314 |
| United Kingdom | 424 | 417 | 424 | 458 | 409 |
| Italy | 333 | 328 | 333 | 360 | 321 |
| Germany | 212 | 209 | 212 | 229 | 204 |
| Finland | 182 | 179 | 182 | 196 | 175 |
| Ireland | 121 | 119 | 121 | 131 | 117 |
| Denmark | 91 | 89 | 91 | 98 | 88 |
| Others | 303 | 298 | 303 | 327 | 292 |
| **Total** | **3,030** | **2,980** | **3,030** | **3,270** | **2,920** |

Source: (1) Swedish Waste Management (2022): KAPACITETSUTREDNING 2022; (2) The Swedish Environmental Protection Agency (2022): *Import och export av avfall*
Notes: Shares fixed to 2022.

# 03 | Energy balances & yields from WtE

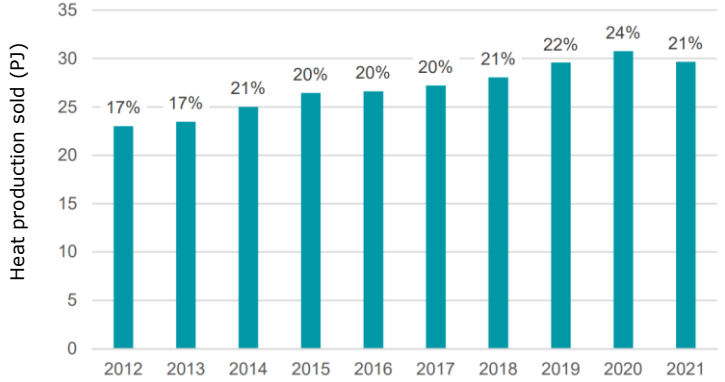
# Heat production is the key energy product of Danish Waste-to-Energy plants

Figure 2.1. Total electricity and heat production from 2011 to 2021, *(dedicated incineration plants)*



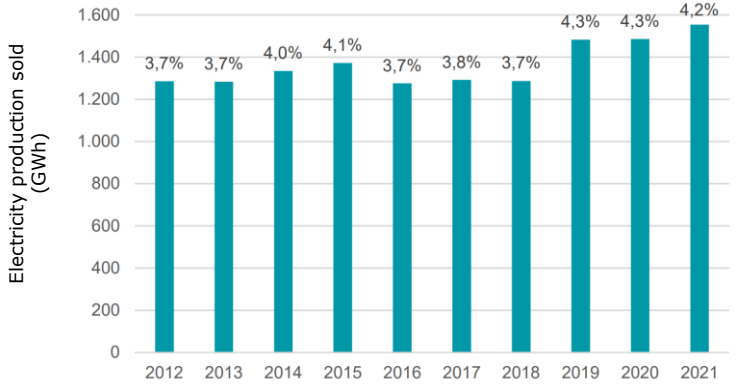

- Heat production is the primary and more consistently growing output, while electricity production has been rather constant.
- Heat output increased by approximately 30% from 2011 to 2021
- Electricity output followed a less consistent trajectory, with periods of decline (notably 2011–2013 and 2015–2018), and modest growth afterwards.

Figure 2.2. Incineration plants' sold production of heat, 2011-2021, *(percentage indicates the share of incineration plants' production relative to Denmark's total district heating supply)*




- WtE plants have played an increasingly important role in Denmark's district heating sector, with consistent growth in both volume and national share.
- WtE plants play a central role to ensure heat supply in Denmark
- The increase in the heat production has been relatively steady, with the share remaining constant only between 2015 and 2017.

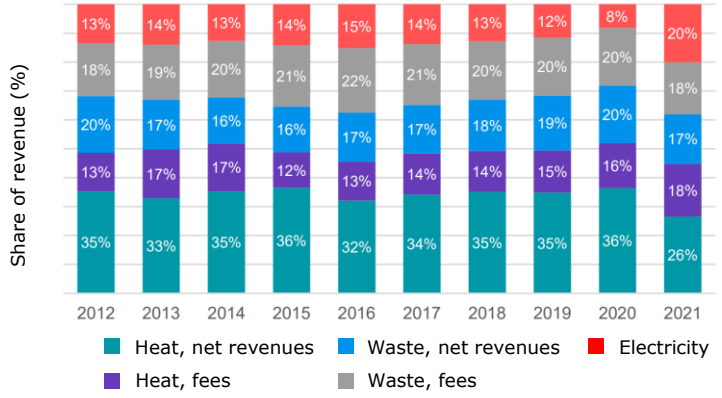
Figure 2.3. Incineration plants' sold production of electricity, 2011-2020, *(percentage indicates the share of incineration plants' production relative to Denmark's total electricity supply)*




- Electricity generation from WtE plants is a stable but limited contributor to Denmark's electricity supply, with less predictable year-on-year development.
- Historically no clear upward or downward trend is observed, and annual figures show moderate fluctuations for the WtE electricity production.

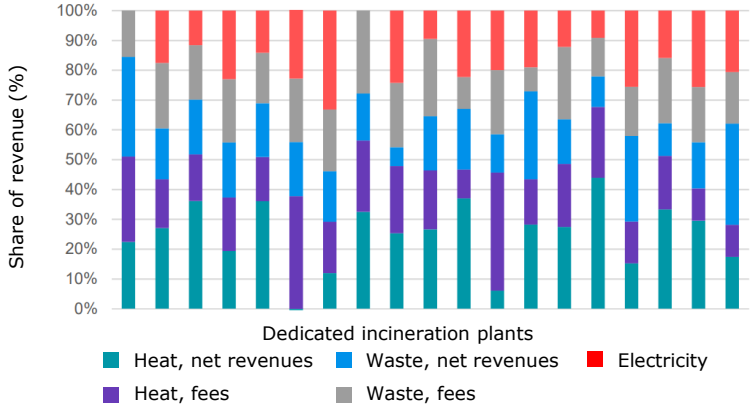
# Heat sales consistently drive most Waste-to-Energy revenue

Figure 2.4. Distribution of total revenues (percentage), 2011-2021, *(dedicated incineration plants, fixed prices)*




- Across all years, net income from heat sales constitutes the largest share of total revenue
- Figure 2.4 shows a significant shift in total revenue distribution in 2021, mainly because electricity revenue more than doubled due to higher prices.
- Until 2021, electricity represent the smallest share of total revenue across all years

Figure 2.5. Distribution of total revenues per plant (percentage), 2011-2021 *(dedicated incineration plants, fixed prices)*




- When comparing net income from heat, electricity, and gate fees, heat accounts for the largest share of total revenue in most cases.
- Only 3 out of 19 dedicated WtE plants generate more net income from gate fees than from heat sales.

Figure 2.6. Development in the average weighted waste heat price excl. taxes, 2011-2021 *(dedicated incineration plants, fixed prices)*

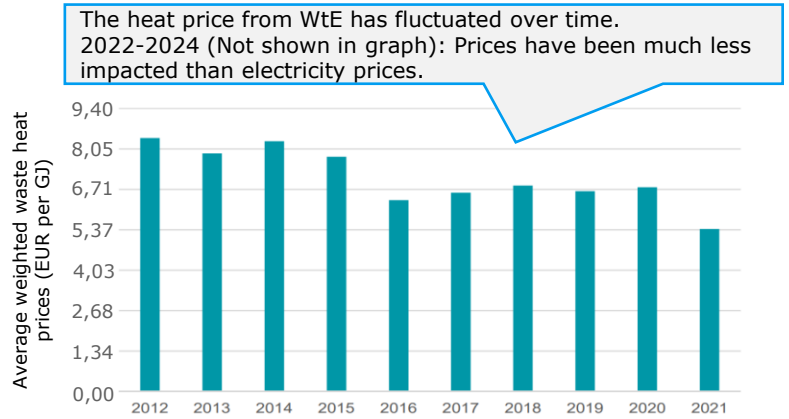


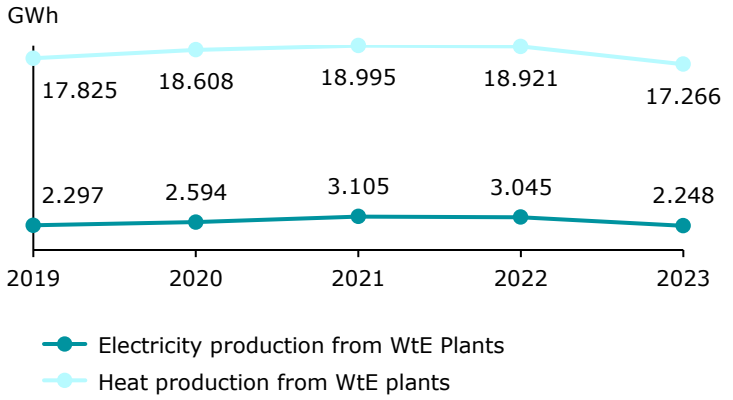

Figure 2.7. Development in the average electricity price excl. taxes, 2015-2024 *(dedicated incineration plants, fixed prices)*


Ramboll

Sources: BEATE 2021 Report ; Energipriser - Danmarks Statistik
Notes: DKK-EUR conversion rate: 7,45

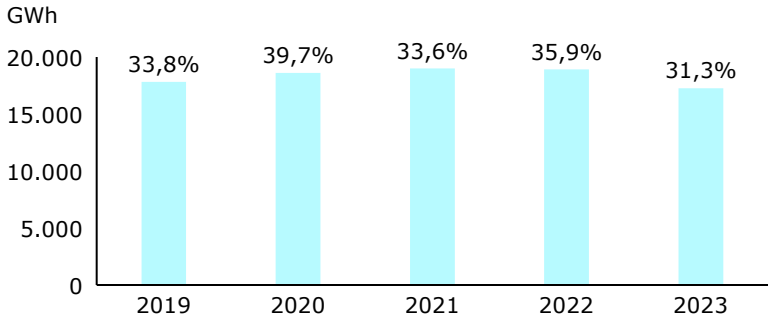
# The Waste-to-Energy sector in Sweden is predominantly focused on heat production

Figure 2.8. Total electricity and heat production from WtE plants in Sweden (2019-2023)



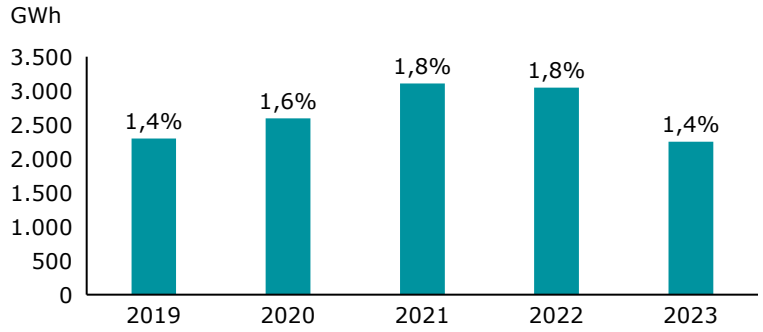

- Heat is by far the dominant output from WtE plants in Sweden
- There has been no significant growth in heat or electricity production over the observed period.

Figure 2.9. Incineration plants' production of heat, 2019-2020, *(percentage indicates the share of incineration plants' production relative to Sweden's total heat production)*




- As in Denmark, WtE plants in Sweden play a central role to ensure national heat supply
- Over the last years the heat supply has been approximately stable, annual figures show moderate fluctuations for the WtE heat production.

Figure 2.10. Incineration plants' production of electricity, 2019-2020, *(percentage indicates the share of incineration plants' production relative to Sweden's total electricity production)*




- Electricity generation from WtE plants is a stable but limited contributor to Sweden's electricity supply, with less predictable year-on-year development.
- No clear upward or downward trend is observed, and annual figures show moderate fluctuations for the WtE electricity production.

 Sources: 2023 Swedich Waste Management, AvfallSverige (2023); District heating, Statistics Sweden (2024); Electricity production, Statistics Sweden (2024)

# Heat and electricity prices in Sweden have increased significantly over time, with noticeable local fluctuations

Figure 2.11. Heat prices in dedicated Swedish municipalities in 2014 and 2024

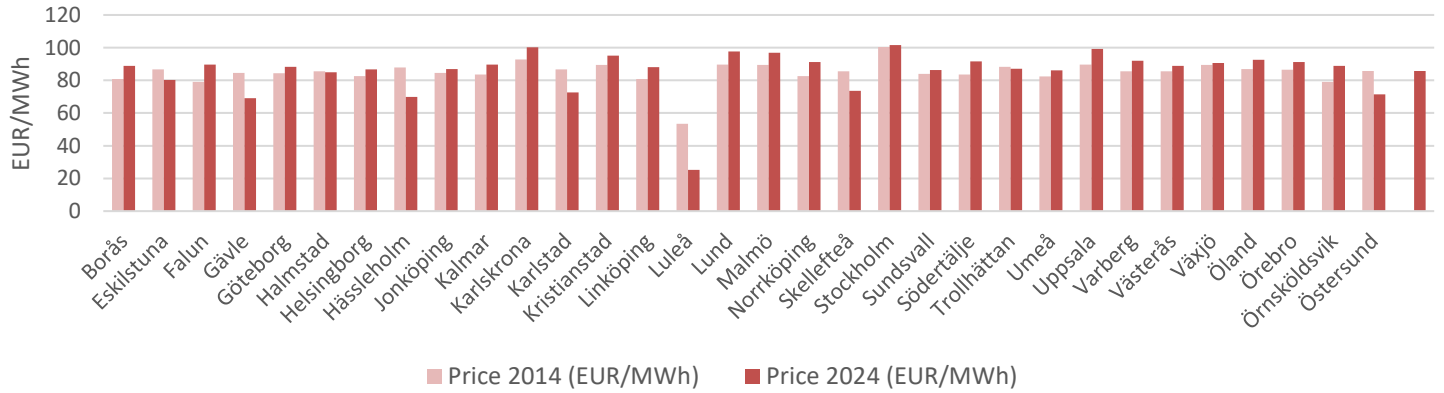
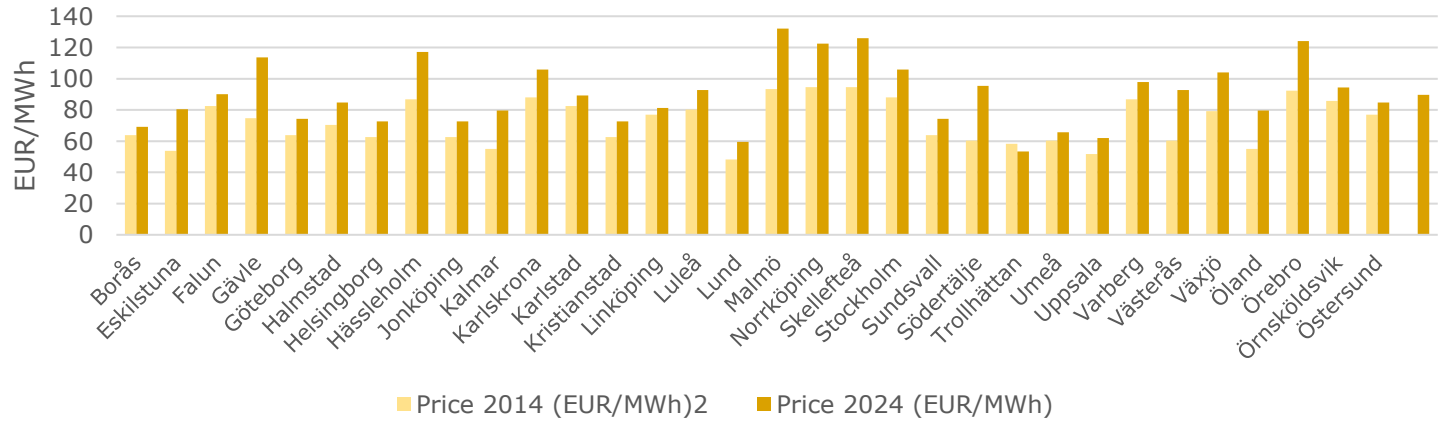



Figure 2.12. Electricity prices in dedicated Swedish municipalities in 2014 and 2024




**It is the case for both heat and electricity prices that**

i. Prices in 2024 are generally higher than those in 2014, indicating that energy price increase over the last 10 years across Sweden.

ii. There is significant fluctuation in prices across municipalities, indicating local conditions affecting the price levels.

**Additional observations for heat prices**

- When leaving out Luleå, which is characterized as an outlier in this case, the heat price fluctuates around an average of 71.3 EUR/MWh in 2014 and 91.4 EUR/MWh in 2024

**Additional observations for electricity prices**

- The relatively larger price fluctuations in the electricity price, compared to the heat price, indicates higher electricity price volatility
- The electricity price fluctuates around an average of 60.0 EUR/MWh in 2014 and 93.6 EUR/MWh in 2024.

Ramboll Sources: UNDERBARA RESA GENOM SVERIGE – en avgiftsstudie för 2024, Nils Holgerssin-Rapporten (2024)
Notes: SEK-EUR conversion rates: 2014 – 0,1099; 2024 – 0,08745

# Example of 2 Waste-to-Energy plants in Denmark and in Sweden show very high efficiencies & waste heat utilization

There is generally a strong focus on delivery of district heating in Denmark and in Sweden. Thanks to generally low district heating return temperatures of around 40°C and forward temperatures < 90°C, the WtE plants are able reach very high efficiencies.

**Example WtE plant Copenhagen (ARC)**

- Efficiencies (Energy output / LHV) of around **107%** possible: Energy output 191 MW DH and 49.8 MW electricity export for 223.6 MW LHV (lower heating value) waste input
- In 2023: 590 kt of waste were incinerated; total delivery of 1,299 GWh district heating and 336 GWh/a electricity

**Example WtE plant Malmo (Sysav)**


- Average efficiency (Energy output / LHV) in 2023 of **96%**
- In 2023: 615 kt of waste were incinerated; total delivery of 1,441 GWh district heating and 169 GWh electricity


Sources: Ramboll internal, efaidnbmnnnibpcajpcglclefindmkaj/https://a-r-c.dk/app/uploads/2024/06/ARC-Aarsrapport-2023.pdf, https://issuu.com/sysav/docs/sysav_rsredovisning_2023?fr=sYjk0ODcyNzE0ODE

# Example of a business case for a future WtE plant in Denmark

**New WtE plant with a capacity of around 200 kt/a**

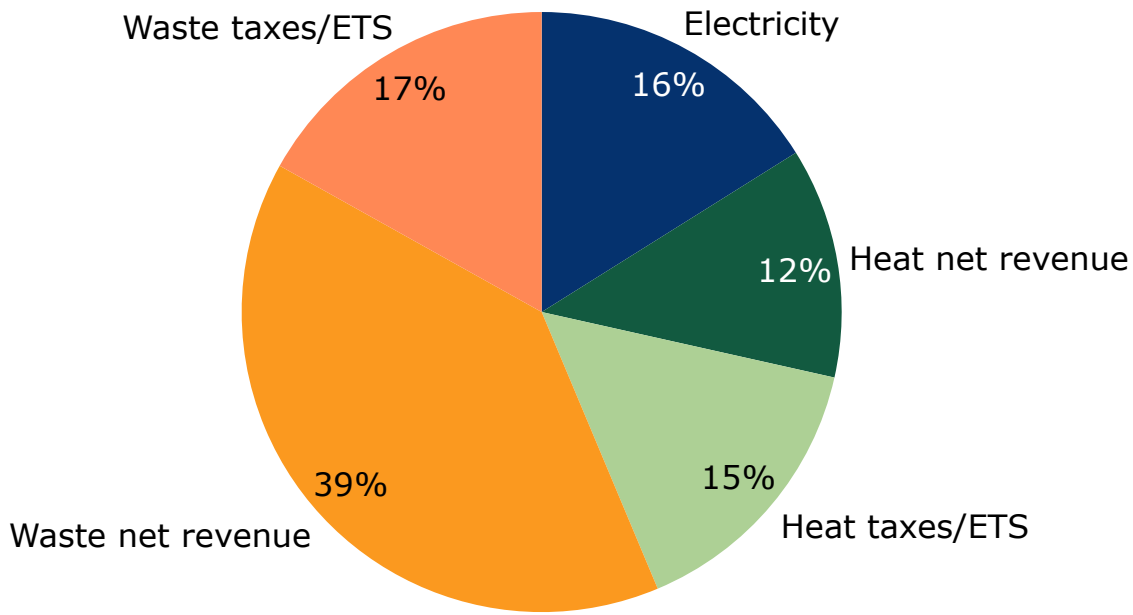
**WtE business case for 2030**

1) Waste income via gate fee: 24.5 Mio. EUR/a (thereof taxes/ETS: 30%)
2) Heat* income from selling DH: 12 Mio. EUR/a (thereof taxes/ETS: 55%)
3) Electricity income from selling electricity: 7 Mio EUR/a

***District heating price regulations in Denmark***

*1) District heating producers such as WtE plants are not allowed to generate profit selling district heating, so the maximum selling price is limited by heat production cost*
*2) District heating producers such as WtE plants are not allowed to be more expensive than alternative heat sources*
*3) The maximum heat price is defined by law (yearly calculation of a national heat price limit)*

**Split of total revenue**




*Gate fee: 56%, Heat: 27%, Electricity: 16%*

# 04 | ETS for WtE in Sweden & Denmark

# The EU ETS is made up of several legal texts which cover various aspects of the operating mechanisms

Main text & Associated Delegated Acts

**EU ETS main text**
Directive 2003/87/EC

**Mechanisms:** Overall rules for the EU's GHG cap and trade system

Based on the EU-ETS directive, the National regulations are derived and implemented in each member country, respectively with local differences.

**Sectors:** Stationary Installations (Power generation, manufacturing, etc. listed in Annex I) and Aviation (intra-EU) and Maritime

**Free allowances Delegated Act**
Delegated Regulation (EU) 2019/331

Sets out the rules for allocating free allowances

**Verification & Accreditation for ETS**
Implementing Regulation (EU) 2018/2067

Sets out rules related to the way reported emissions will be verified and accredited for the EU ETS

**Implementing Act 25a(3) on International Aviation** *(Pending)*

Will set out rules for accounting for carbon credits for international Aviation and flights in scope of EU ETS

**Monitoring and Reporting Regulation for ETS**
Implementing Regulation (EU) 2018/2066

Sets out rules related to the way emissions will be monitored, measured, and reported for the EU ETS

**Delegated Act on storage in long-lived products**
*Pending*

Will set out rules on CCU in long-lived products which can be used to avoid paying the ETS

Supplementing Regulations & Directives

**MRV for Maritime**
Regulation (EU) 2015/757

Sets out rules on to the monitoring, reporting and verification of emissions in the maritime sector

**Delegated Act on verification activities**
Delegated Regulation (EU) 2023/2917

Sets out rules on how to have monitoring activities approved and related authorities

**ETS II**
Directive 2023/959

Establishes a separate ETS for the Buildings and Road Transport sectors – amending the ETS main text and the MRV for the ETS

**CBAM**
Regulation 2023/956

Sets out border adjustment mechanism tied to the EU ETS price to prevent carbon leakage

**Effort sharing regulation**
Regulation (EU) 2018/842

Sets GHG reduction targets up to 2030 for non-ETS sectors based on Member States



Note: The relevant legal texts are highlighted in blue.
All references to legal texts are referring to the name of the original legislation. When searching these, EUR LEX should be used, and the latest consolidated version should be considered.

# WtE plants are included in the national ETS schemes in both DK and SE, and an additional $CO_2$ tax is added in DK

| |  |  |
|---|---|---|
| Waste incineration plants covered by the national ETS regulation | ~20 WtE plants | ~37 WtE plants |
| Annual EU ETS price level in 2024 | ~65€/t$CO_2$ (annual weighted average) | ~65€/t$CO_2$ (annual weighted average) |
| National $CO_2$ tax targeting WtE plants additionally in 2024 | 26€/t fossil $CO_2$* | The Swedish $CO_2$ tax only targets non-EU ETS sectors |
| National monitoring & reporting observations | For bigger plants either direct measurement of fossil $CO_2$ concentration or calculation of fossil $CO_2$ via BIOMA (software) calculation through chemical characteristics | Direct furnace measurement of $CO_2$ concentration of fossil $CO_2$ of biggest plants & subsequent direct derivation to smaller plants |
| Free allowances for WtE plants | | |
| Share of required allowances covered by free allocation for WtE plants in 2022 (%) | ~26% | ~31% |
| National fossil $CO_2$ emission trend of the WtE sector | Stable with an increase in the past years | Steady increase last 10 years; rather stable last 3 years |



Note: *only for heating share of emissions

DEEP DIVE

# In addition to the EU ETS, Danish WtE plants are targeted by a $CO_2$ tax and the new 2025 GHG emission tax

## Implementation of the ETS in Denmark

As of Jan 1st, 2013, waste incineration plants which are primarily used for district heating were included in the national ETS regulation that implements the EU-ETS directive in Denmark. While WtE plants that treat municipal solid waste, and similar mixtures need to surrender emission allowances respectively for their amount of fossil $CO_2$ emissions, WtE plants that treat hazardous waste only are not targeted by the EU-ETS.

## $CO_2$ taxation

- Since 1992 Denmark has a $CO_2$ tax. For WtE plants, the tax applies additionally to ETS, but only to the fossil $CO_2$ emission* of the heating share.
- However, in 2025 a broader restructuring of industry taxation came into force, the so called "green tax reform". This included the reduction of certain taxes on WtE, a significant increase of the $CO_2$ tax as well as the phase-in of a new GHG emission tax.
- Unlike the $CO_2$ tax, the GHG emission tax targets all fossil GHG ($CO_2e$**) emissions as well as both the heating and electricity activities from WtE plants and is based on the same calculation method as the EU-ETS.

## Price levels for WtE plants

**EU ETS price 2024:**
~65€/$tCO_2$
(Jan. - Dec. weighted average)

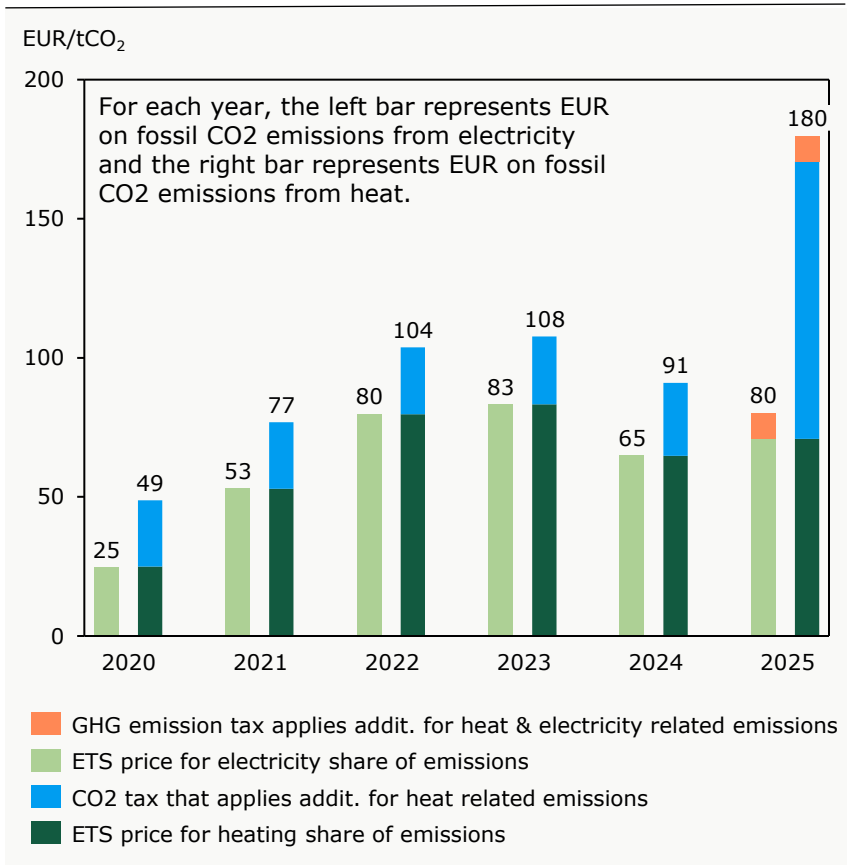
**EU ETS price 2025:**
~71€/$tCO_2$
(Jan.-May weighted average)

**$CO_2$ tax rates:**
2024: ~25€/$tCO_2$
2025: ~111€/$tCO_2$

**GHG tax rates:**
2024: N/A
2025: ~11€/$tCO_2$

*Remark: All above prices are stated in 2025-prices*

**Historic development of ETS and emission taxes on CO2**

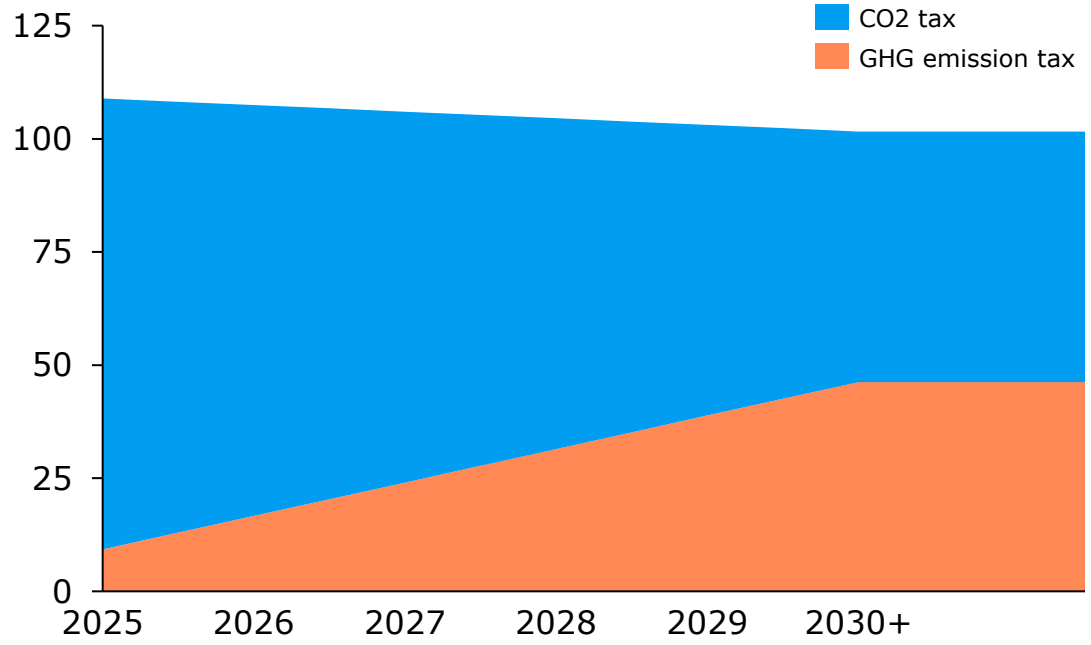



Notes: *only the fossil CO2 emissions are targeted, but CO2e/all GHG emissions **GHG are defined as $CO_2$ $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$
Sources: European Commissions (2023) "Tax in Europe Database V3, Indirect Taxes – Energy and Electricity"; Danish Tax Agency [Skattministeriet] (2022) "$CO_2$-afgiftsloven"; Reuters (2022) "Denmark agrees Corporate Carbon Tax"; Expert Group for a Green Tax Reform (2022) "Green Tax Reform" ; energy.instrat.pl (2025) "CO2 emission allowances price in EU ETS system"; Retsinformation (2025) "Bekendtgørelse af lov om afgift af CO2e-emissioner fra kvoteomfattede sektorer"; EEA, 2022: Early warning assessment Denmark; Nordic Council of Ministers (2024) "Waste incineration in the Nordic countries;TemaNord 2024-524"; Klima-, Energi- og Forsyningsudvalget (2024) "Klimastatus og -fremskrivning 2024"; Ramboll expert interviews

DEEP DIVE

# Green tax reform aims to support DK's climate targets & includes a decrease of $CO_2$ & an increase of GHG emission tax

## $CO_2$ & GHG emission taxation developments between




| Tax developments | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|
| CO2 tax [€/tCO2] | 99.7 | 90.8 | 81.9 | 73.1 | 64.2 | 55.4 |
| GHG (CO2e) emission tax [€/tCO2e] | 9.3 | 16.7 | 24.1 | 31.4 | 38.9 | 46.3 |

## Commentary on taxation developments

- The reformed Danish **$CO_2$ tax (in blue)** will decrease from its base level in 2025 of ~100€/t$CO_2$ to ~55€/t$CO_2$ in 2030. The development is based on a predefined annual reduction share in the regulation until it reaches a stable level in 2030 and onwards.
- The newly created **GHG emission tax (in orange)** will increase from its introductory price at ~9€/t$CO_2$e in 2025 to ~46€/t$CO_2$e in 2030.
- Even though the two taxes have different scopes, the total tax sum of these taxes are kept on a stable level from 2025, with aim being approx. 100 €/t$CO_2$.
- After the green tax reform, the overall tax levels for WtE plants are slightly higher than before and rely more on the waste fractions incinerated then the energy output.
- Tax rates can be adjusted according to ETS development. If the ETS develops differently than forecasted, the Danish tax rates may be adapted.

## Commentary on the green tax reformation

- The main driver of the reform is supporting Denmark's carbon reduction targets in 2030. Via this broader reform, the government expects an additional GHG emission reduction of around 4.3 mio. tonnes by 2030.
- It creates stable framework conditions and ensures that green energy is made more affordable than fossil fuels.



Sources: Danish Tax Agency [Skattministeriet] (2022) "$CO_2$-afgiftsloven"; Retsinformation (2020) "Bekendtgørelse af lov om kuldioxidafgift af visse energiprodukter"; Retsinformation (2024) "Lov om ændring af lov om kuldioxidafgift af visse energiprodukter, lov om energiafgift af mineralolieprodukter m.v., lov om afgift af naturgas og bygas m.v., lov om afgift af stenkul, brunkul og koks m.v. og forskellige andre love"; Retsinformation (2025) "Bekendtgørelse af lov om afgift af CO2e-emissioner fra kvoteomfattede sektorer"; Finansministeriet (2022), "Regeringen indgår bred aftale om en ambitiøs grøn skattereform"; Ramboll expert interviews; External market expert interviews

DEEP DIVE

# Historical $CO_2$ prices have not directly reduced emissions in waste incineration; 2025 reform is expected to drive change

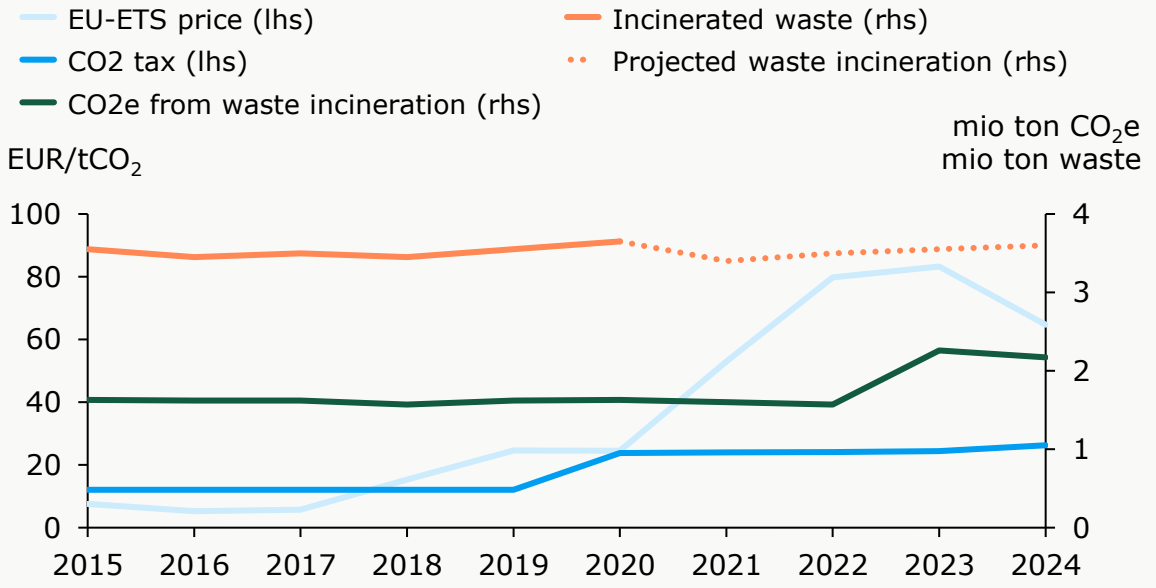
## Development of fossil $CO_2$ emissions

- Since 1990, the emissions from WtE plants in Denmark increased as well as the number of WtE plants. In comparison, landfill emissions and total waste sector emissions decreased.
- The emissions from WtE have stagnated since 2015 with a slight increase around 2023.
- Note that the pricing of $CO_2$ may still contribute to fulfilling climate goals in an indirect way, e.g. through financing of climate initiatives.

## Other observations

- In addition to the $CO_2$ emissions tax, emissions from waste incineration are subject to NOx and sulphur taxes.
- Moreover, WtE plants are required to pay energy taxes. A waste heat tax is levied on the amount of heat produced, including heat used at the plant for indoor and water heating. The waste heat tax is coupled with an additional tax charged per GJ produced heat, calculated, in principle, based on the energy content of combustible waste.
- New Danish legislation aims at reducing the waste incineration capacity. Adjusted future capacities are expected to be utilised by Danish waste in favour of imports.

## Historic development of carbon prices & CO2 emissions




- Both EU-ETS and $CO_2$ tax rise between 2015 and 2023, while the latter continues with a slight increase in 2024, the EU-ETS decreases.
- In the same time horizon, the fossil GHG emissions are stable with a slight increase around 2023.
- Hence WtE plants to date seem to be rather influenced by other dynamics such as utilisation & energy yield.

Notes: *$CO_2$e is defined as GHG emissions according to the IPCC; ** The significant increase in $CO_2$e emissions from 2022 to 2023 are partly stemming from a changed emission calculation & estimation method
Sources: European Commissions (2023) "Tax in Europe Database V3, Indirect Taxes – Energy and Electricity"; Danish Tax Agency [Skattministeriet] (2022) "$CO_2$-afgiftsloven"; Reuters (2022) "Denmark agrees Corporate Carbon Tax"; Expert Group for a Green Tax Reform (2022) "Green Tax Reform" ; energy.instrat.pl (2025) "CO2 emission allowances price in EU ETS system"; Retsinformation (2025) "Bekendtgørelse af lov om afgift af CO2e-emissioner fra kvoteomfattede sektorer"; EEA, 2022: Early warning assessment Denmark; Nordic Council of Ministers (2024) "Waste incineration in the Nordic countries;TemaNord 2024-524"; Klima-, Energi- og Forsyningsudvalget (2024) "Klimastatus og -fremskrivning 2024"; Ramboll expert interviews

DEEP DIVE

# In Sweden, WtE facilities (i.e. facilities with energy recovery) are covered by the ETS, while co-incinerators are not

## Implementation of the ETS in Sweden

The Swedish competent authority (CA), the Environmental Protection Agency (Naturvårdsverket) distinguishes between WtE facilities (energy recovery, particularly district heating) and co-incineration facilities.

While **WtE facilities are regulated under the EU ETS,** the co-incineration facilities are not. In practice, most large Swedish plants are WtE facilities and therefore **need to surrender allowances for the fossil $CO_2$ emissions under the EU ETS**.

**Average EU-ETS price 2024**

**~65€/t$CO_2$**
(annual weighted average)

## $CO_2$ taxation

- The Swedish carbon tax (Koldioxidskatt), introduced in 1991, was one of the world's first carbon tax schemes as an addition to broader energy taxation legislation (Skatt på energi). After major revision in 1994, it has been updated regularly since then. The tax only applies to sectors not covered by the EU ETS, i.e., for **WtE facilities that have been included in the Swedish ETS scheme, the Swedish carbon tax does not apply**. As of 2023, approximately 95% of all fossil $CO_2$ emissions in Sweden were either covered by the carbon tax, or the EU ETS. The tax varies on the carbon content of the fuels and by sector. The carbon tax rate was frozen at 2021 levels for 2022.


Sources: Avfall Sverige: Swedish Waste Management 2023; Nordic Council of Ministers, 2024: Waste incineration in the Nordic countries. TemaNord 2024-524.; IEA Bioenergy; Swedish government (2023) "Carbon Tax Sweden – General Info"; Naturvardsverket 2024, "El och fjärrvärme, utsläpp av växthusgaser"; Naturvardsverket 2024, "Avfall, utsläpp av växthusgaser"; Naturvardsverket 2024, "Analys av avfallsenergianläggningar som del av EU ETS"; Ramboll expert interviews;

DEEP DIVE

# There is no direct correlation between rising $CO_2$ prices and fossil GHG emission development in Swedish waste incineration

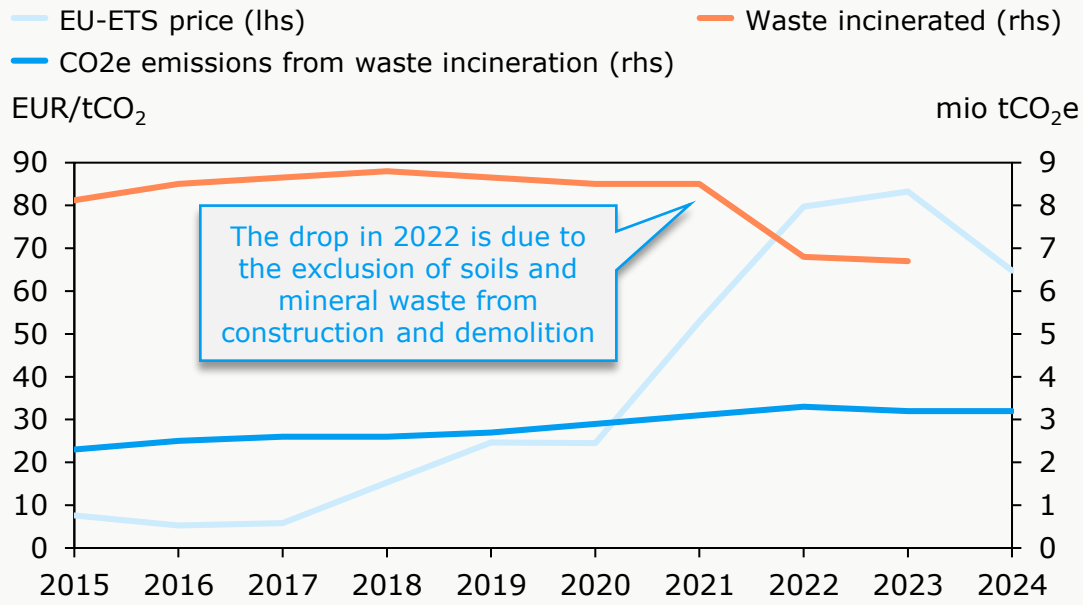
## Development of fossil $CO_2$ emissions

- Swedish $CO_2$e emissions from WtE plants are steadily increasing between 2015 and 2022 from approx. 2.3 m tons of $CO_2$e to 3.2 m tons of $CO_2$e. A slight decrease can be observed after 2022.
- The waste development in Sweden shows an increase in separation and collection, especially of biogenic waste. It is mostly treated separately through anaerobic digestion. Plastic waste though is still increasing in municipal waste by ~1% per year and partly explains the trend.
- Note that the pricing of $CO_2$ may still contribute to fulfilling climate goals in an indirect way, e.g. through financing of climate initiatives.

## Other taxes

- In 2020-2023, WtE plants were charged a waste incineration tax of 11.22 EUR/t waste, with the objective of significantly increasing recycling rates. This objective was not fulfilled and to maintain profitability of combined heat and power production, the tax was removed. It was the 2nd time (1st in 2010) that such a tax was withdrawn, due to low or no measured effects.

## Historic development of carbon prices & CO2 emissions




- Both fossil $CO_2$e emissions as well as ETS price increased until 2022. Since 2023 emissions are rather stable while the ETS price peaked in 2023 and decreased in 2024.
- Therefore, currently the rising EU-ETS price does not seem to lead to a positive dynamic on reducing WtE plants environmental impact. Other dynamics such as utilisation & energy yield might have a larger influence.


Sources: Avfall Sverige: Swedish Waste Management 2023; Nordic Council of Ministers, 2024: Waste incineration in the Nordic countries. TemaNord 2024-524.; IEA Bioenergy; Swedish government (2023) "Carbon Tax Sweden – General Info"; Naturvardsverket 2024, "El och fjärrvärme, utsläpp av växthusgaser"; Naturvardsverket 2024, "Avfall, utsläpp av växthusgaser"; Naturvardsverket 2024, "Analys av avfallsenergianläggningar som del av EU ETS"; Ramboll expert interviews;

# Both Denmark and Sweden apply standardised methods for monitoring and reporting fossil $CO_2$ emissions from WtE plants

The Monitoring and Reporting Regulation (MRR) for ETS sets out rules related to the way emissions will be monitored, measured, and reported under the EU ETS. Since 2024, WtE installations that handle municipal solid waste and are above 20MW need to monitor, report and verify their fossil $CO_2$ emissions. The following rules apply as set out in the table below:

| Tier Level | Accuracy | Description | Applicable Categories of WtE plants |
|---|---|---|---|
| Tier 1 | Low | Default values (e.g. IPCC or EU defaults) | A (min), B (approval) |
| Tier 2a | | Default fossil $CO_2$ of MSW | A, B (with justification) |
| Tier 2 | | Country or installation-specific values | A (optional), B (min) |
| Tier 3 | | Direct measurement & laboratory analysis | B (preferred), C |
| Tier 4 | High | Continuous measurement or CEMS | C (only very large) |

WtE plant categorisation

| Category | Definition |
|---|---|
| A | < 50,000 t fossil $CO_2$ |
| B | 50,000 – 500,000 t fossil $CO_2$ |
| C | > 500,000 t fossil $CO_2$ |

## National monitoring and reporting approaches

The Danish Competent Authority (CA), who verifies the reports, is the Danish Energy Agency. They are mainly accepting two methods for the monitoring and reporting duties:

1. Direct measurements:
   - Sampling of flue gas several times over the year
   - Measurement of fossil $CO_2$ content of flue gas by C14 determination
2. Bioma modelling
   - Is a scientifically developed software model that calculates the amount fossil $CO_2$ emitted based on several routinely measured operating data from WtE plants.

Across all Danish facilities, the "direct measurement" method remains the most widely used approach. **National emission factors** is a third option that can be used for smaller plants (that do not use the two above mentioned methods).

The Swedish Competent Authority (CA), is the Swedish Environmental Protection Agency. They are also mainly focusing on two methods for the monitoring and reporting duties:

1. Direct measurements:
   - The biggest facilities are sampling flue gas several times per year
   - Measurement of fossil $CO_2$ content of flue gas by C14 determination
2. Application of deriving emission factors from national direct measurements
   - The majority of facilities in Sweden are using emission factors that are derived from the direct measurements
   - The latest numbers for that calculation are the following:
     - Biomass share: 53.36%
     - Calorific value: 11.58 GJ/ton
     - Preliminary EF: 93.27 CO2/TJ


Sources: European Commission (2018), "Commission Implementing Regulation (EU) 2018/2066 on the Monitoring and Reporting of Greenhouse Gas Emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council"; Ramboll expert interviews, Naturvardsverket 2024, "Bilaga 1 till beslutsprotokoll med diarienummer NV-24-048007";

# Free allocation of emission allowances will decrease over time until 2030 in line with the free allowances delegated act

WtE facilities are regulated under the EU Emissions Trading System (EU ETS) as "stationary installations" under the category "combustion of fuels" (as determined by respective CAs), which means they are part of the EU ETS system and qualified for free allocation of emission allowances. Most of the WtE plants using municipal solid waste as fuel are integrated into district heating networks and continue to receive free allowances, albeit fewer than in the past.

- According to Danish authorities the facilities were able to apply for the following share of free allowances based on their $CO_2$ emissions of their eligible district heating supply over the years. It also includes the estimated projection of available future allowances:

| 2019 | 2020 | 2021-2025 | 2026-2030 | 2031 |
|---|---|---|---|---|
| 50% | 40% | 30% | 20% | 0% |

- In 2022 the ETS verified $CO_2$ emissions in Denmark were:
  - ~917,272 $tCO_2$
- Of these emissions, the following number of allowances were allocated free:
  - ~236,370 tCO2 - which corresponds to ~26%

- Phase 3 of EU ETS (2013–2020):
  - the five largest WtE facilities in Sweden received free allowances covering approximately 30–70% of their verified emissions.
  - Some smaller facilities even received allocations exceeding their reported emissions.
- Phase 4 of EU ETS (2021–2030):
  - The share of free allowances is expected to decrease to around 20–45%, depending on the facility's characteristics and benchmark category

| EU-ETS Phase | Year | Free allowances |
|---|---|---|
| Phase 3 | 2013-2020 | Around 70%-30% |
| Phase 4 | 2021-2030 | Around 45%-20% |

- In 2022 the ETS verified $CO_2$ emissions in Sweden were:
  - ~2,240,267 $tCO_2$
- Of these emissions, the following number of allowances were allocated free:
  - ~681,320 tCO2 - which corresponds to ~31%



Sources: Klima-, Energi- og Forsyningsudvalget 2022-23, "Dokumentationsnotat – Effektvurdering af lovforslag om ny organisering af affaldsforbrændingssektoren"; Naturvardsverket 2024, "Analys av avfallsenergianläggningar som del av EU ETS"; Ramboll expert interviews;

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