Optimised biomass usage for electricity & district heating in Denmark towards 2040

Ea Energy Analyses

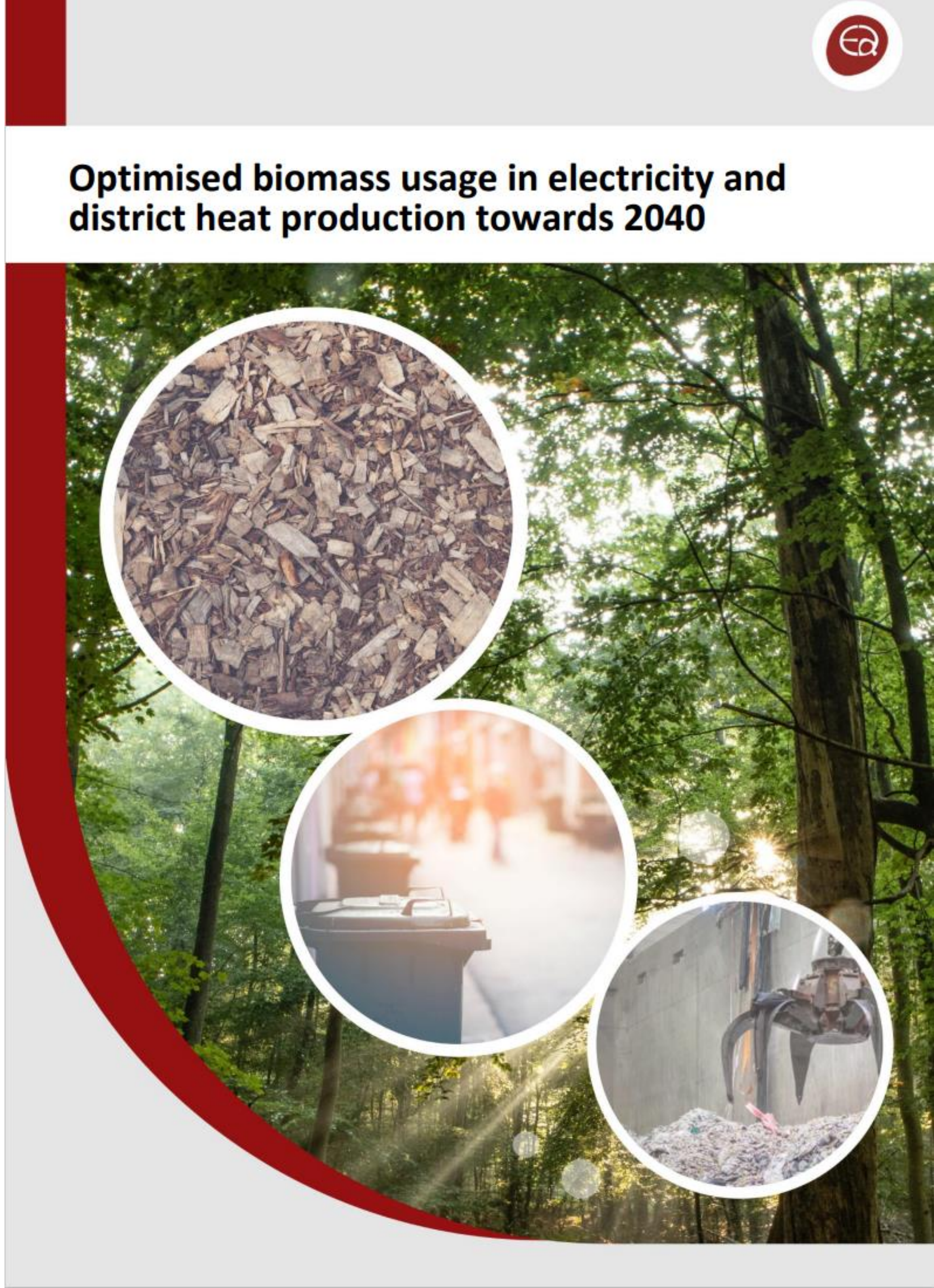
Using an average CO_2 coefficient for biomass based on historical data

March, 2022

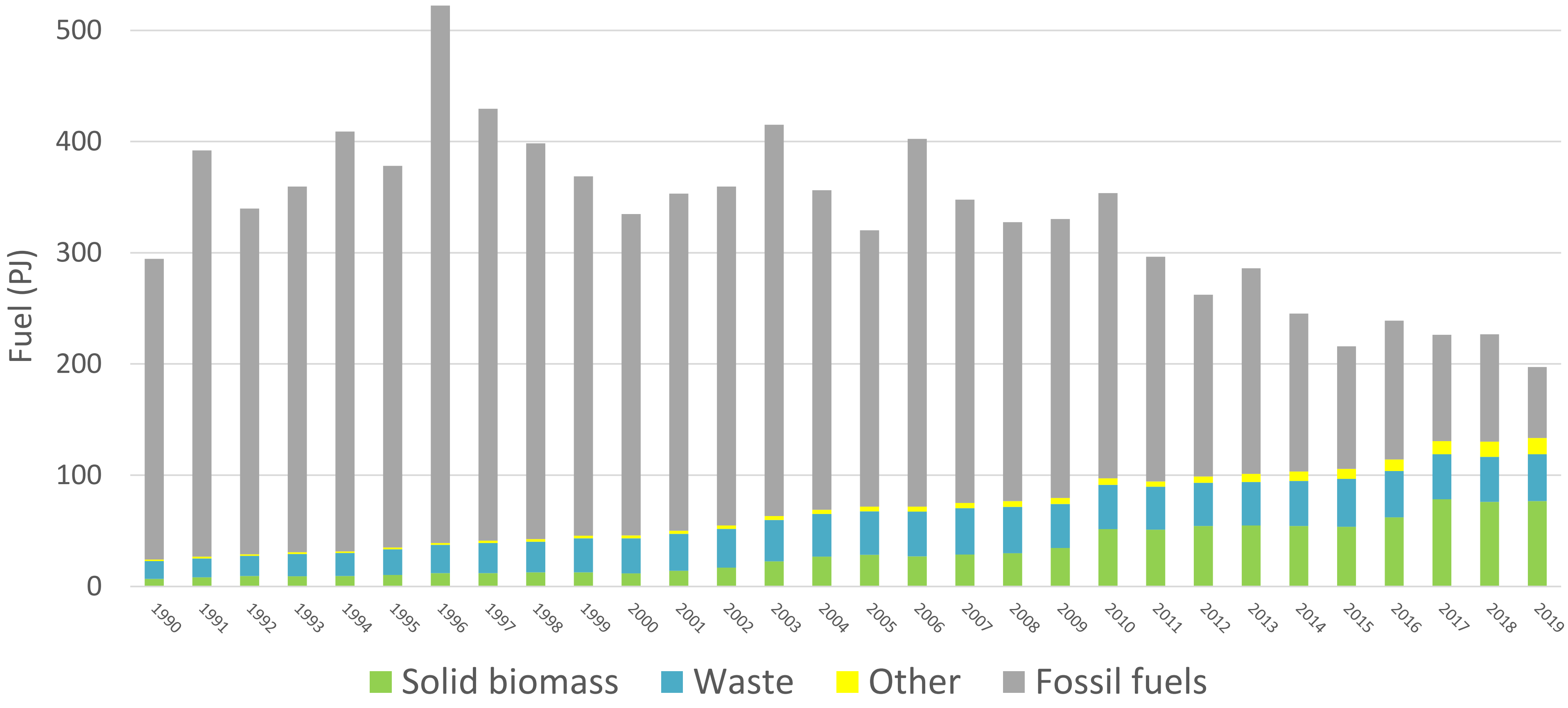
Purpose of the analysis

Based on the understanding that biomass combustion is not carbon neutral, the green Danish think tank CONCITO has requested an analysis of the optimal biomass use in the Danish electricity and district heating sector towards 2030 and 2040.

The analysis should take into consideration the most recent knowledge concerning how combustion of biomass results in a carbon release from the biogenic carbon pool.

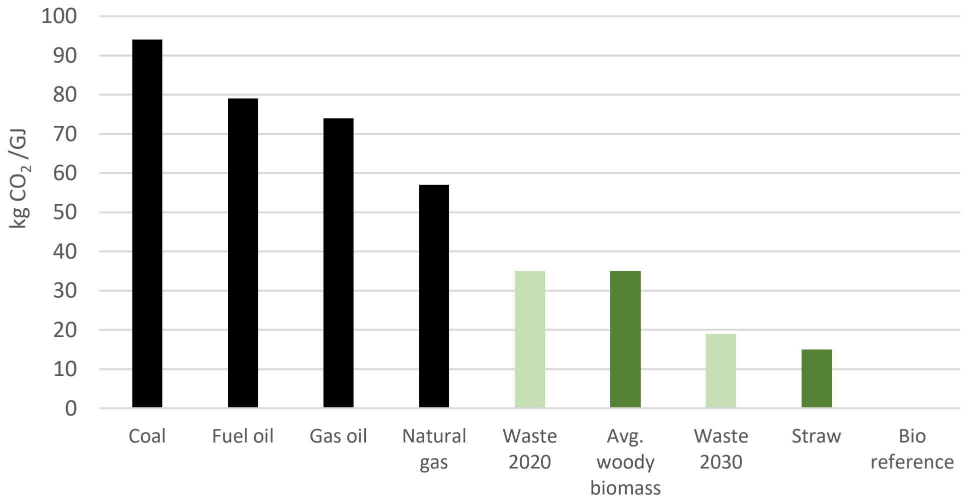


Substantial increase in biomass for electricity and district heating in Denmark

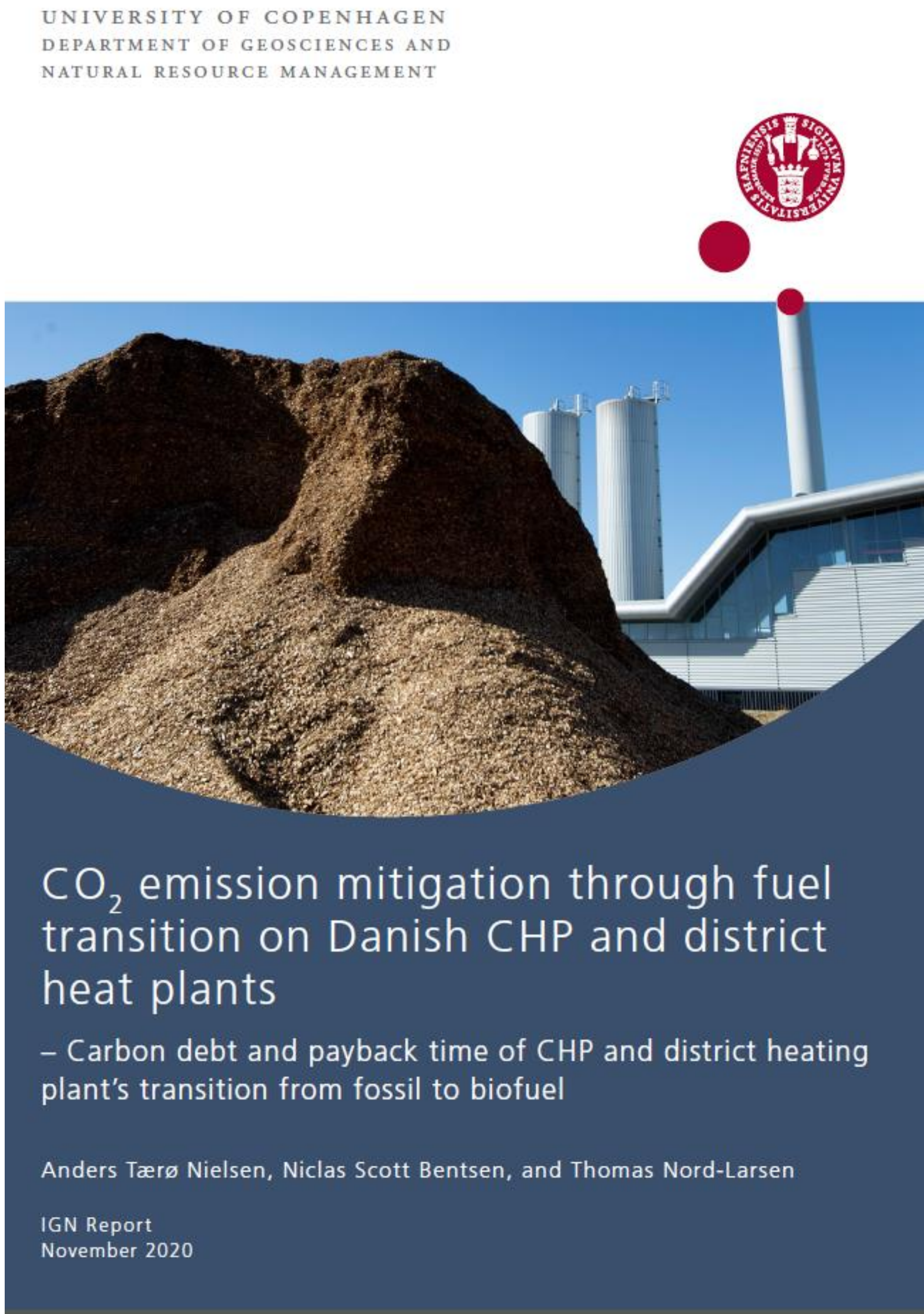


CO_2 factor for woody biomass

- Based on app. 10-year operational data from 10 existing Danish plants.
- 32% of biomass sourced from Denmark, 41% from Baltic countries, 7% from Russia and Belarus, and 7% from the USA, & 6.5% with unknown origin.
- 24% residual products from forest (branches and tops), 34% stems, 36% residual products from industry.
- CO_2 emission recalculated by Ea equates to a 30-year time horizon.



*35 kg/GJ woody biomass equals a counterfactual decay- half life of 20 years


UNIVERSITY OF COPENHAGEN
DEPARTMENT OF GEOSCIENCES AND NATURAL RESOURCE MANAGEMENT

CO_2 emission mitigation through fuel transition on Danish CHP and district heat plants

– Carbon debt and payback time of CHP and district heating plant's transition from fossil to biofuel

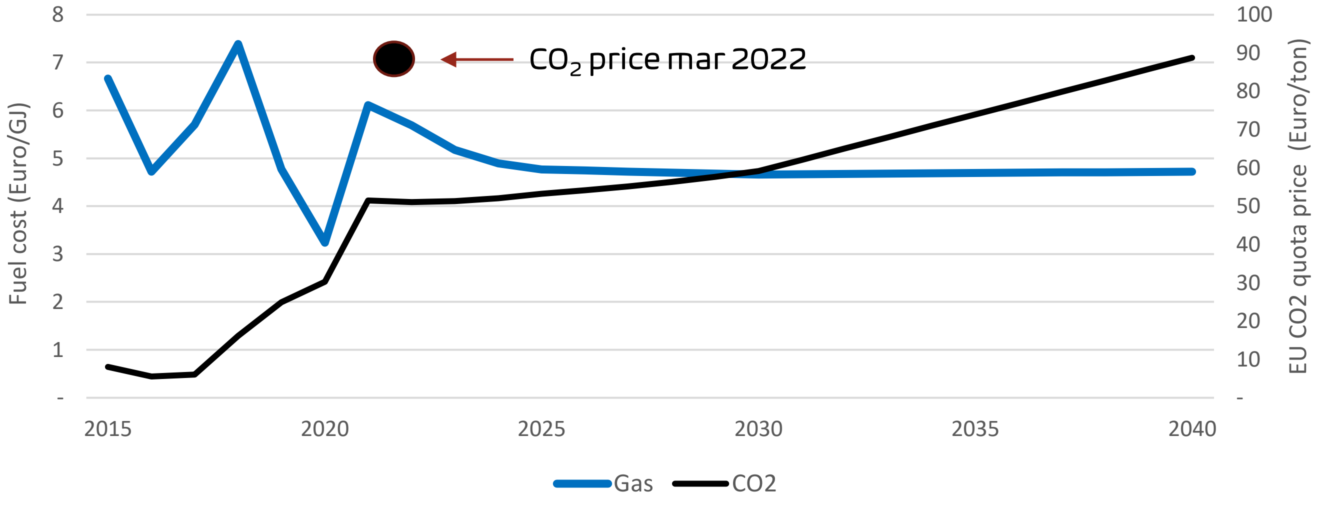
Anders Tærø Nielsen, Niclas Scott Bentsen, and Thomas Nord-Larsen

IGN Report
November 2020

EU Gas price mar 2022 (off the chart!)

Method and assumptions

- Purpose: Calculate the socio-economic cost of inadequate CO_2 regulation in LULUCF sector.
- Via system analysis of energy sector in NW Europe towards 2040 with Balmorel model.
- Using optimal investments in grid and production capacity based on demand projections, available technologies, forecasted EU CO_2 quota prices and commodity prices*.
- A series of scenarios were developed utilsing standard CO_2 emission factors for coal, oil, gas, MSW, and <u>varying CO_2 emission factors for woody biomass and straw.</u> In the reference scenario, the CO_2 emission from biomass is zero according to EU calculation rules.



*Commodity prices based on WEO 2020 and forwards. **Pre-Ukraine invasion**

Scenario Calculations

- Based on life-cycle analysis of actual biomass types described in the IGN report (slide 4), a reference half-life of the actual average woody biomass used for production of electricity and district heating in ten existing plants in Denmark was calculated.
- The calculated half-life CO_2 value includes both natural decay in the forest bed for the residue part, and indirect emissions for the portion of biomass that alternatively found other uses according to the above mentioned reference.
- The deducted half-life values were then transformed to CO_2 emission factors using a 30-year time perspective. The average biomass burned has a calculated 20 year half-life and a 35 kg/GJ emission factor. If a longer time perspective had ben used, the calculated emission factor would have been lower – and vice-versa.

Explanatory notes for the data in the table on the following slide:

- Row 1 displays the discounted CO_2 cost in the reference scenario using the relevant emission factor and the general CO_2 price projection. For the historical biomass average (35 kg CO_2/GJ), the CO_2 cost is 1.64 billion €.
- Row 2 shows the discounted CO_2 cost in each scenario if the relevant CO_2 factor and the general CO_2 price is internalised in decision making by the electricity and district heating plant owners. For the historical average (35 kg CO_2/GJ), the total cost is 1.38 billion €.
- The socio-economic benefit from internalising the CO_2 cost in decision making is therefore 1.64 – 1.38 = 0.26 billion €. This benefit is composed of a sector loss of 0.22 billion € and a benefit to the "rest of society" of 0.26 + 0.22 = 0.48 billion € in that scenario.

Socioeconomic results – when CO_2 reduction has a cost

- When net-CO_2 emission from burning biomass for energy is included, the real societal cost of burning biomass is revealed.
- In the 35 kg scenario, the CO_2 cost can be reduced from 1.64 to 1.38 billion € if investments and dispatch is optimised. The model assumes that power plants pay CO_2 costs according to the CO_2 factor for all fuels.
- In the 35 kg scenario, 193 PJ of biomass (app. 18 mil. tonnes) is saved, corresponding to 12 mil. tonnes of net CO_2 reduction.
- The extra cost for the electricity and heat sector is 0.22 billion €, corresponding to 1.1 €/GJ biomass reduced.

Socioeconomics	Early bio phase out LULUCF 0kg	15 years LULUCF 25kg	20 years LULUCF 35kg (35 kg scenario)	25 years LULUCF 45kg	30 years LULUCF 50kg	Early bio phase out LULUCF 35kg
CO_2 cost in reference scenario, assuming biomass is *not* zero CO_2 (billion €)	-	1.21	1.64	2.08	2.34	1.64
Total cost in scenario (billion €)	**-0.03**	**1.07**	**1.38**	**1.62**	**1.77**	**1.25**
- Of which LULUCF of biomass (billion €)	-	0.95	1.16	1.28	1.39	1.03
- Of which Denmark's electricity and district heating sector (billion €)	-0.03	0.12	0.22	0.34	0.39	0.22
Biomass savings during the time period (PJ)	42	169	193	229	260	251
Average total savings from reducing biomass usage (€/GJ biomass reduced)	**0.8**	**0.8**	**1.3**	**2.0**	**2.2**	**1.5**
Average sector-cost of reducing biomass usage (€/GJ biomass reduced)	**-0.8**	**0.7**	**1.1**	**1.5**	**1.5**	**0.9**

Scenario results – biomass demand

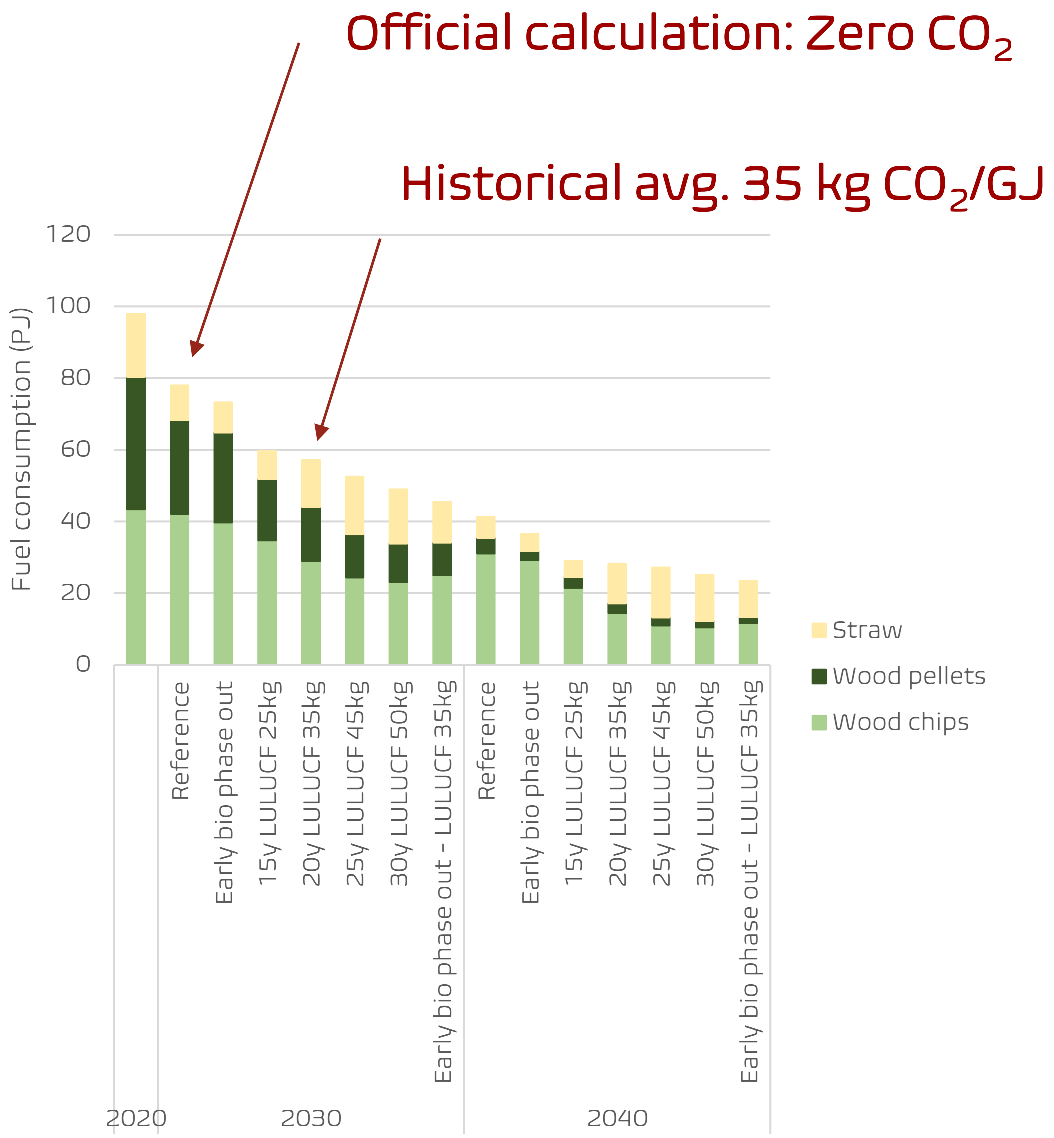
- *In the reference scenario, the CO_2 emission from biomass is zero according to EU calculation rules.*

Results

- Biomass consumption decreases towards 2040 in all scenarios.
- When applying the calculated average CO_2 factor of 35 kg/GJ, the optimal reduction path is steeper.

Overall conclusion

- By assuming zero emission, the development is sub-optimal incurring a socioeconomic loss.



Internalisation of CO_2 cost of biomass results in decreased biomass consumption

	2030	2040
Reference – unchanged regulation and policy	-20 %	-60 %
With internalised CO_2 emission cost of biomass	-40 %	-70 %
+ With permitted scrapping of biomass plants before end of technical life	-55 %	-75 %

List of possible incentives discussed in the danish project

i. Include an emission factor of 35 kg CO_2/GJ wood biomass and 15 kg of CO_2/GJ straw in the socio-economic calculation assumptions, unless better data can be demonstrated for specific projects.

ii. Internalisation of the CO_2 effect through the price of biomass, for instance via a tax. The challenge is the difference in CO_2 effect from different biomass types.

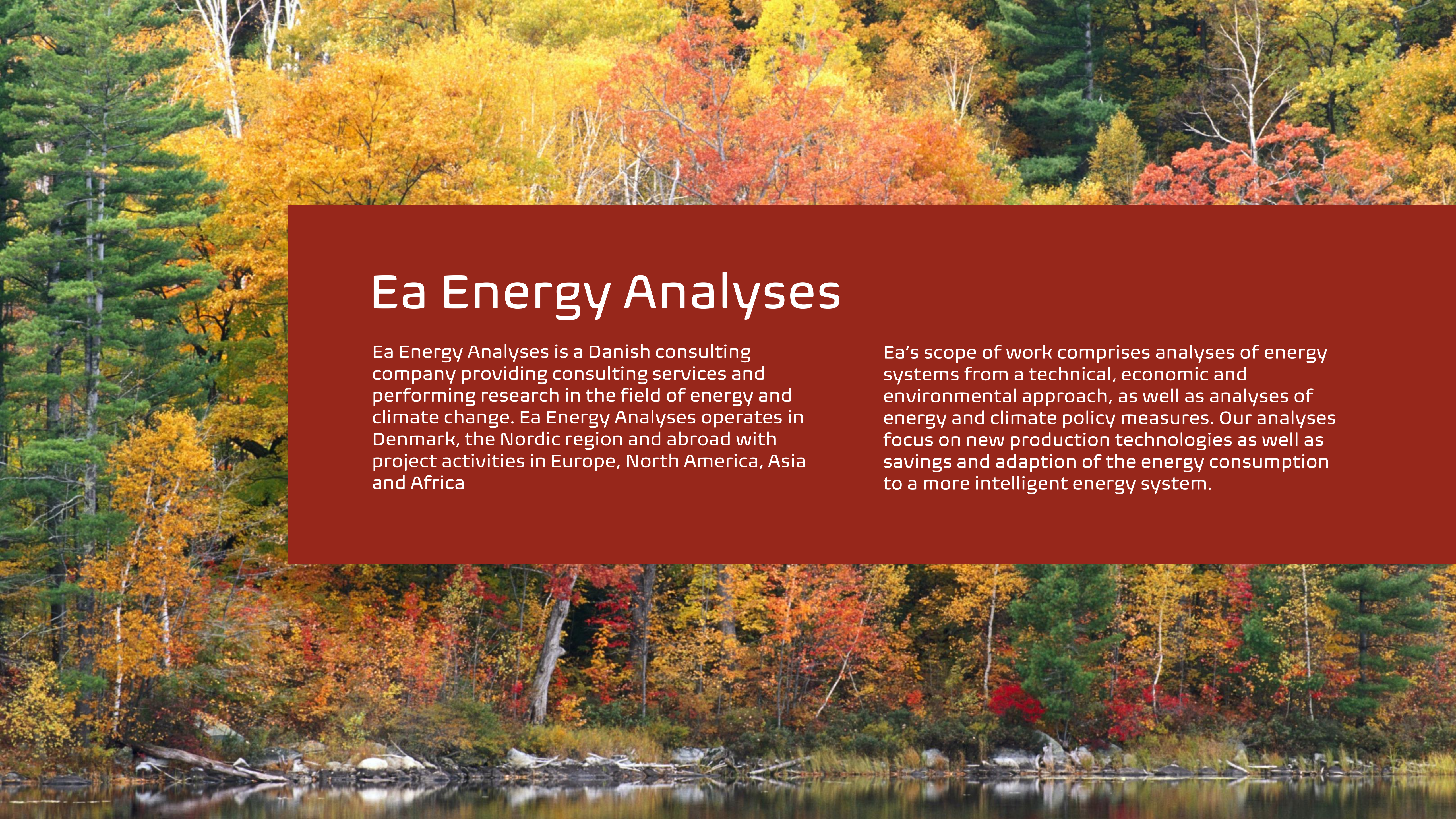
iii. Politically decide on a limit for the combustion of biomass and the establishment of a system of national combustion quotas for biomass.

iv. Link the LULUCF sector more closely to other climate legislation, incentivising forest operators to internalise the CO_2 value themselves in their pricing of the forest's various products. It is a challenge to define an appropriate baseline.

v. Tighten sustainability requirements for biomass.

vi. Develop a heat pump strategy for the Danish district heating sector to accelerate the expansion rate of large heat pumps by hedging risks, experience collection, etc.

vii. Combinations of the above.



Ea Energy Analyses

Ea Energy Analyses is a Danish consulting company providing consulting services and performing research in the field of energy and climate change. Ea Energy Analyses operates in Denmark, the Nordic region and abroad with project activities in Europe, North America, Asia and Africa

Ea's scope of work comprises analyses of energy systems from a technical, economic and environmental approach, as well as analyses of energy and climate policy measures. Our analyses focus on new production technologies as well as savings and adaption of the energy consumption to a more intelligent energy system.