

Interreg
Baltic Sea Region



Co-funded by
the European Union



ENERGY TRANSITION

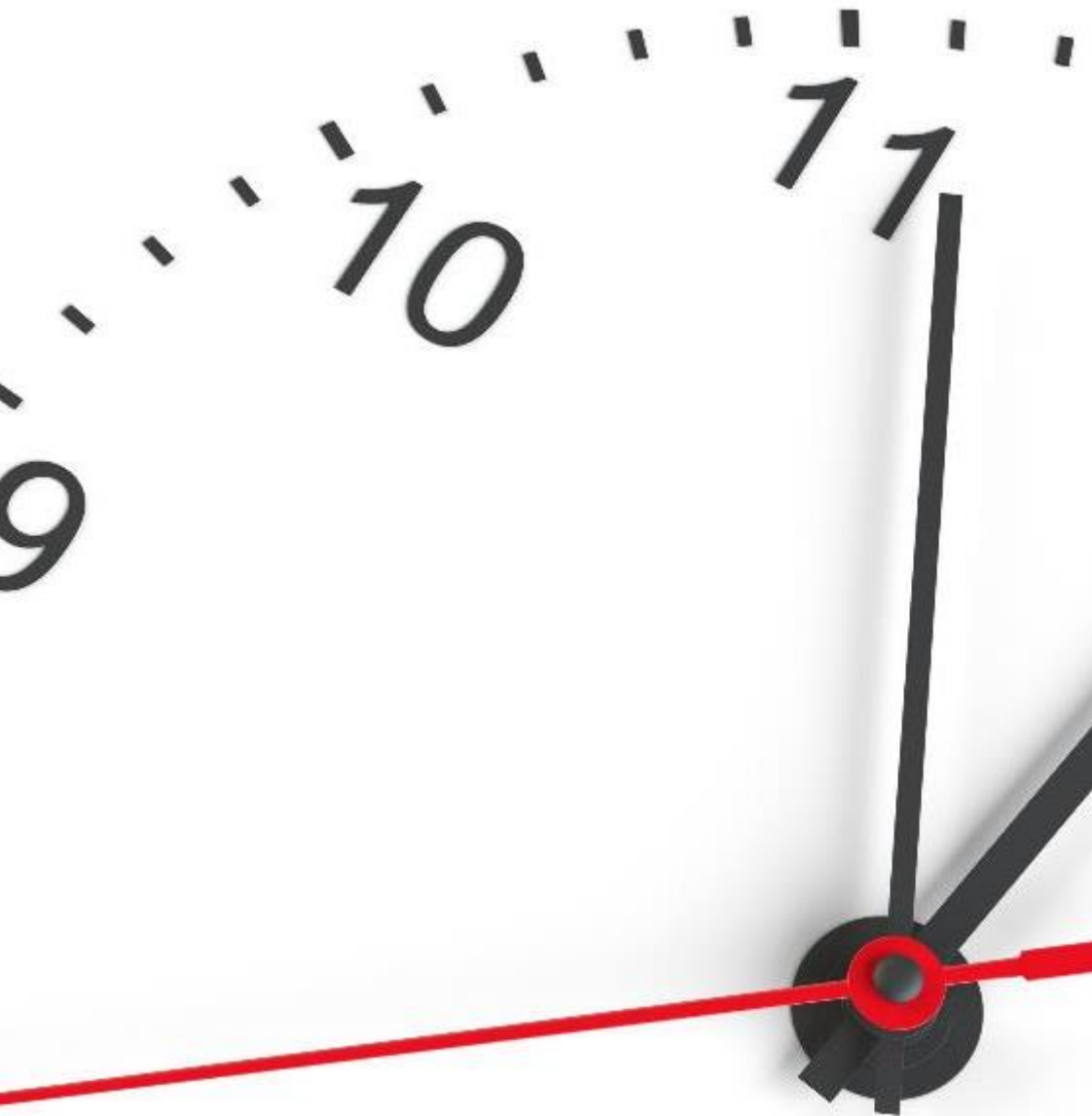
Climate-4-CAST

Cost Effective Actions?

Climate-4-CAST - module 4 | 07-05-2026
Anders R. Laugesen, Aarhus Municipality

interreg-baltic.eu/project/climate-4-cast/





Agenda

Shadow prices: Concept & calculation

What are they and how are they calculated?

Theoretical framework

Formulas, discounting, scopes

Practical usage in Aarhus Municipality

Climate-action-plan and CADS tool

Two examples of calculations

Forestry and energy-efficient buildings | 2

What are shadow prices?

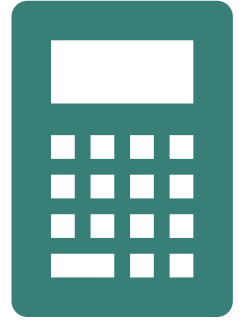
A key tool for cost-effective climate action

- Cost per ton of CO₂e reduced — a common scale (DKK / ton CO₂e)
- Lets us rank actions and prioritize the most cost-effective
- Central tool in our 2025–2030 climate action plan



Calculating shadow prices

The formula and three types of shadow prices



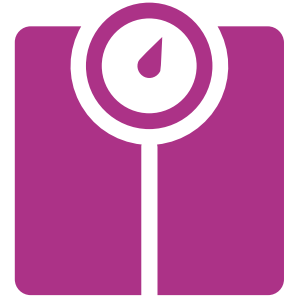
The formula

- Shadow price = discounted costs / discounted CO₂e reductions

Three types of shadow prices

- **Budget-economic** — cost to the municipality
- **Time-corrected** — favours early reductions
- **Societal** — broader impact on citizens & businesses

Theoretical framework



What and why?

What is cost-effectiveness analysis?

- Ranks actions by cost per ton CO₂e reduced — most reduction per krone wins

Why does it matter?

- Limited budgets — maximum climate impact per krone
- Transparent, data-driven climate decisions

Theoretical framework

What and why?

$\sum_{t=0}^T$: The number of years we are interested in

$t = 0$: the starting year of actions

T : the end of our calculations

- maybe a target year? (2030, 2040)

r : the discounting rate

X_t : the budget cost of the action in year t

ΔCO_2e_t : the yearly change in CO₂e relative to BAU

Discounted price per tons of CO₂e:

$$\frac{\sum_{t=0}^T \frac{X_t}{(1+r)^t}}{\sum_{t=0}^T \frac{\Delta CO_2e_t}{(1+r)^t}}$$

=

$$\frac{\textit{Sum of discounted costs}}{\textit{Sum of discounted reductions}}$$

Discounting rate?

What to use?

The Danish Ministry of Finance has done a lot of research into this

Provides recommended discounting rates for different time frames

We use 3.5 percentage for the first 35 years



Tabel 1
Nøgletalskatalog

Nøgletal	Anbefaling	Bemærkninger
Vækstraten for real BNP pr. indbygger, lang sigt ¹⁾	1,0 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Udviklingen i timeproduktiviteten, hele økonomien, lang sigt ¹⁾	0,9 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Udviklingen i forbrugerpriserne, lang sigt ¹⁾	1,8 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Udviklingen i nettoforbrugerpriserne, lang sigt ¹⁾	1,8 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Udviklingen i BVT-deflatoren, lang sigt ¹⁾	2,0 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Udvikling i reallønnen, langt sigt ^{1) 2)}	1,1 pct.	For forventninger på kort sigt henvises til seneste Økonomisk Redegørelse.
Diskonteringsrente	0-35 år: 3,5 pct. 36-70 år: 2,5 pct. Efter 70 år: 1,5 pct.	Se baggrundsnotat, <i>Den samfundsøkonomiske diskonteringsrente</i> , for en nærmere beskrivelse af opgørelsesmetoden.
Nettoafgiftsfaktor	1,28 (28 pct.)	Se baggrundsnotat, <i>Dokumentationsnotat om opgørelse af nettoafgiftsfaktoren</i> .

Scopes and correct calculations



Using the right scope is critical for useful shadow prices

Scope 1-2: Territorial emissions

- Direct emissions in the municipality (transport, energy, agriculture) — target: neutrality by 2030
- Shadow prices for the climate action plan **must use scope 1-2 CO2 reductions** in denominator

Scope 3: Consumption-based emissions

- Indirect emissions (goods, services, construction) — used for procurement
- Wrong scope choice makes shadow prices **misleading**

Usage in Climate action plan

What to use?

Our Climate action plan included cost effectiveness analysis for (almost) all suggested actions

Color codes to distinguish between scopes/aims

Does the action target the emissions as society or as a company?

Indsatser i kommunen som samfund

Nr.	Titel	Årlig CO ₂ e-reduktion Scope 1-2 (tons)	Årlig CO ₂ e-reduktion Scope 3 (tons)	Samlet kommunal omkostning (kr.) ved 1 ton reduceret CO ₂ e i 2030
NL1	Omdannelse til skov og natur.	18.000*	-	-
NL2	Udtagning af lavbundsjord.	15.000	-	290
NL3	Klimatilsyn og klimahandleplaner.	4.000	-	330
NL4	Biogen energipark.	36.000**	6.000	30
I alt		73.000	6.000	-

* Effekten af at plante træer vurderes til at være omtrent 18.000 tons CO₂e i 2030, mens den maksimale effekt på omtrent 30.000 tons CO₂e forventes at være nået i 2040.

** Hertil 2.000 tons i forventet overskudsvarme, som tilskrives energidomænet.

Indsatser i kommunen som koncern

Nr.	Titel	Årlig CO ₂ e reduktion Scope 1-2 (tons)	Årlig CO ₂ e reduktion Scope 3 (tons)	Samlet omkostning (kr.) ved 1 ton reduceret CO ₂ e i 2030
TM4	Kommunale bæredygtige anlæg.	1.000	3.000	1.320
TM5	Kommunale emissionsfri maskiner og kørsel.	2.000	-	660
I alt		3.000	3.000	-

Usage in CADS tool

Easy overview

The CADS tool presents easy to use prices per reduction

We are still working on actual time discounting

Show: ☰ List ▾

Type	Name	Included in scenario	Total impact 2018-2030	Annual impact 2030	Net cost 2018-2030	Cost efficiency	
Energy	Carbon Capture and Storage	✖	0 t	0 t/yr	0	0	▾
Energy	Energy Efficiency Improvements	✓	-21,800 t	-5,850 t/yr	5,000,000 M DKK	229 M DKK/t	▾
Energy	Energy Efficient Municipal Buildings	✓	-3,560 t	-1,610 t/yr	7,500,000 M DKK	2,110 M DKK/t	▾
Energy	Expansion of Renewable Energy	✓	-5,690 t	-3,350 t/yr	42,500,000 M DKK	7,470 M DKK/t	▾
Energy	Green District Heating of the Future	✓	-14,400 t	6,020 t/yr	6,000,000 M DKK	418 M DKK/t	▾
Energy	Sustainable Municipal Facilities	✓	-4,000 t	-1,000 t/yr	4,500,000 M DKK	1,130 M DKK/t	▾

Shadow price example: afforestation

Real values	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Funds, DKK	7.250.000 kr.	7.250.000 kr.	7.250.000 kr.	7.250.000 kr.	7.250.000 kr.	7.250.000 kr.										
Yearly reductions, CO2e (1)	21.300	21.300	21.300	21.300	21.300	30.900	30.900	30.900	30.900	30.900	43.700	43.700	43.700	43.700	43.700	52.500
Discounted values	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Funds, DKK	7.250.000 kr.	7.004.831 kr.	6.767.953 kr.	6.539.085 kr.	6.317.956 kr.	6.104.305 kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.
Sum of reductions, CO2e	21.300	20.580	19.884	19.211	18.562	26.017	25.137	24.287	23.466	22.672	30.980	29.932	28.920	27.942	26.997	31.337
Reduction in target year (2030)	30.900															
Yearly funds	7.250.000															
Shadow price (2030)	318 kr.															
Shadow price (2040)	101 kr.															

Shadow price example: energy-efficient municipal buildings

Real values	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Funds, DKK	5.000.000 kr.	5.000.000 kr.	5.000.000 kr.	5.000.000 kr.	5.000.000 kr.	5.000.000 kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.
Yearly reductions, CO2e (1)	83	167	250	333	417	500	500	500	500	500	500	500	500	500	500	500
Yearly reductions, CO2e (2)	2.291	2.291	1.964	1.964	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Discounted values	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Funds, DKK	5.000.000 kr.	4.830.918 kr.	4.667.554 kr.	4.509.714 kr.	4.357.211 kr.	4.209.866 kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.	- kr.
Sum of reductions, CO2e	2.374	2.375	2.067	2.072	1.789	1.798	1.738	1.679	1.622	1.567	1.514	1.463	1.414	1.366	1.320	1.275
Reduction in target year (2030)	2.136															
Yearly funds	5.000.000															
Shadow price (2030)	2.210 kr.															
Shadow price (2040)	1.005 kr.															