UNECE

ENERGY

Workshop: The path to climate neutrality

Building blocks of a new methodology for determining an economic mix of measures

UNECE Group of Experts on Energy Efficiency - TF Industry

18 January 2023, 14h00–16h00 CET (online)

Agenda

ENERGY

5 min	Opening	**Igor Litvinyuk** Secretary, Group of Experts on Energy Efficiency **Stefan M. Buettner** Chair, Group of Experts on Energy Efficiency
		Diana Wang Colibrit **Stefan M. Buettner** Group of Experts on Energy Efficiency
10 min		***1. Establishing clarity on terminology and identifying 'status quo'***
20 min		***2. Measures to reduce emissions: the main categories and how they differ***
10 min		***3. The role of opportunity costs, time, and external effects***
20 min		***4. A proposed approach to economic assessment: how it works and how it is applied?***
30 min		***5. Practice, application, and Q&A***
10 min		***6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment***
10 mins	Q&A and expert discussion	**All**
5 min	Closing	**Stefan M. Buettner** Chair, Group of Experts on Energy Efficiency

Opening & Housekeeping

ENERGY

Igor Litvinyuk
Secretary, Group of Experts on Energy Efficiency

Stefan M. Buettner
Chair, Group of Experts on Energy Efficiency

Diana Wang
ColibrIT

1. Establishing clarity on terminology and identifying ‘status quo’

Stefan M. Buettner

Chair, Group of Experts on Energy Efficiency

1. Establishing clarity on terminology and identifying ‘status quo’

Defining different neutralities and what is needed to achieve them

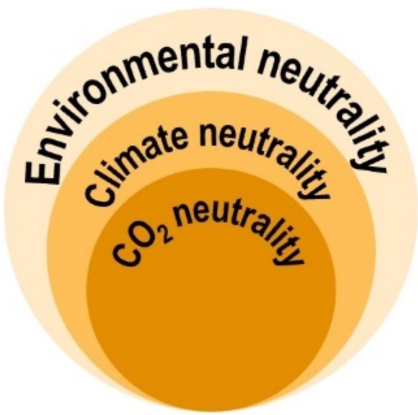


Illustration based on UNECE GEEE-7/2020/INF.2

Reduction & compensation of:

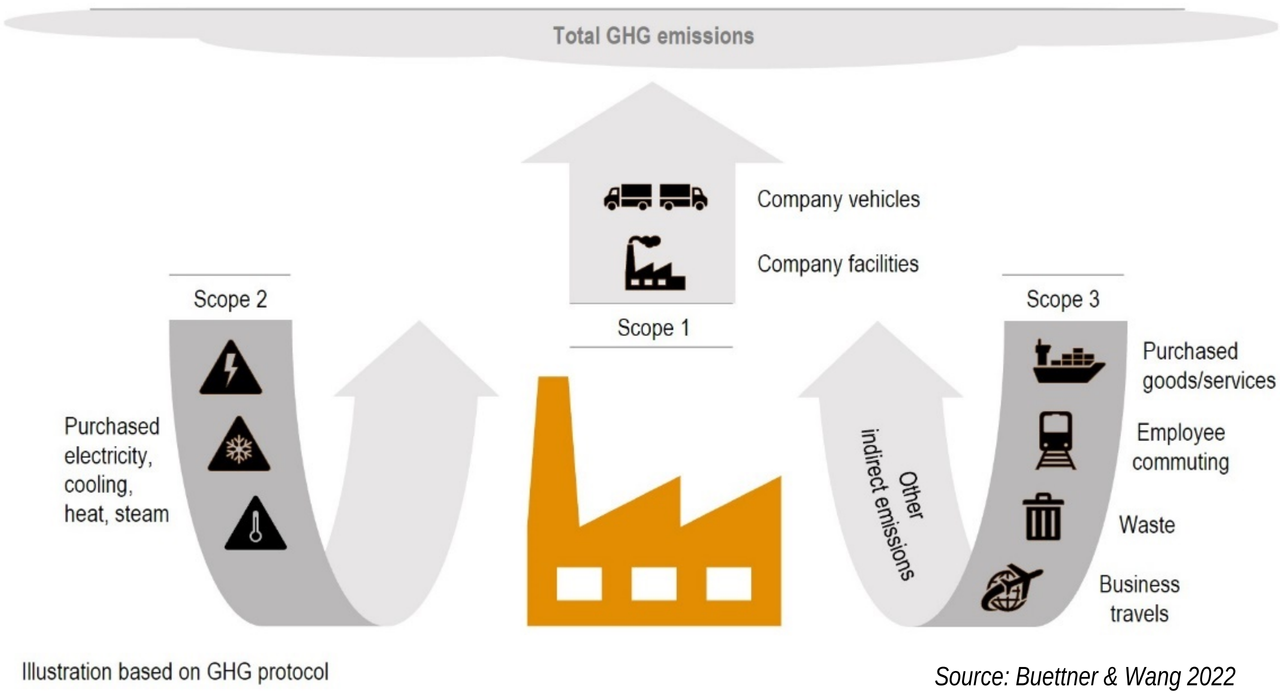
1. CO_2 emissions
2. CO_2 + non-fluorinated greenhousegases (CH_4, N_2O) + fluorinated GHGs (HFC, PFC, SF_6, NF_3)
3. CO_2 + non-fluorinated GHGs + fluorinated GHGs + all other substances that negatively impact the environment and health e.g., particulate matter, soot, NOx, SO_2

Source: Buettner & Wang 2022

1. Establishing clarity on terminology and identifying 'status quo'

ENERGY

Scopes of emission footprint assessment



Source: Buettner & Wang 2022

⇒ ***Clarity in terminology & its meaning, as well as targets is essential***

1. Establishing clarity on terminology and identifying 'status quo'

Awareness of own emission footprint, requirements and regulations

- Determining energy-related emissions simple if consumption data per energy source and its composition are available
- Challenging to determine process-related emissions
- Familiarity with emission pricing systems and what they include is important (what emissions / energy-& process)

1. Establishing clarity on terminology and identifying ‘status quo’

Three categories of measures to address the emissions footprint

Focusing on emissions that are primarily under the direct control of decision-makers in the company

- Reduction of greenhouse gases by adapting *how* one does business (efficiency and processes)
- Substitution of *what* one does business with (energy sources and materials)
- Offsetting the greenhouse gases emitted.

1. Establishing clarity on terminology and identifying 'status quo'

ENERGY

Why is a novel approach is needed for decarbonization

- Only measures paid off in short term being implemented
- micro level: product cycles, risk could be overlooked
- meso- or macro level: economically less efficient to apply the "traditional" payback time methodology
- costs of non-action, availability barriers, price risks for energy, emission prices not taken into account

2. Measures to reduce emissions: the main categories and how they differ

Stefan M. Buettner

Chair, Group of Experts on Energy Efficiency

2. Measures to reduce emissions: the main categories and how they differ

Overview of the six types of measures and their impact

Source: Buettner & Wang 2022

2. Measures to reduce emissions: the main categories and how they differ

3 **Self-generated renewable energy**	Installation of PV systems Waste heat recovery	One-off investments Additional supporting systems e.g., energy storage might be needed	↓ Energy costs ↓ Energy-related emissions ↑ Possibility of additional maintenance costs
4 **Purchase of renewable energy**	Renewable Energy Power Purchase Agreements (PPAs)	No one-off investments	↑ Energy costs ↓ Energy-related emissions

Source: Buettner & Wang 2022

2. Measures to reduce emissions: the main categories and how they differ

5 **Certificates/ Projects**	Purchase of carbon credits Worldwide green projects financing	No one-off investments	Additional company expenses No effect on real energy- & process-related emissions
6 **CO_2 storage, binding & use**	Carbon capture, utilisation, and storage (CCUS)	One-off investments	Additional operating costs No effect on energy costs Net emissions

Source: Buettner & Wang 2022

2. Measures to reduce emissions: the main categories and how they differ

Reference Scenario: Do not act

- *Economic one-off effect*: There are no investments.
- *Lasting effect: Emissions levy vary from countries, incur additional cost.*
- *Conclusion:*
  - neither emissions nor ongoing energy costs are reduced
  - noticeable additional ongoing costs can be incurred for the emissions released (depending on location and clients).
  - Depending on the pricing model, these costs per unit of emissions can vary.

Source: Buettner & Wang 2022

Source: Buettner & Wang 2022

3. The role of opportunity costs, time, and external effects

Stefan M. Buettner
Chair, Group of Experts on Energy Efficiency

Diana Wang
ColibrIT

3. The role of opportunity costs, time, and external effects

System view: external factors with strong influence

Types of measures to be assessed in the context of:

- one's own objectives and
- the overall system in which one operates in

taking into account:

  - legal and regulatory requirements
  - geographical circumstances
  - the availability on the market
  - societal expectations
  - impact of one's own choice of (non-)action

3. The role of opportunity costs, time, and external effects

Share of renewable generation compared to share of energy consumed by industry

2019	Electricity (Totals)			Energy (Totals)		
Regions [49] \ Shares	Supply		Final Consumption	Supply		Final Consumption
	renewables	low carbon	Industry	renewables	low carbon	Industry
World	26%	36%	42%	14%	19%	29%
OECD	27%	45%	32%	12%	21%	22%
Non-OECD Total	25%	30%	49%	16%	19%	35%
Non-OECD Americas	68%	70%	38%	34%	36%	28%
Non-OECD Europe and Eurasia	19%	37%	42%	5%	12%	27%
Non-OECD Asia (incl. China)	25%	29%	55%	14%	16%	43%
Middle East	3%	3%	23%	1%	1%	28%
Africa	21%	22%	38%	48%	48%	14%
EU-27 [50,51]	34%	.	36%	20%	.	26%
China	27%	32%	60%	10%	12%	49%
Germany	40%	52%	45%	16%	22%	25%
Italy	40%	40%	41%	19%	19%	21%
Japan	18%	24%	36%	8%	12%	29%
South Africa	5%	10%	52%	6%	8%	38%
USA	18%	37%	20%	8%	18%	17%

orange:
demand exceeds supply

yellow:
supply almost meets demand

green:
demand is met by supply

low carbon
= renewables + nuclear

Source: Buettner & Wang 2022 based on IEA World Energy Balances Highlights and Eurostat

3. The role of opportunity costs, time, and external effects

- Demand cannot be met at the present and could lead to price increases for green electricity tariffs.
- Severe events lead to reduced electricity supply, drives up the unit price for energy.
- Difficult to switch all energy needs to renewable or low-carbon sources, reasons as follows:
  a) The gap to meet the industrial sector‘s needs is larger
  b) alternatives are less mobile or require new infrastructures

3. The role of opportunity costs, time, and external effects

- The availability of emission reduction certificates and credible climate protection projects is limited
- Increased risk of falling prey to dishonest projects.
- A shortage of skilled workers in the construction sector.
- Longer waiting times and higher costs for priority treatment are expected

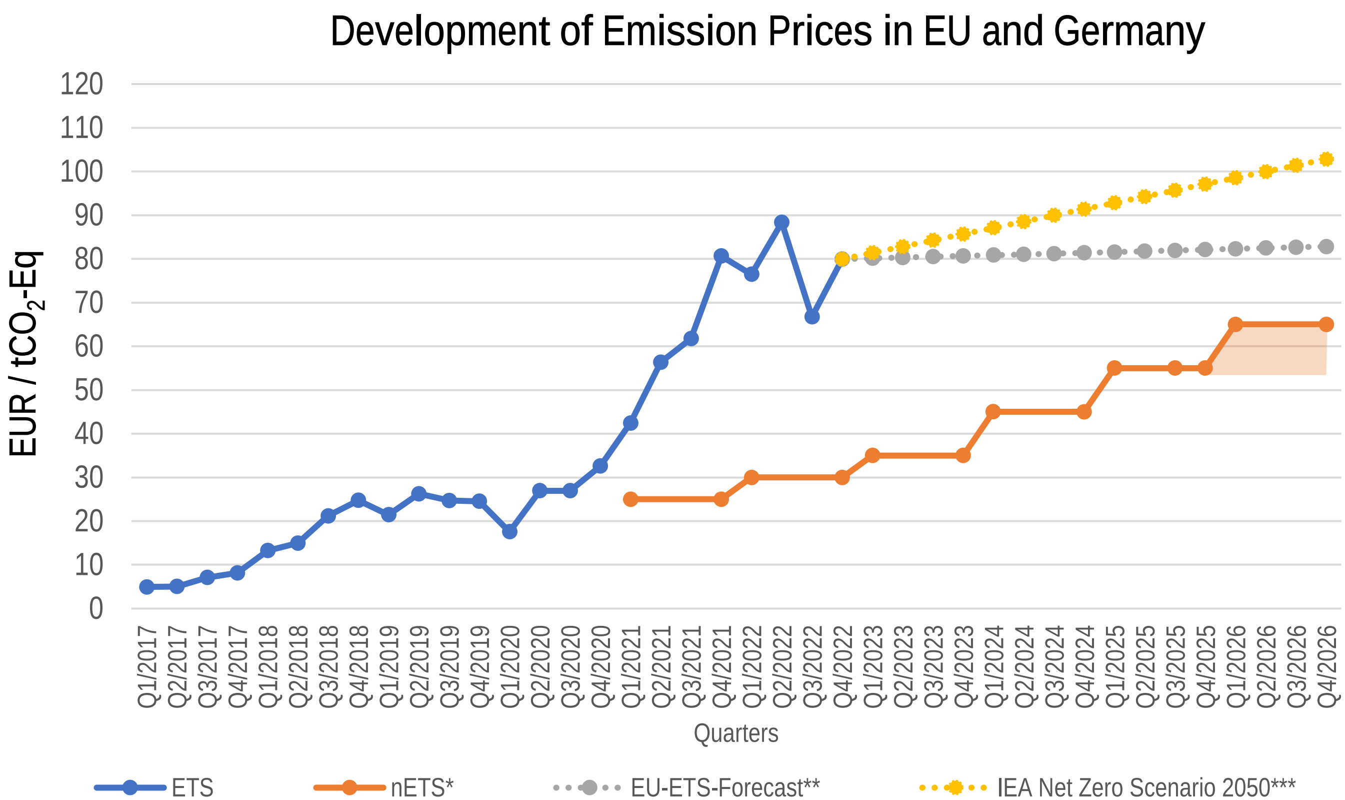
Bottom line: Prioritise on-site actions

1. Build resilience against availability/price shocks
2. Reduce the risk of having to wait in line
3. Minimise the procrastination costs

3. The role of opportunity costs, time, and external effects

ENERGY

Consideration of price fluctuations



Source: Buettner & Wang 2022

- Market based system (EU ETS) and its forecasts for 2030
- fixed-price system with staggered increases (German nETS) that is charged on energy-related emissions not covered by EU ETS

3. The role of opportunity costs, time, and external effects

Consideration of price fluctuations

- energy and emission price developments influence how cost savings change over time
- various factors influence emissions and energy prices, but they can also influence each other
  - higher emission prices => rising demand for electricity from renewables =>increasing prices for green electricity
  - unless: expansion of renewable energies parallels rise in demand

=> counteracting a price increase by augmenting supply.

3. The role of opportunity costs, time, and external effects

	In comparison with the Reference Scenario *--> dependence on development of energy/emission prices*	
Reduction measures	• energy consumption	• permanent reduction
	• energy costs	• permanent reduction --> less dependent
	• emission	• permanent reduction
	• emission costs	• permanent reduction --> less dependent

3. The role of opportunity costs, time, and external effects

ENERGY

	In comparison with the Reference Scenario *--> dependence on development of energy/emission prices*	
Substitution measures	• energy consumption	• no change
	• energy costs	• reduction --> dependence or complete independence (100% self-generation)
	• emission	• significant reduction
	• emission costs	• permanent reduction --> less dependent or complete independence (100% renewables)

3. The role of opportunity costs, time, and external effects

	In comparison with the Reference Scenario --> dependence on development of energy/emission prices	
Measures to compensate	• energy consumption	• no change
	• energy costs	• no change
	• emission	• no change
	• emission costs	• reduction --> dependence on the certificate/ project price development

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Diana Wang
ColibrIT

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

A new economic efficiency calculation

For each energy source	*First Step*	*Second Step*
Energy amount	Energy amount $_{Reference}$	Energy amount $_{New}$
Energy price	Energy Price $_{Reference}$	Energy Price $_{New}$
Emission amount (energy-related and process-related)	Emission amount $_{Reference}$	Emission amount $_{New}$
Emission price	Emission Price $_{Reference}$	Emission Price $_{New}$

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

A new economic efficiency calculation

$$\begin{aligned} Savings\ (N,E) = \sum_{t=1}^{N}\sum_{e=1}^{E} \Big(& Energy\ price_{Reference}(t,e) * Energy\ amount_{Reference}(t,e) \\ & - Energy\ price_{New}(t,e) * Energy\ amount_{New}(t,e) \Big) \\ + \sum_{t=1}^{N}\sum_{e=1}^{E} \Big(& Emission\ price_{Reference}(t,e) * Emission\ amount_{Reference}(t,e) \\ & - Emission\ price_{New}(t,e) * Emission\ amount_{New}(t,e) \Big) \end{aligned}$$

t: year, e: energy source

Equation 1. Calculation of aggregated savings for a measure option

4. A proposed approach to economic assessment: how it works & it is applied?

A new economic efficiency calculation

1. Map the current situation by determining

- the energy consumption and energy costs separated by energy sources,
- the emissions of the consumed energy, converted in CO2-equivalents, and the corresponding emission costs,
- the process-related emissions, converted in CO2-equivalents, and the associated emission costs

2. Make assumptions about

- the future development of energy prices
- the future development of emission costs
- the impact of the measure option

3. Calculate the aggregate savings

$$\begin{aligned} Savings\ (N,E) = &\sum_{t=1}^{N}\sum_{e=1}^{E}\Big(Energy\ price_{Reference}(t,e) * Energy\ amount_{Reference}(t,e) \\ &- Energy\ price_{New}(t,e) * Energy\ amount_{New}(t,e)\Big) \\ &+ \sum_{t=1}^{N}\sum_{e=1}^{E}\Big(Emission\ price_{Reference}(t,e) * Emission\ amount_{Reference}(t,e) \\ &- Emission\ price_{New}(t,e) * Emission\ amount_{New}(t,e)\Big) \end{aligned}$$

4. Calculate the Investment

- cost of acquisition
- ongoing costs

$$Investment\ (N) = \sum_{t=1}^{N} costs_{acquisition}\ (t) + \sum_{t=1}^{N} costs_{ongoing}\ (t)$$

5. Assess the net savings

$$net\ savings\ (t) = Savings\ (t,\ E) - Investment\ (t) > 0$$

5 Minute Break

4. A proposed approach to economic assessment: how it works & it is applied?

Applying the new economic efficiency calculation: examples for the six measure types

Assumptions:

1. One energy source:
   electricity with an emission factor of 0.4 gCO_2-eq/kWh

2. Energy price:
   0.20 EUR/kWh with a linear increase of 2 % per year

3. Emission price:
   30 EUR/tCO_2-eq with an increase of 5.00 EUR per tCO_2-eq per year

4. A proposed approach to economic assessment: how it works & it is applied?

Reference Scenario: No action is taken

Exemplary with assumed amounts and prices for energy and emissions.

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount Reference	Emission price Reference	Emission costs Reference	Total costs Reference
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000
t_1	1.000	20.40	204,000	600	35.00	21,000	225,000
t_2	1.000	20.81	208,080	600	40.00	24,000	232,080
t_3	1.000	21.22	212,242	600	45.00	27,000	239,242
t_4	1.000	21.65	216,486	600	50.00	30,000	246,486
t_5	1.000	22.08	220,816	600	55.00	33,000	253,816
				(…)			
t_{10}	1.000	24.38	243,799	600	80.00	48,000	291,799
				(…)			
t_{30}	1.000	36.23	362,272	600	180.00	108,000	470,272

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Measure type 1: Energy efficiency

Exemplary scenario in which an energy efficiency measure is implemented.

Year	Energy amount New	Energy price Reference	Energy costs New	Emission amount New	Emission price Reference	Emission costs New	Total costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	700	20.40	142,800	480	35.00	16,800	159,600	65,400
t_2	700	20.81	145,656	480	40.00	19,200	164,856	67,224
t_3	700	21.22	148,569	480	45.00	21,600	170,169	69,072
t_4	700	21.65	151,541	480	50.00	24,000	175,541	70,946
t_5	700	22.08	154,571	480	55.00	26,400	180,971	72,845
				(…)				
t_{10}	700	24.38	170,659	480	80.00	38,400	209,059	82,740
				(…)				
t_{30}	700	36.23	253,591	480	180.00	86,400	339,991	130,282

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Measure type 2: process decarbonisation

Exemplary scenario in which a process decarbonisation measure is implemented.

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1,000	20.40	204,000	550	35.00	19,250	223,250	1,750
t_2	1,000	20.81	208,080	550	40.00	22,000	230,080	2,000
t_3	1,000	21.22	212,242	550	45.00	24,750	236,992	2,250
t_4	1,000	21.65	216,486	550	50.00	27,500	243,986	2,500
t_5	1,000	22.08	220,816	550	55.00	30,250	251,066	2,750
				(…)				
t_{10}	1,000	24.38	243,799	550	80.00	44,000	287,799	4,000
				(…)				
t_{30}	1,000	36.23	362,272	550	180.00	99,000	461,272	9,000

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

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Measure type 3: self-generation of renewable energy

Exemplary scenario in which a measure of type 3 is implemented.

Year	Energy amount New	Energy price Reference	Energy costs New	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	500	20.40	102,000	400	35.00	14,000	116,000	109,000
t_2	500	20.81	104,040	400	40.00	16,000	120,040	112,040
t_3	500	21.22	106,120	400	45.00	18,000	124,121	115,121
t_4	500	21.65	108,243	400	50.00	20,000	128,243	118,243
t_5	500	22.08	110,408	400	55.00	22,000	132,408	121,408
(…)								
t_{10}	500	24.38	121,899	400	80.00	32,000	153,899	137,899
(…)								
t_{30}	500	36.23	181,136	400	180.00	72,000	253,136	217,136

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Measure type 4: purchase of renewable energy

Exemplary scenario in which a measure of type 4 is implemented.

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1,000	20.40	204,000	200	35.00	7,000	211,000	14,000
t_2	1,000	20.81	208,080	200	40.00	8,000	216,080	16,000
t_3	1,000	21.22	212,242	200	45.00	9,000	221,242	18,000
t_4	1,000	21.65	216,486	200	50.00	10,000	226,486	20,000
t_5	1,000	22.08	220,816	200	55.00	11,000	231,816	22,000
				(…)				
t_{10}	1,000	24.38	243,799	200	80.00	16,000	259,799	32,000
				(…)				
t_{30}	1,000	36.23	362,272	200	180.00	36,000	398,272	72,000

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Measure type 5: compensation through certificates or projects

Exemplary scenario in which a measure of type 5 is implemented.

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount Reference	Emission price New	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1,000	20.40	204,000	600	21.00	12,600	216,600	8,400
t_2	1,000	20.81	208,080	600	24.00	14,400	222,480	9,600
t_3	1,000	21.22	212,242	600	27.00	16,200	228,442	10,800
t_4	1,000	21.65	216,486	600	30.00	18,000	234,486	12,000
t_5	1,000	22.08	220,816	600	33.00	19,800	240,616	13,200
				(…)				
t_{10}	1,000	24.38	243,799	600	48.00	28,800	272,599	19,200
				(…)				
t_{30}	1,000	36.23	362,272	600	108.00	64,800	427,072	43,200

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Measure type 6: carbon capture, storage, binding and use

Exemplary scenario in which a measure of type 6 is implemented

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1,000	20.40	204,000	400	35.00	14,000	218,000	7,000
t_2	1,000	20.81	208,080	400	40.00	16,000	224,080	8,000
t_3	1,000	21.22	212,242	400	45.00	18,000	230,242	9,000
t_4	1,000	21.65	216,486	400	50.00	20,000	236,486	10,000
t_5	1,000	22.08	220,816	400	55.00	22,000	242,816	11,000
				(…)				
t_{10}	1,000	24.38	243,799	400	80.00	32,000	275,799	16,000
				(…)				
t_{30}	1,000	36.23	362,272	400	180.00	72,000	434,272	36,000

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Economic effects of the sequence of implementation of measure types

Scenario 1: first measure type 1, second measure type 4

Year	Energy amount New	Energy price Reference	Energy costs New	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	700	20.40	142,800	480	35.00	16,800	159,600	65,400
t_2	700	20.81	145,656	200	40.00	8,000	153,656	78,424
t_3	700	21.22	148,569	200	45.00	9,000	157,569	81,672
t_4	700	21.65	151,541	200	50.00	10,000	161,541	84,946
t_5	700	22.08	154,571	200	55.00	11,000	165,571	88,245
				(…)				
t_{10}	700	24.38	170,659	200	80.00	16,000	186,659	105,140
				(…)				
t_{30}	700	36.23	253,591	200	180.00	36,000	289,591	180,682

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Economic effects of the sequence of implementation of measure types

Scenario 2: first measure type 4, second measure type 1

Year	Energy amount New	Energy price Reference	Energy costs New	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1.000	20.40	204,000	320	35.00	11,200	215,200	9,800
t_2	700	20.81	145,656	200	40.00	8,000	153,656	78,424
t_3	700	21.22	148,569	200	45.00	9,000	157,569	81,672
t_4	700	21.65	151,541	200	50.00	10,000	161,541	84,946
t_5	700	22.08	154,571	200	55.00	11,000	165,571	88,245
				(…)				
t_{10}	700	24.38	170,659	200	80.00	16,000	186,659	105,140
				(…)				
t_{30}	700	36.23	253,591	200	180.00	36,000	289,591	180,682

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Example for possible measures on-site

Scenario 3: first measure type 1, second measure type 2, third measure type 3

Year	Energy amount New	Energy price Reference	Energy costs New	Emission amount New	Emission price Reference	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	700	20.40	142,800	480	35.00	16,800	159,600	65,400
t_2	700	20.81	145,656	430	40.00	17,200	162,856	69,224
t_3	125	21.22	26,530	200	45.00	9,000	35,530	203,711
t_4	125	21.65	27,061	200	50.00	10,000	37,061	209,426
t_5	125	22.08	27,602	200	55.00	11,000	38,602	215,214
				(…)				
t_{10}	125	24.38	30,475	200	80.00	16,000	46,475	245,324
				(…)				
t_{30}	125	36.23	45,284	200	180.00	36,000	81,284	388,988

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Example for possible measures off-site

Scenario 4: first measure type 4, second measure type 5

Year	Energy amount Reference	Energy price Reference	Energy costs Reference	Emission amount New	Emission price New	Emission costs New	Total Costs New	Savings (N, E, t)
	MWh	ct/kWh	EUR	tCO_2-eq	EUR/tCO_2-eq	EUR	EUR	EUR
t_0	1,000	20.00	200,000	600	30.00	18,000	218,000	0
t_1	1.000	20.40	204,000	320	35,00	11,200	215,200	9,800
t_2	1.000	20.81	208,080	320	34,00	10,880	218,960	13,120
t_3	1.000	21.22	212,242	320	38,25	12,240	224,482	14,760
t_4	1.000	21.65	216,486	320	42,50	13,600	230,086	16,400
t_5	1.000	22.08	220,816	320	46,75	14,960	235,776	18,040
				(…)				
t_{10}	1.000	24.38	243,799	320	68,00	21,760	265,559	26,240
				(…)				
t_{30}	1.000	36.23	362,272	320	153,00	48,960	411,232	59,040

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

ENERGY

Cumulated ongoing energy and emission costs

Comparison of overall costs and savings of the scenarios 1, 2, 3 and 4.

	Total (ongoing) costs [EUR]			Savings [EUR]		
	$t_1 - t_5$	$t_1 - t_{10}$	$t_1 - t_{30}$	$t_1 - t_5$	$t_1 - t_{10}$	$t_1 - t_{30}$
Reference scenario	1,196,624	2,578,743	10,210,888	0	0	0
Scenario 1	797,937	1,688,420	6,447,922	398,687	890,323	3,762,966
Scenario 2	853,537	1,744,020	6,503,522	343,087	834,723	3,707,366
Scenario 3	433,649	650,164	1,935,432	762,975	1,928,579	8,275,456
Scenario 4	1,124,504	2,391,823	9,154,768	72,120	186,920	1,056,120

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Cumulated ongoing energy and emission costs

Effect of measure types on energy and emission amounts

	Energy amount [MWh]		Emission amount [tCO_2-eq]	
	(total) remaining	for calculation	(total) remaining	for calculation
Reference Scenario	1.000		600	
Measure type 1	700		480	
Measure type 2	1.000		550	
Measure type 3	1.000	500	400	
Measure type 4	1.000		200	
Measure type 5	1.000		600	
Measure type 6	1.000		600	400

Source: Buettner & Wang 2022

4. A proposed approach to economic assessment: how it works & it is applied?

Expenditure

- $Investment\ (N) = \sum_{t=1}^{N} costs_{acquisition}(t) + \sum_{t=1}^{N} costs_{ongoing}(t)$

Equation 2. Calculation of aggregated investments for a measure option

- $Savings\ (N, E) - Investment\ (N)\ \geq 0$

Equation 3. Determining economic viability for a measure option within period of use.

- $Savings\ \left(t_{adj.payback}, E\right) - Investment\ \left(t_{adj.payback}\right)\ = 0$

Equation 4. Determining the adjusted payback time.

- $net\ savings\ (t) = Savings\ (t, E) - Investment\ (t) > 0\ ; \quad t < N$

Equation 5. Determining the net savings in (t), provided t < N

5. Practice, application, and Q&A

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6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

ENERGY

Stefan M. Buettner

Chair, Group of Experts on Energy Efficiency

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

Selection of measures: combining economic efficiency and system view

Result of comparing scenarios and their outcomes:

⇒ it makes sense to prioritise on-site actions (1, 2, 3, 6)

⇒ crucial to keep an eye economic factors, but also on all external factors and act quickly to

(a) build resilience against availability-, price- and other shocks,

(b) reduce the risk of having to wait in line

(c) minimise the “procrastination costs” of missed savings opportunities.

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

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Selection of measures: combining economic efficiency and system view

A “good” choice of measures is also subject to temporal changes:

If climate neutrality is to be achieved in the short term:

- focus on measures (4) and (5).

To minimise the costs of climate neutrality and build resilience initiate

- accompanying local efficiency measures (1)
- on-site energy generation (3).

These have a longer implementation horizon but generate the savings for

- measures against process emission (2)
- to capture (6) (process) emissions
- to reduce the purchase of energy from external sources (4) and offsets (5)

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

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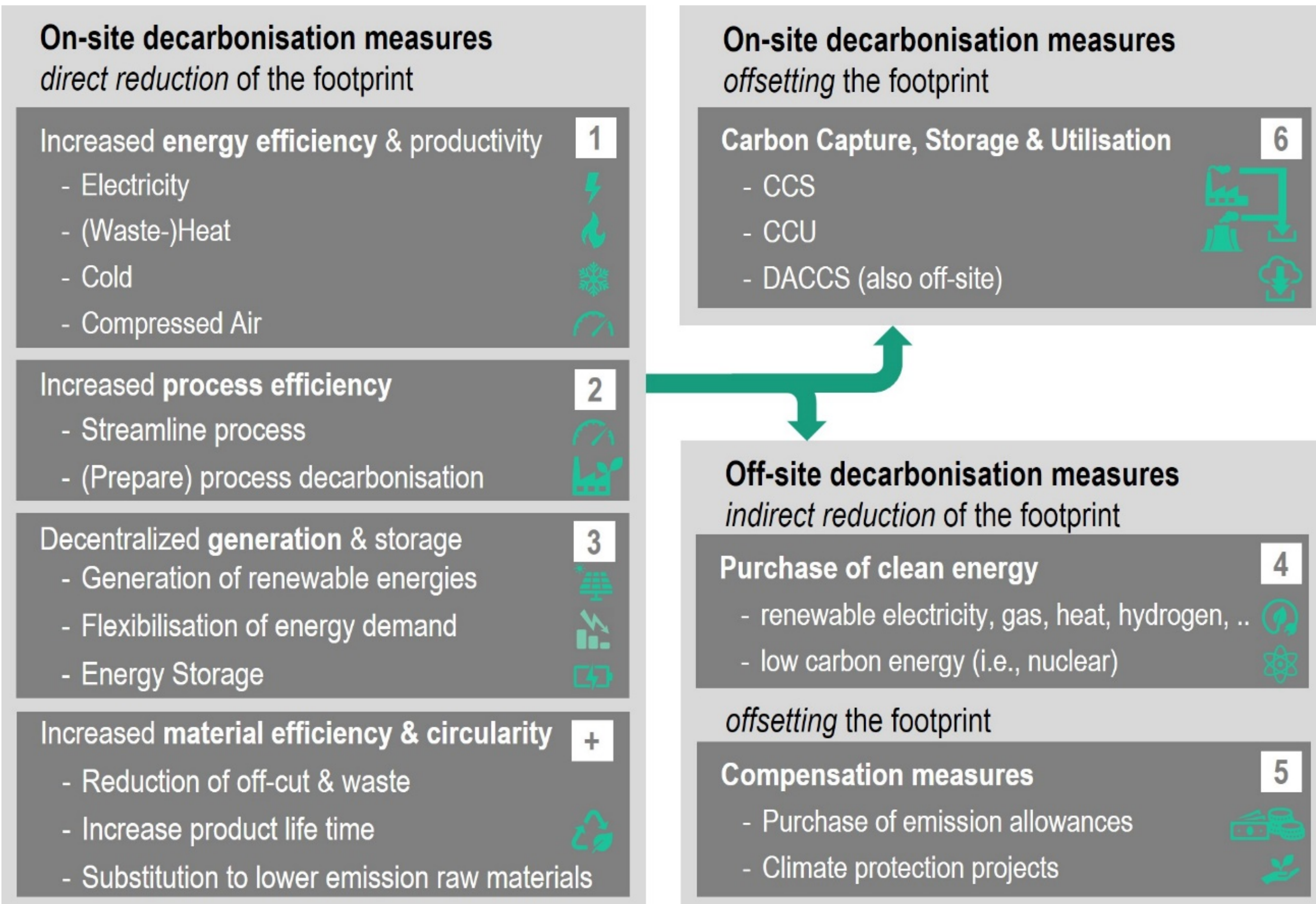

Source: Buettner & Wang 2022 based on EEP & Fraunhofer IPA

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

Creating a ranking system to determine one's ideal mix of measures

Not only the economic performance of measures of relevance, but also how:

a) it fits into the general (decarbonisation) strategy of the company, notably the **reason why** decarbonisation is pursued,

b) it performs in respect to the company's **decision-making determinants** and

c) its impact depends/builds on and **interacts**/is **compatible with other measures**,

d) it contributes to company risks, production **risks or resilience** (if at all), and how

e) effective it is to reach the **ambition level** (certain GHG savings by certain time).

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

Possible indicators of a scoring model / table (by variable type)

metric (years)	metric (figures)	binary or ordinal	nominal	filter
useful life	net savings (t)	impact on resilience	type of measure	on-/off-site measure
intermediate target	investment height	risk of failure/to operations	requirement for measure	investment < ...
target year	GHG savings	addressing motivators	type of emission addressed	cost per … < ...
adjusted payback time	*rank*	meeting decision criterion	scope addressed	skills exist
…	*weighting factor*	fits to strategy	description of measure	net savings (t) > 0
	score	…	...	adj.PT < useful life
	…			…

Definitions		optimise for (i.e.)
∑(weighting factors) =! 1	z = number of measures	goal achieved cheapest [or quickest]
Score = ∑(weighting factor x measure score), the higher the better		best impact on ... (resilience, image, risk, strategy, ..)

Source: Buettner & Wang 2022

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

Economic measures whose useful life is shorter than the time span until the milestone year not unlikely.

Therefore: assessment of all economic measures to compile the ideal mix of measures for achieving

- intermediate objectives *(i.e., a certain reduction target by 2030)*
- the overall objective *(i.e., achieving net-zero by 2040)*
- sustaining the desired outcome *(i.e., maintaining a net-zero emission footprint infinitively)*

taking into account useful lives and changing prices.

6. Advanced application: scoring, ranking, and dynamic adaptation to changing environment

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Exemplary shape of ranking table extract (random figures)

Target Year 20XX Milestone Target Year 20YY

Measure	Type	Score	Rank	meeting decision criterion [Filter]	impact on resilience	address-ing motivator	figure of numeric decision criterion	**net savings (t)**	GHG saved p.a.	...	depends on
Description	1-6	metric	[1 … z]	[0 ; 1]	[-1 ; 0 ; 1]	[0 … 5]	metric	metric	metric	…	
Example using random figures				cost per tonne saved < 150€/t_{CO2}		image	cost per tonne saved		energy - related t_{CO2eq}	…	
Weighting Factor					*20%*	*10%*	*15%*	*25%*	*30%*		
Solar PV	3	25.3	1	1	1	5	119.00 €	100,812 €	200	…	(roof)space
Green Tariff	4	22.6	2	1	-1	3	2.65 €	90,000 €	400	…	availability
EE-Measure	1	11.4	3	1	1	4	125.00 €	45,487 €	120	…	skill
CO_2-allowance	5	10.9	4	1	0	0	45.00 €	43,300 €	200	…	availability
ProcessDecarb.	2	-47.2	5	0	0	3	200.00 €	- 188,750 €	0	…	skill
CCUS	6	-238.7	6	0	0	1	250.00 €	- 955,000 €	0	…	regulation

Source: Buettner & Wang 2022

Types 2 and 6 will become essential to address process emissions in the long term.

Q&A and expert discussion

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All

Conclusion & Closing

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Stefan M. Buettner

Chair, Group of Experts on Energy Efficiency

Conclusion & Closing

- One-off and permant costs play a different role depends on the nature of one‘s own economic activity.
- The economic efficiency calculations need to be carried out for all available alternative actions.
- To evaluate the possible alternative actions, mapping economic aspects in a spreadsheet makes sense
- Political milestones and target dimensions are of great importance
- Changing the mix of measures in order to maintain net-zero state.
- Formulas stay robust despite different prices, policies and availabilities across the world.
- This tool is considered to be scientifically and technically sound for decision making and planning.
- Applying the principles and determinants described in this report allow one to determine one’s optimal pathway to reducing the greenhouse gas footprint.

Upcoming Events

ENERGY

UNECE Group of Experts on Energy Efficiency

Task Force on Energy Efficiency in Industry: bi-monthly open discussion forum

25 January 2022, 14h00–15h30 CET (online)

Tentative agenda

15 min	Opening, updates, and introduction of speakers	**Stefan M. Buettner** Chair, Group of Experts on Energy Efficiency	
15 min	Impulse 1	**Dr Steven Fawkes** Managing Partner, EnergyPro Ltd.	***ESCO-in-a-box: a tool to build capacity in energy efficiency in SME industry***
	Immediate questions		
15 min	Impulse 2	**Volker Dragon** VP Industry Affairs, Siemens	***ESCO in Industry*** *(title tbc)*
	Immediate questions		
40 mins	Q&A and expert discussion		
5 min	Wrap-up, closing remarks, and the way forward	**Stefan M. Buettner** Chair, Group of Experts on Energy Efficiency	

Registration:

https://forms.office.com/r/v8wjE1kXGt

Conclusion & Closing

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Documentation of this workshop will be made available and sent to registrants in the coming weeks

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