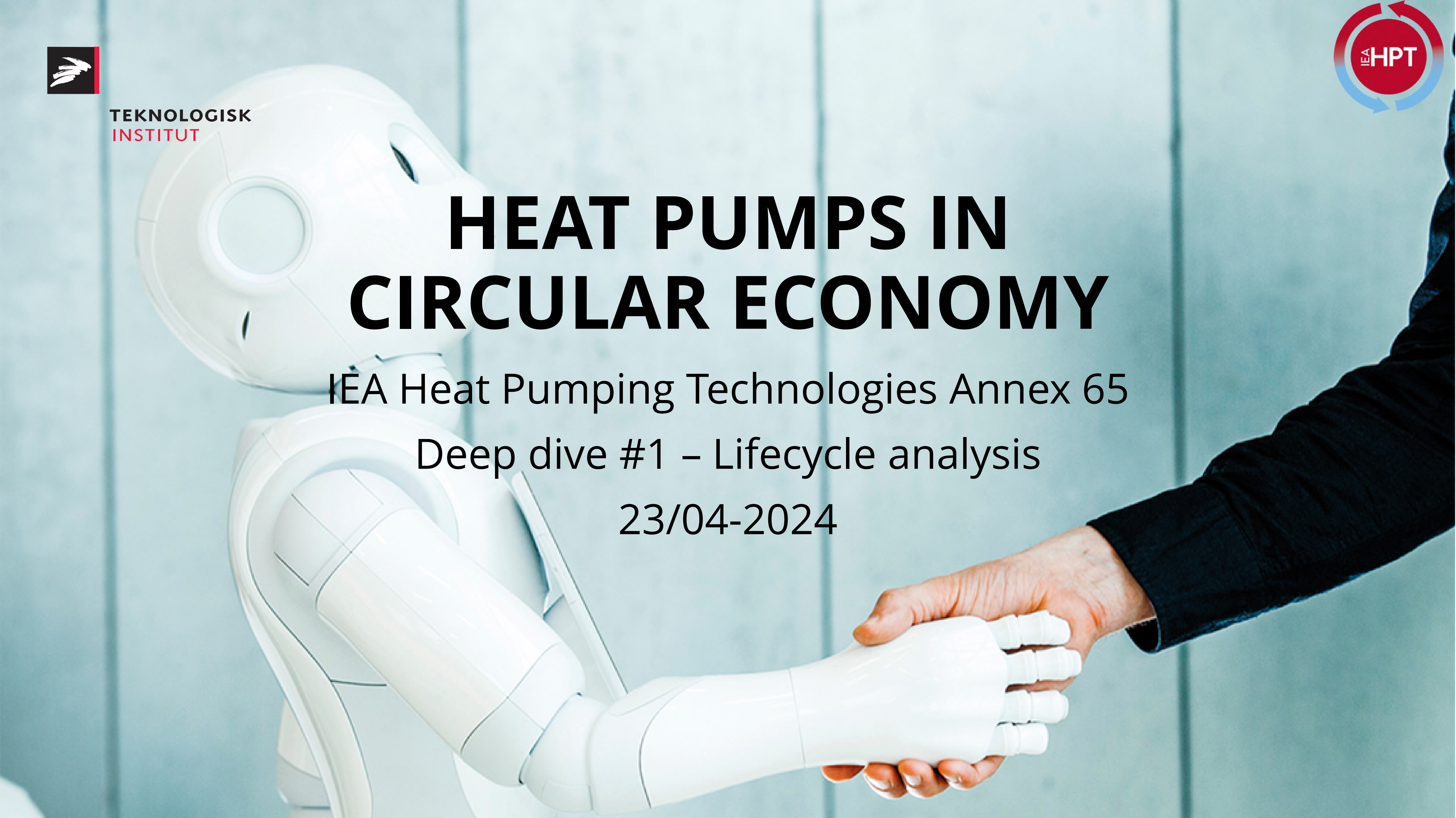

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HEAT PUMPS IN CIRCULAR ECONOMY

IEA Heat Pumping Technologies Annex 65

Deep dive #1 – Lifecycle analysis

23/04-2024

AGENDA

- Welcome and introduction (Jakob, DTI)
  - Brief introduction/update on annex 65
  - Motivation for today's topic
- Presentation of findings from IEA SHC task 71 by Fraunhofer ISE
- Proposal for gathering lifecycle data from Environmental Product Declarations (EPDs) by DTI
- Discussion of presentations
- Future deep dives

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•About Heat Pumping Technologies TCP

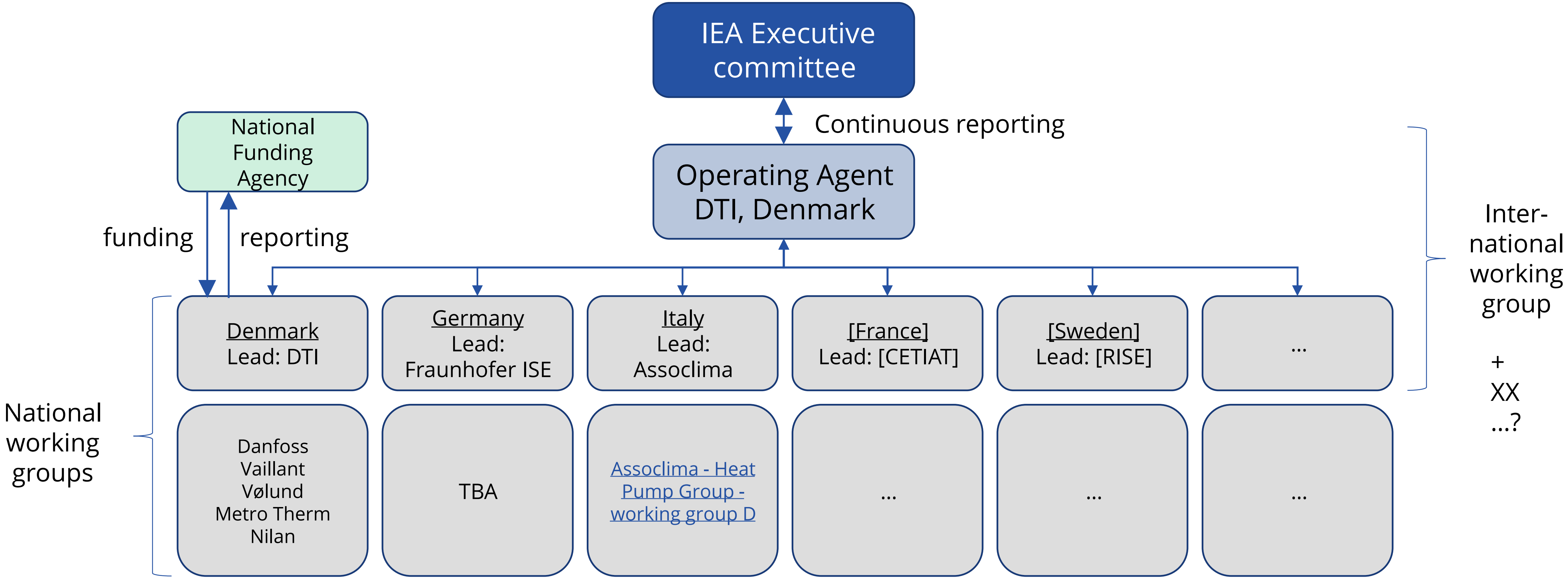
- A Technology Collaboration Programme (TCP) within **the IEA** since **1978**
- An international framework of **cooperation** and **networking** for different HP actors
- A forum to exchange **knowledge** and **experience**
- A contributor to **technology improvements** by RDD&D projects

20 Member Countries

Austria	Denmark	Italy	Spain
Belgium	Finland	Japan	Sweden
Canada	France	Netherlands	Switzerland
China	Germany	Norway	United Kingdom
Czech Republic	Ireland	South Korea	United States

www.heatpumpingtechnologies.org

ANNEX ORGANIZATION



RDD&D Priority Areas 2023-2028

System integration	Robust, sustainable and affordable value chains	Extending operation range and applications	New technologies and refrigerants
			
Sector coupling, energy efficiency, flexibility, resilience, storage, digitalization, positive energy districts	Improving affordability, securing value chains, circular economy, removing barriers for mass deployment	To fulfill demand from all climate zones, new markets, new applications and new demand. Refrigeration in emerging countries.	Non-traditional heat pumping technologies (for heating and cooling) Refrigerants (low GWP, safety etc.)
• Annex 56: IoT for Heat Pumps • Annex 57: Heat pumps in multi-vector energy systems • Annex 61: Heat Pumps in Positive Energy Districts **NEW** • Comfort and Climate Box solutions for cooling and dehumidification • Heat Pumps enabling Flexibility and Sector Coupling • Digital Services for Heat Pumps	• Annex 63 Placement Impact on Heat Pump Acoustics **NEW** • Annex 65 Heat Pumps in a Circular Economy **NEW** • New or alternative business models for heat pumps	• Annex 60: Retrofit Heat Pump in Larger Non-domestic Buildings • Annex 58: High Temperature Heat Pumps • Annex 59: Heat Pumps for Drying • Annex 62: Heat Pumps in residential multifamily buildings in cities **NEW** • Process Integration of High Temperature Heat Pumps	• Annex 53: Advanced cooling and refrigeration technology development • Annex 54: Heat Pump Systems with low GWP Refrigerants • Annex 64: Safety Measures on Flammable Refrigerants **NEW**

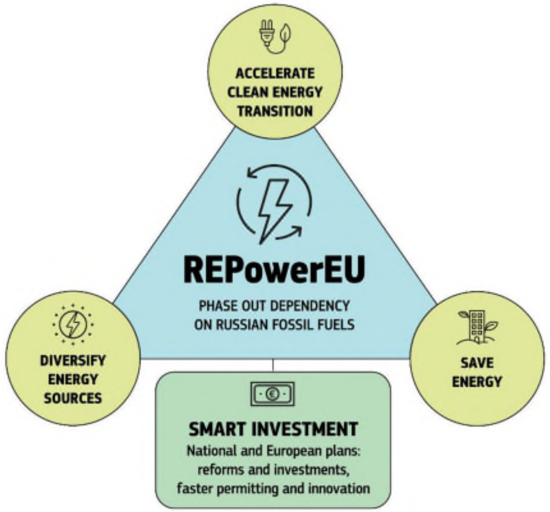
AL

HOW DOES THE ANNEX MATCH CURRENT TRENDS?

Product regulation
- Material efficiency requirements ecodesign for heat pumps
- Development of a repairability score
- A digital product passport for heat pumps

The building sector
- Environmental product declaration (EPD's) for heat pumps to be used in buildings.

Product design
- Carbon footprint in LCA analysis are becoming a competitive parameter.
- Use of light and/or reused materials/components
- Focus critical raw materials
- Upgradeability in products



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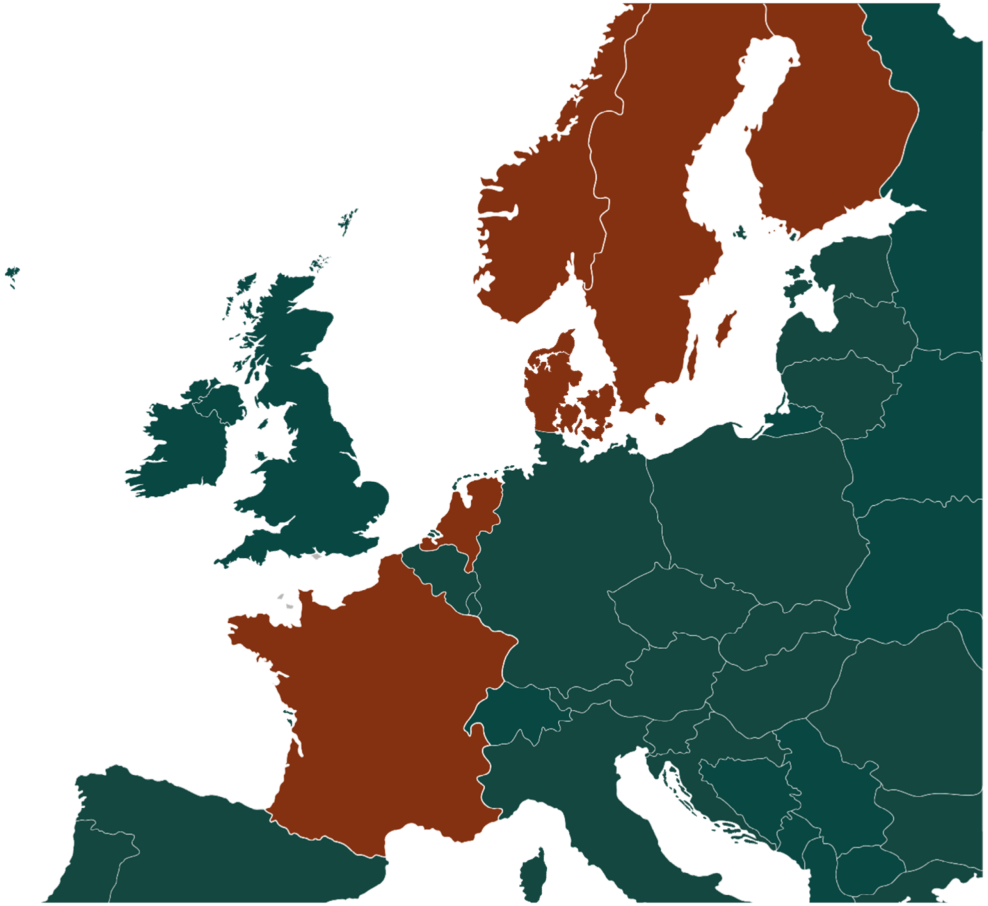
LIFECYCLE CARBON REQUIREMENTS FOR BUILDINGS - EUROPE AS A CASE

- 2012 - Netherlands: (LCA documentation requirements)
- 2018 - Netherlands: (LCA threshold value)
- 2021 - France: (LCA documentation requirements and threshold value)
- 2022 / Jan. - Sweden: (LCA documentation requirements)
- 2022 / End of the year - Norway: (LCA documentation requirements) (expected)
- 2023 / Jan - Denmark: (LCA documentation requirements and threshold value)
- Finland is in progress, official date pending



Red: European countries that have implemented or are in the process of implementing LCA requirements.

Source: Danish Authority of Social Services and Housing, primo 2023

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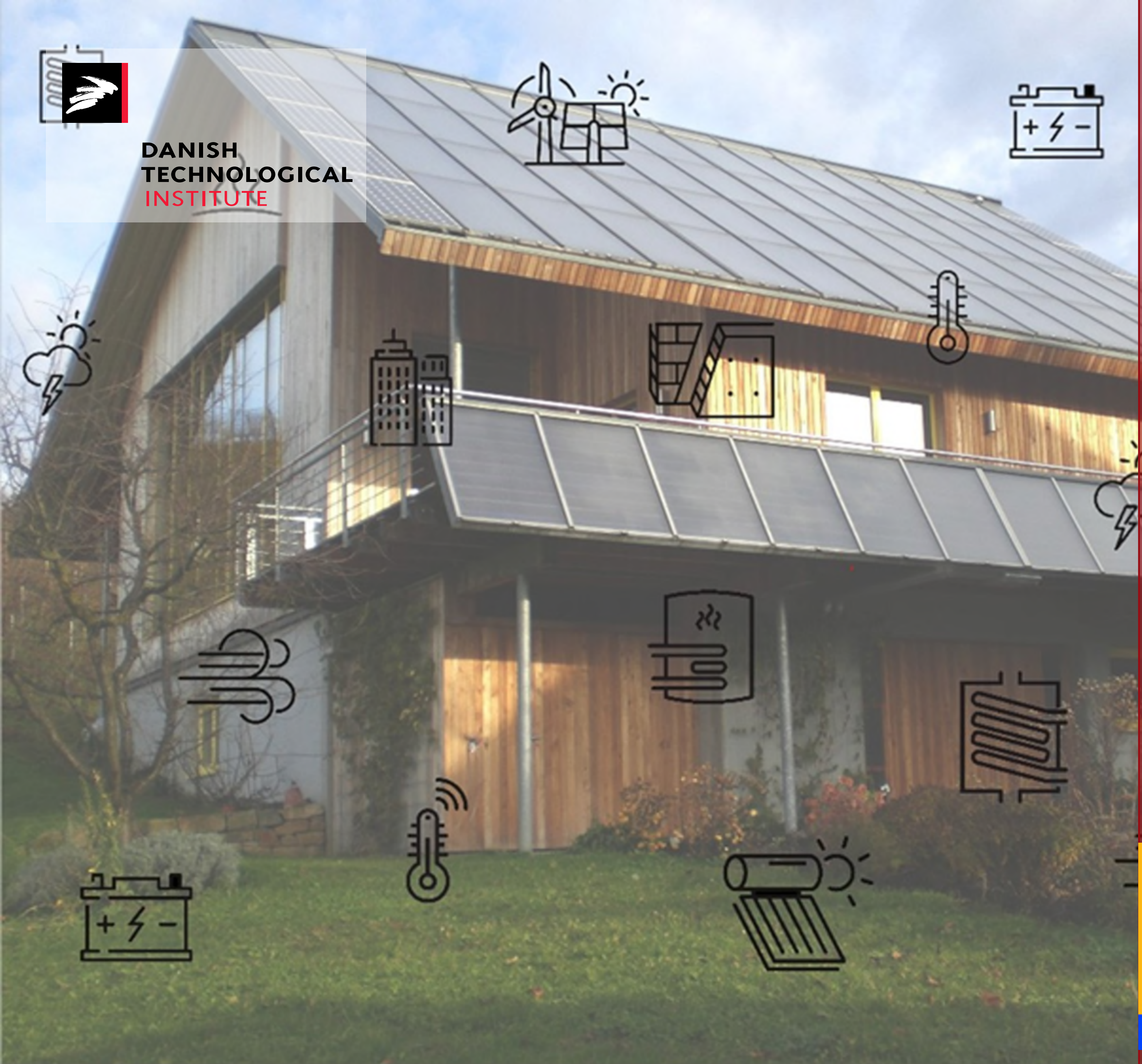

Learning from SHC Task 71: Life Cycle and Cost Assessment for Heating and Cooling Technologies

Task Manager

Dr. Karl-Anders Weiß
Fraunhofer-Institute for Solar Energy Systems ISE, Germany
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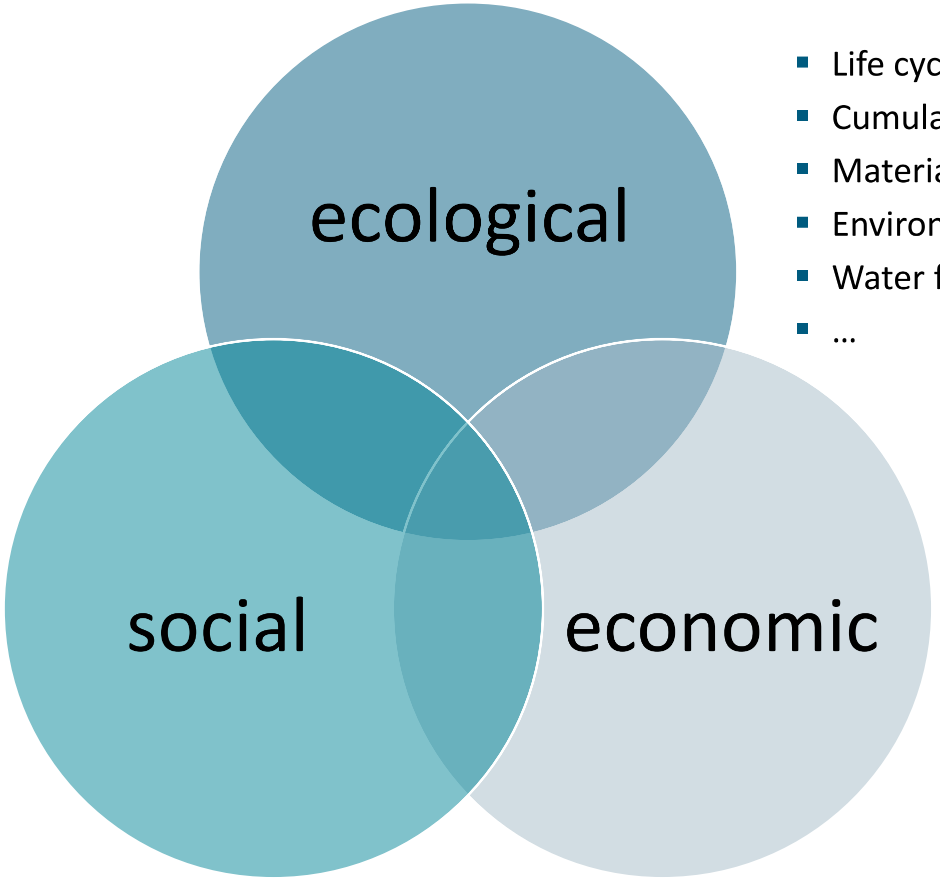
TA$K71

www.task71.iea-shc.org | www.iea-shc.org

Technology Collaboration Programme by iea

Sustainability Assessment



- Life cycle assessment (LCA)
- Cumulative energy demand (CED)
- Material flow analysis
- Environmental impact assessment (EIA)
- Water footprint (WF)
- …

- Life cycle social assessment (LCSA)
- Human development indicator (HDI)
- …

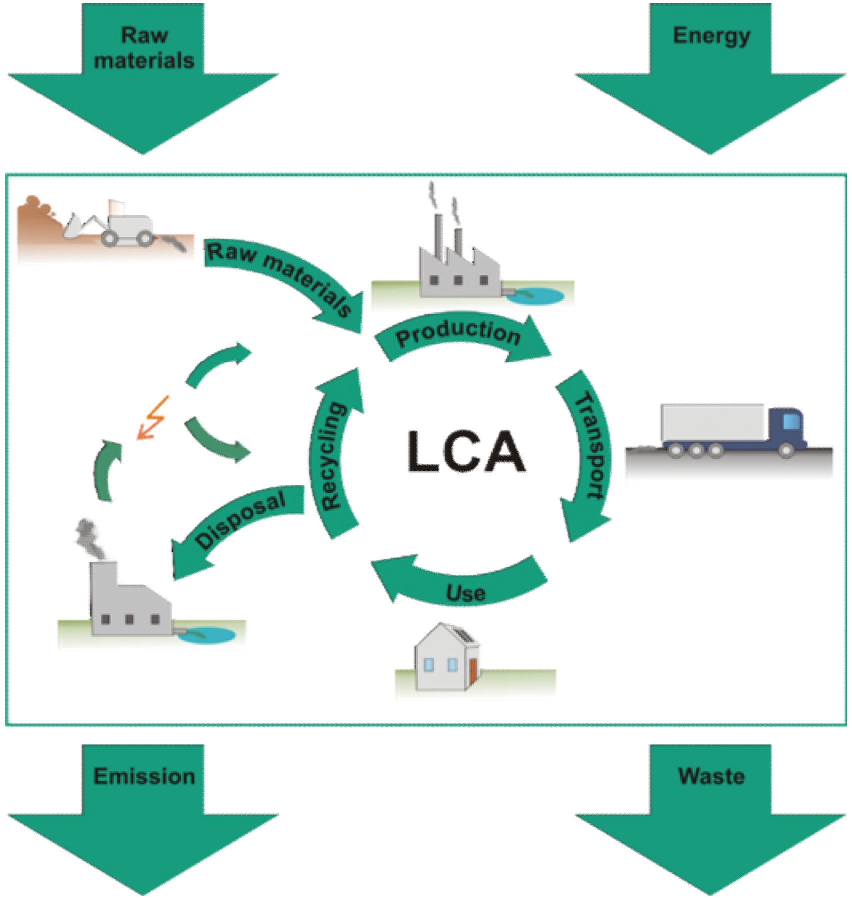
- Life cycle costing (LCC)
- Cost-benefit analysis (CBA)
- …

Life Cycle Assessment (LCA)

Background

- Currently the method of choice for assessing systematic impacts of products or services on ecological sustainability
- Assessment of life cycle phases
- Procedure standardized by ISO 14040 ff, additionally for PV by Guidelines (PVPS) and EU Product Environmental Footprint Category Rules (PEFCR)
- Assessment based on different impact categories (climate change, toxicity, resource and water use, acidification,…) and different impact assessment methods

Resource flows throughout the life cycle



Fraunhofer ISE

Sustainability Assessment at Fraunhofer ISE

Motivation

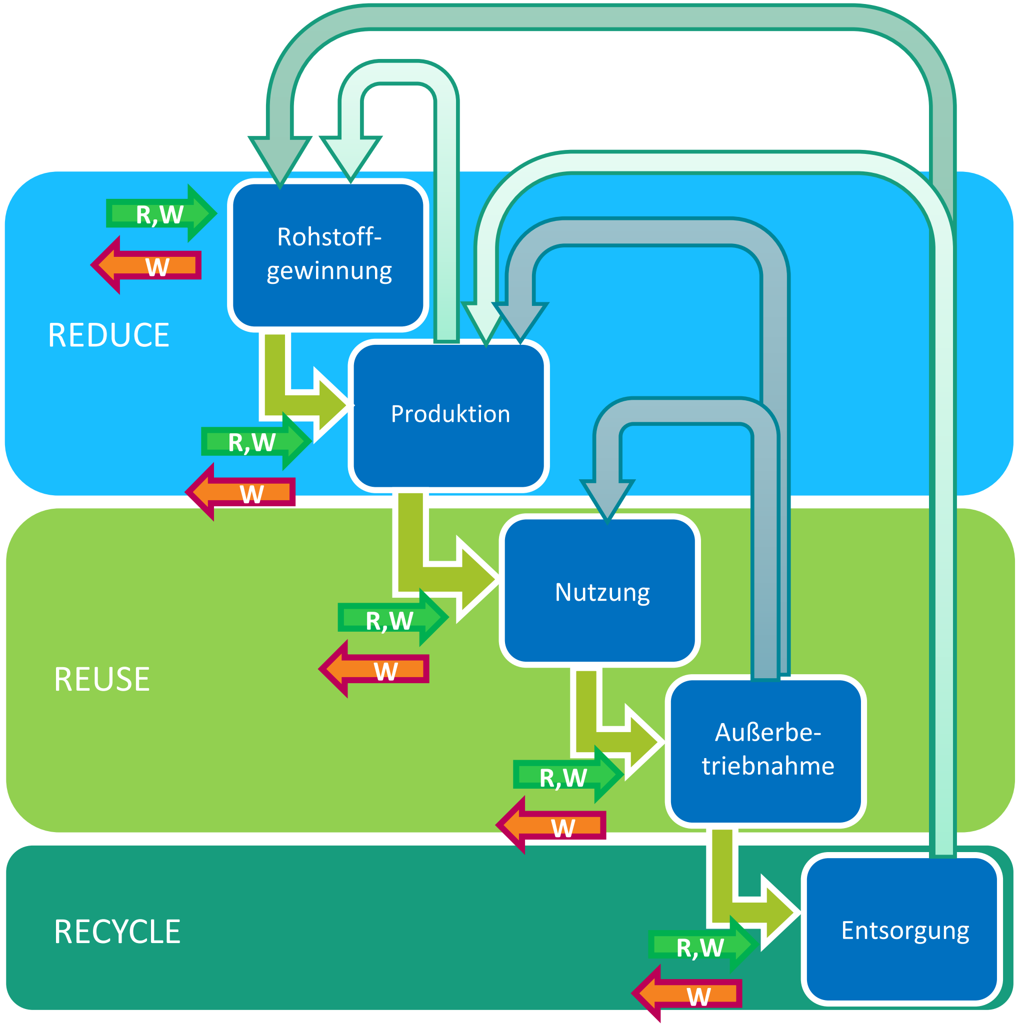
- Climate change, scarcity of resources and loss of biodiversity demand societal and technological transformation
- Sustainability analyses are becoming increasingly important
  - Basis for strategic decisions
  - Legitimation of research, positions and interests
  - Introduction of certificates and labels
- Fraunhofer ISE is listed and active as stakeholder in the Ecodesign / Energy Label work of the European Commission

Fraunhofer ISE

Background

Life Cycle Assessment

- Currently the method of choice for assessing systematic impacts of products or services on **ecological sustainability**
- Assessment of life cycle phases
- Procedure standardized by ISO 14040 ff, additionally for PV by Guidelines (PVPS) and EU Product Environmental Footprint Category Rules (PEFCR)
- Assessment based on different **impact categories** (climate change, toxicity, resource and water use, acidification,…) and different impact assessment methods



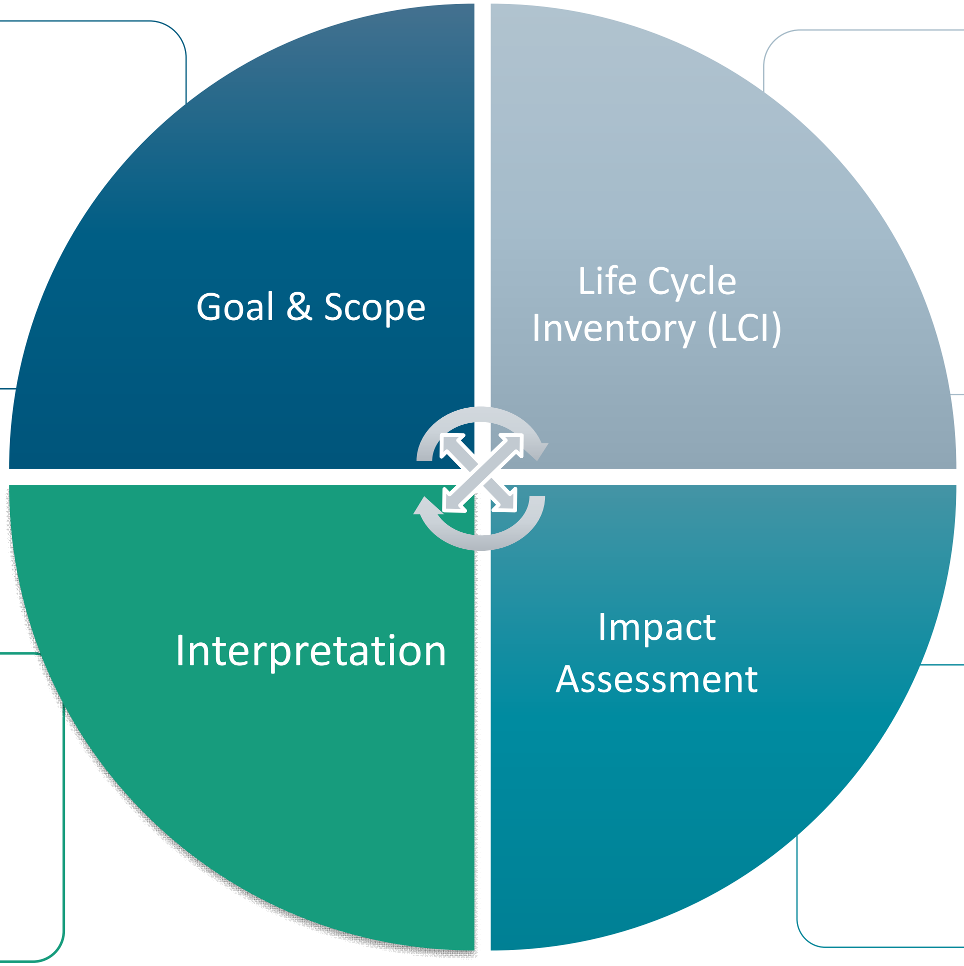
Herceg et.al (2020). Influence of Waste Management on the Environmental Footprint of Electricity Produced by Photovoltaic Systems. *Energies*, *13*(9), 2146.

Life Cycle Assessment

Procedure

Definition of

- Goal and benefit
- Functional unit
- Assumptions
- Product system



- Determination of input and output flows
- Quantification of flows
- Relation to functional unit

- Environmental impact of LCI results
- Investigation of the causal chains

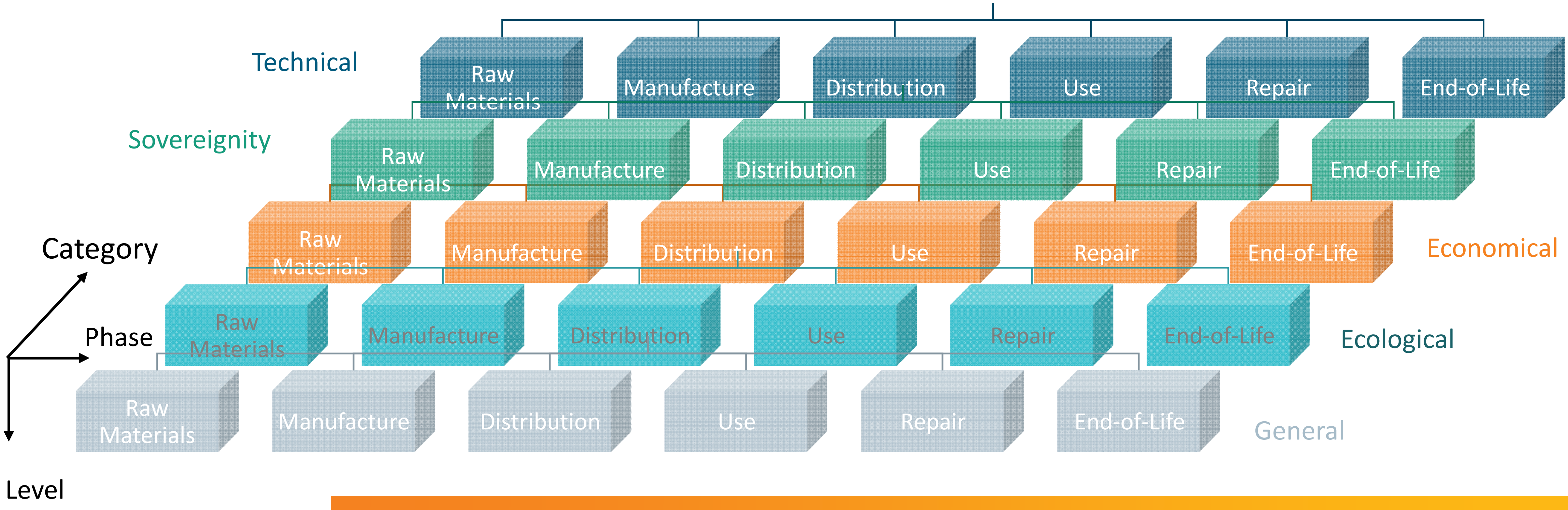
- Checking consistency and transparency
- Conclusion

Fraunhofer ISE

Value Creation Cycles

Multidimensional material-flow analysis

Integrated assessment of **different life stages** and across different **sustainability dimensions**



→ SHC-Task 71: comprehensive assessment of heating technologies across multiple dimensions

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Life Cycle and Cost Assessment for Heating and Cooling Technologies

SHC Task 71

Overview

Duration: 01.01.2023 – 31.12.2025

Lead: Fraunhofer ISE (Karl-Anders Weiß)

Current NPLs

China	Denmark
France	Germany
Italy	Norway
Spain	United Kingdom
Portugal	

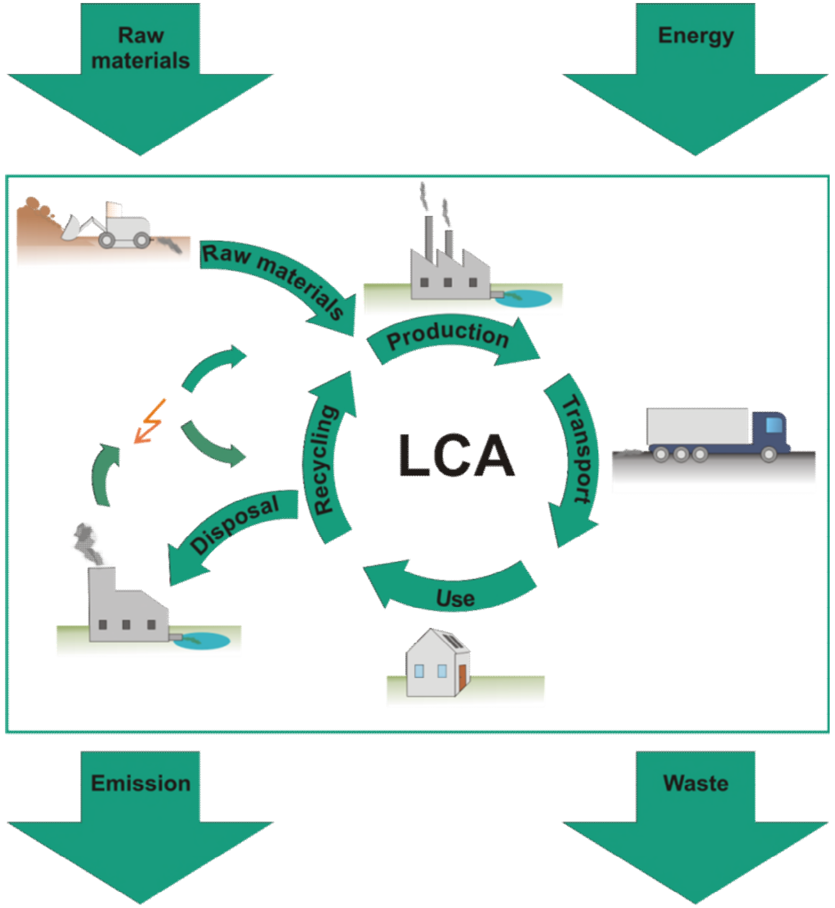
Specific Objectives

Improvement and extension of LCA and LCOH calculation methodology and database for heating and cooling technologies

Development of guidelines on methodologies, system boundaries (included components, lifetime, location of use, interest rate, etc.), impact categories/(CO_2-emissions, toxicity, energy-payback-time, etc.)

Definition of the parameters for location and system specific LCA and cost assessment (climate, electricity mix …)

Close cooperation with ongoing or upcoming SHC-Tasks that want support and other TCPs



What is Task 71?

Users and investors want heating that is **sustainable & efficient**

So far there is no way to **assess heating technologies** across the board

Missing data and models

Task 71 aims to close that gap

By introducing methodology and comparable data forma

By providing heating reference systems & scenarios **globally**

Structure in Place

Subtask A: Cooperation with ongoing or upcoming SHC-Tasks and related Tasks from other programs

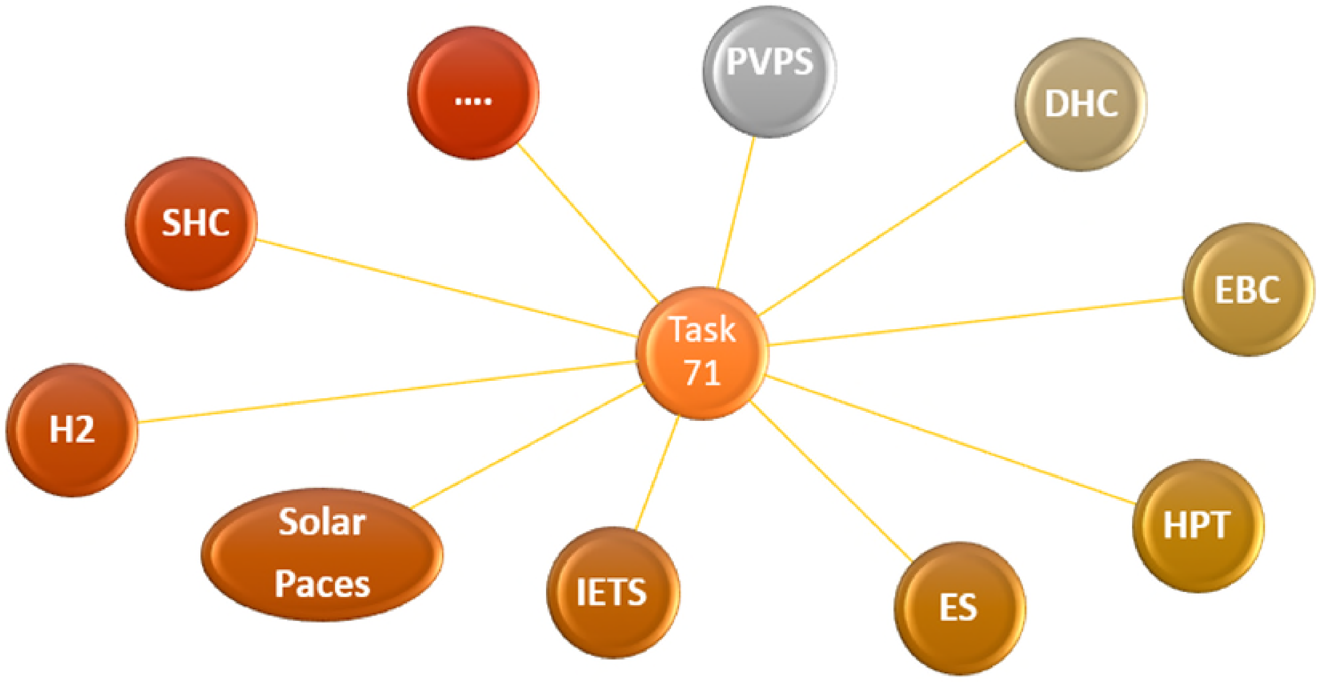
Subtask B: Methodology adaptation

Subtask C: Data of different technologies and components

Subtask D: Reference systems and their requirements, scenarios and optimization

Subtask E: Dissemination, networking and policy involvement

Collaboration with other SHC Tasks, IEA TCPs, outside organizations/institutions



PVPS: Photovoltaic Power Systems Programme

DHC: District Heating and Cooling

EBC: Energy in Buildings and Communities

HPT: Heat Pumping Technologies

ES: Energy Storage

IETS: Industrial Energy-Related Technologies and Systems

SolarPACES: Solar Power and Chemical Energy Systems

H2: Hydrogen TCP

SHC: Solar Heating & Cooling

First Draft of Methodology Guideline

IEA SHC Task 71: Life Cycle and Cost Assessment
for Heating and Cooling Technologies
Methodology Guidelines, Draft January 2024

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 71: Methodology Guidelines on Life Cycle and Cost Assessment for Heating and Cooling Technologies

Draft Report

DRAFT

Status January 2024

Authors:

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Zurich University of Applied Sciences ZHAW

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Karl-Anders.Weiss@ise.fraunhofer.de
http://www.ise.fraunhofer.de

- ✓ outline of structure and content
- ✓ first draft of specific content (where possible)
- ✓ identification of open aspects to be consolidated within Task 71

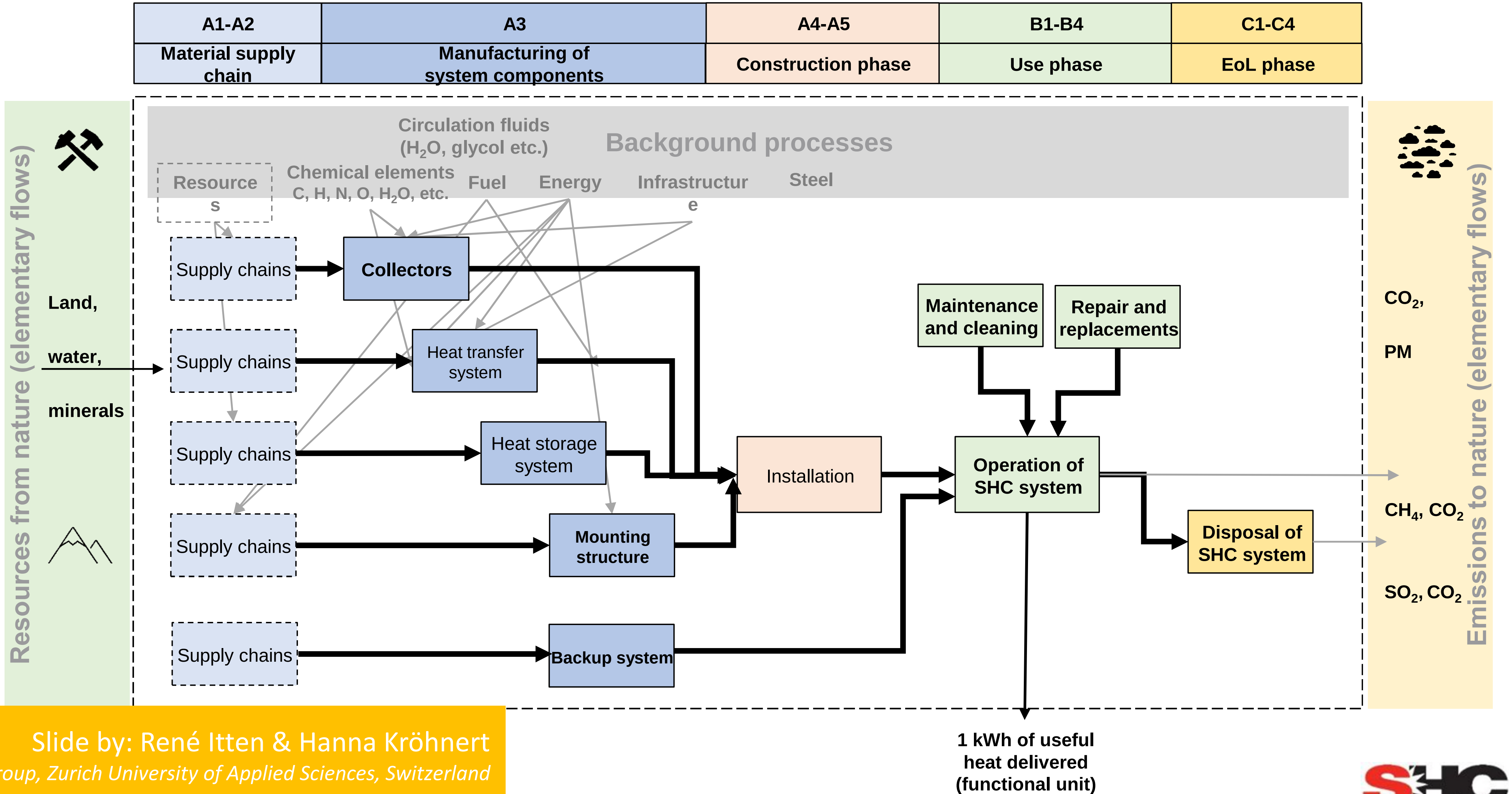
Slide by: René Itten & Hanna Kröhnert
LCA Research Group, Zurich University of Applied Sciences, Switzerland

Let’s have a closer look at…

- Functional unit
- System boundaries:
  - system model
  - included components
  - excluded components
- Life expectancies of components
- System performance
- Life cycle impact assessment methods
- Interpretation

Slide by: René Itten & Hanna Kröhnert
LCA Research Group, Zurich University of Applied Sciences, Switzerland

System boundaries: updated system model



Slide by: René Itten & Hanna Kröhnert

LCA Research Group, Zurich University of Applied Sciences, Switzerland

Life Cycle Impact Assessment methods

- Current draft includes a list of 19 recommended impact categories and corresponding Life Cycle Impact Assessment (LCIA) methods.
- Recommended LCIA methods are largely following the recommendations of the PVPS methodology guideline.

Table 3: Midpoint indicators and recommended methods for the Life Cycle Impact Assessment of solar heating and cooling technologies.

Impact category	Indicator	Unit	Recommended default LCIA method	Robust-ness
Indicators required according to the PEF guide and PEFCR				
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC, based on (IPCC, 2021)	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs 1999 as in WMO assessment	I
Human toxicity, cancer	Comparative Toxic Unit for humans (CTU_h)	CTU_h	USEtox model (Rosenbaum et al., 2008)	III
Human toxicity, non- cancer	Comparative Toxic Unit for humans (CTU_h)	CTU_h	USEtox model (Rosenbaum et al., 2008)	III
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al., 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235}	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al., 2000)	II
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg $NMVOC_{eq}$	LOTOS-EUROS model (van Zelm et al., 2008) as implemented in ReCiPe	II
Acidification	Accumulated Exceedance (AE)	mol $H+_{eq}$	Accumulated Exceedance (Posch et al., 2008; Seppälä et al., 2006)	II
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N_{eq}	Accumulated Exceedance (Posch et al., 2008; Seppälä et al., 2006)	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P_{eq}	EUTREND model (Struijs et al., 2009) as implemented in ReCiPe	II

Slide by: René Itten & Hanna Kröhnert
LCA Research Group, Zurich University of Applied Sciences, Switzerland

SHC Task 71: LCA & LCOH for Heating and Cooling Technologies

Learnings

- Life Cycle Assessment is the method of choice for the assessment of ecological sustainability
- For a comprehensive sustainability assessment additional dimensions must be adressed, including the supply chain and material security
- Task 71 focusses on the economic and ecological assessment of heating technologies, to provide data for fair and tranparent comparisons
- Current status of the LCA in Task 71: First draft of methodology guidelines provided by the responsible sub-task leader René Ittn

QUESTIONS OR COMMENTS?

?

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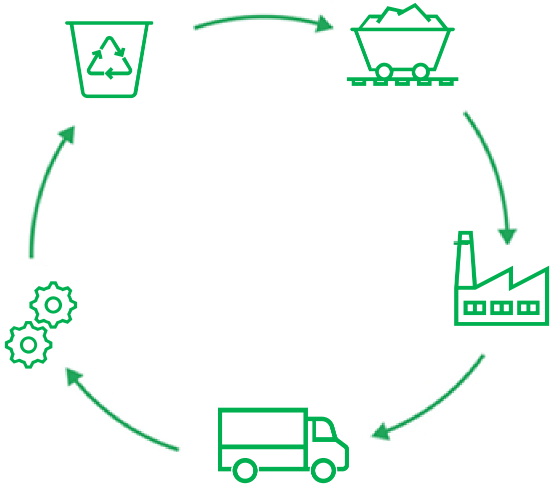


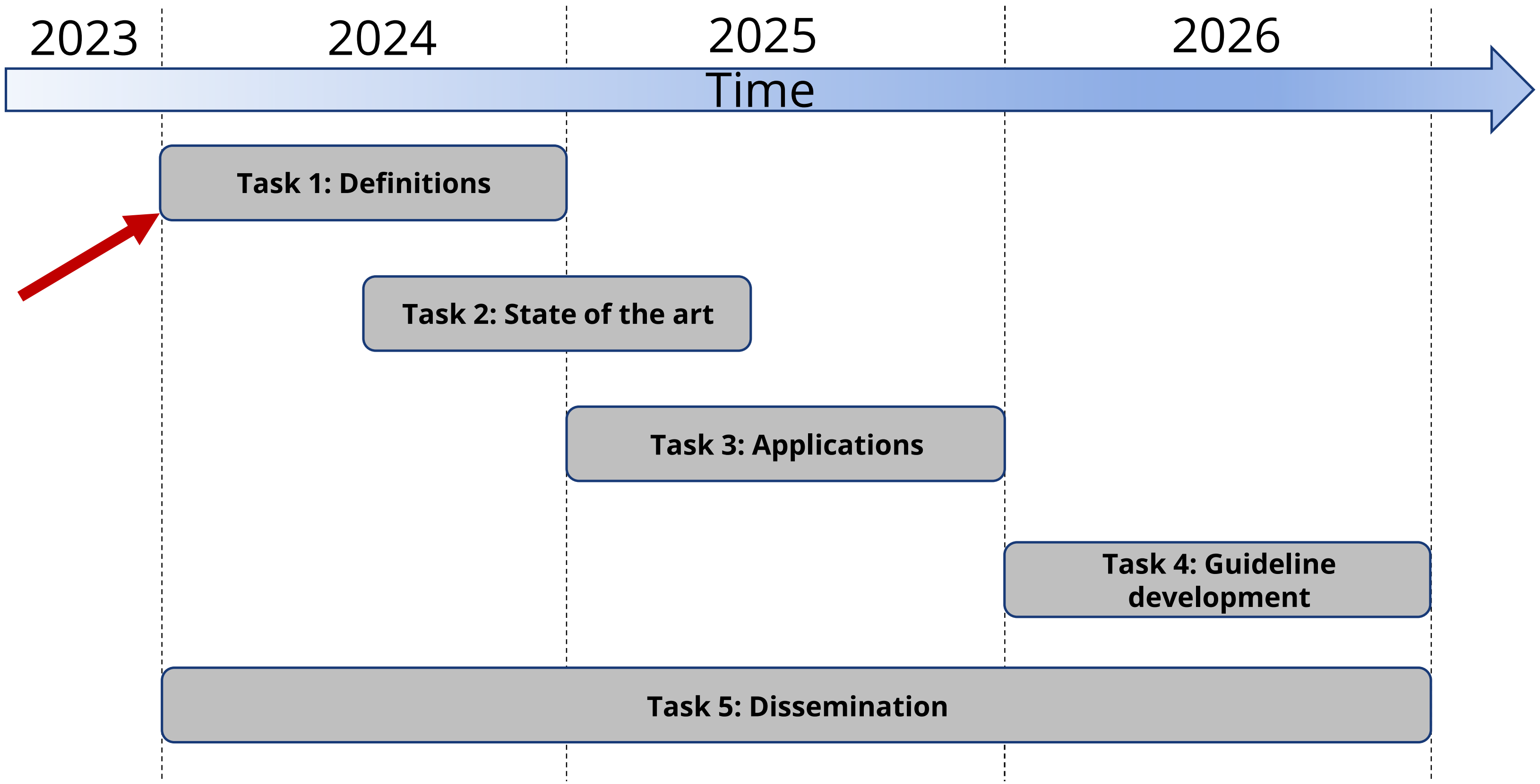
LCA: **L**ife **C**ycle **A**ssessment

EPD: **E**nvironmental **P**roduct **D**eclaration

Annex 65 ‘Heat pumps in a circular economy

Data collection of lifecycle analysis of heat pumps

TIMELINE



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TASK 1 - DEFINITIONS AND DELIMITATION

The task aims to explore frameworks for circular economy and material efficiency and definitions will be established. This is expected to be based on:

- Evaluation of the standards for material efficiency in energy related products (literature study)
- Exploring the links to relevant regulation linked to materials in heat pumps such as WEEE, ROHS, etc. which will be mapped out. (literature study)
- A literature study to establish state of the art of lifecycle analyses conducted on domestic heat pumps will be carried out, and learnings from the various studies will be shared.
- Case study descriptions of previous common measures in heat pump design for domestic applications to lower the impact of materials. (literature study+interviews)

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DATA COLLECTION ON LIFECYCLE IMPACT OF HEAT PUMPS

Motivation

- Collect data and create database for lifecycle impact of heat pumps based on:
  - Public EDPs
  - Ecodesign data required to be public.
- The template should be agreed upon by the participating parties to ensure data is collected in the same manner.
- The activity is similar to is inspired from Annex 58 (link)

Template for Heat Pump Lifecycle Data collection

Heat pump and supplier name	*Model name:* [] *Manufacturer:* [] *Available in which countries:* []
EPD data	*Type of EPD:* [Type]
Technical data	*Performance in design point:* • *Heat pump type:* [Air-air, Air-water, liquid-water etc.] • *Application:* [Space heating, combination heater, domestic hot water only] • *Refrigerant:* [R134a, R290, R407C, R32...] • *Dimensions* [length, width, height] • *Heating capacity:* [E.g. 1 MW] $SCOP_{Heating}$: [E.g. 3.1. Please also state how this COP is determined] *Reference service lifetime:* [years] *Weight:* [NUMBER] kg
Flow diagram	[INSERT FLOW DIAGRAM]

Example

Material distribution

Material	*Weight-% of declared product*
[Steel]	[NUMBER]
[aluminium]	[NUMBER]
[Copper]	[NUMBER]
[Plastic]	[NUMBER]
[Other]	[NUMBER]

Lifecycle data about this heat pump from environmental product declaration

	Lifecycle indicators									
	A1-A3	A4	A5	B1	B2-B7	C1	C2	C3	C4	D
GWP [kg CO2 eq.]										
ODP [kg R11 eq.]										
Total use of non-renewable primary energy										

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PROPOSED PROCESS

Process for data collection

- The format for data collection is agreed upon
  - The proposed template is located on the Teams link for the annex: link
  - Comments for the template should be handed in by **May 22nd**.
  - The data format is adopted after revision of comments and published on annex website.
- Data for case collection
  - National contacts collect data from each country in the adopted format during 2024 and maybe in 2025.
  - Ecoplatform only have 3 EPDs for heat pumps so far.

Ambition for the data collection

- Establish a baseline for lifecycle analysis of heat pumps
- Overview of which product category rules are applied
- If data match, then it is possible to make comparison analysis possible on:
  - Material footprint
  - Lifecycle carbon footprint
  - Refrigerants
  - Capacities
  - Energy efficiency (SCOPs)
  - Recycled content at end-of-life

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WORD OR EXCEL FOR DATA COLLECTION?

- The current format is based on Word where data from the EPD is transferred to as a case description.
- For layout purposes Word is easier to maintain a consistent and simple layout for case description.
- After the data has been collected it should be transferred to Excel to make a database and make further analysis possible.

Question

- Theoretically Excel can be used to collect data and then transferred automatically to Word assigned data cells - Is it worth the effort to facilitate the use of Excel?

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QUESTIONS OR COMMENTS TO THE PRESENTATIONS?

CURRENT LIST OF DEEP DIVES

Completed topics

- Lifecycle data collection to streamline data collection
- Presentation of LCA analysis of heat solutions (learnings from IEA SHC by Fraunhofer ISE)

Proposal topics

- Horizontal products standards and their implications for heat pumps
- If available case descriptions of common measures to lower impact of materials
- Take-back systems for heating solutions
- Identification of priority parts for heat pumps in a lifetime perspective
- New business models in relation to circularity aspects of heat pumps
- Mapping of end-of-life handling and TRL-levels for various technologies (Danish group proposal)
- What do to with used spare parts (Danish group proposal)

Questions

- Any other topics that would be interesting?
- Does anybody have any input to share for a topic?
- Any topics that should have increased focus?

THANK YOU FOR PARTICIPATING

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