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Solar collectors versus solar PV panels in DH

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4DH
4th Generation District Heating Technologies and Systems

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Problem definition

- Energy balance towards 4th DH systems brings challange for flexibility of renewable electricity resources:
  - ~~Fossil fuel~~
  - Biomass
  - Gheothermal energy
  - Solar
    - Collectors
    - PV

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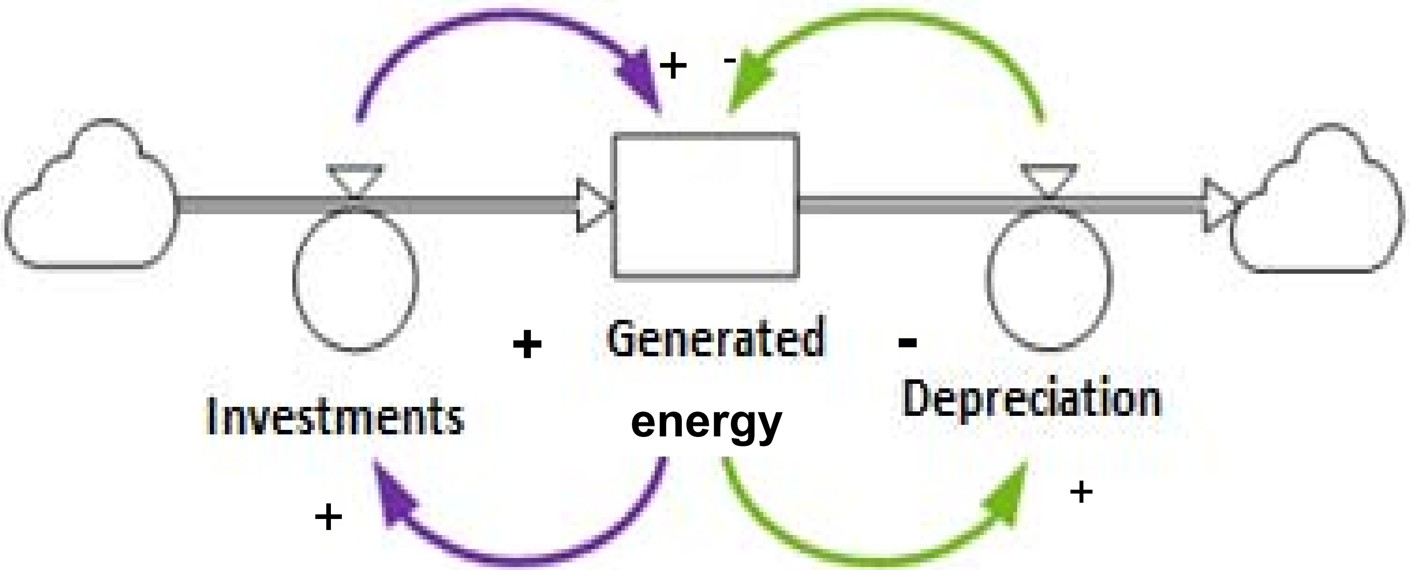
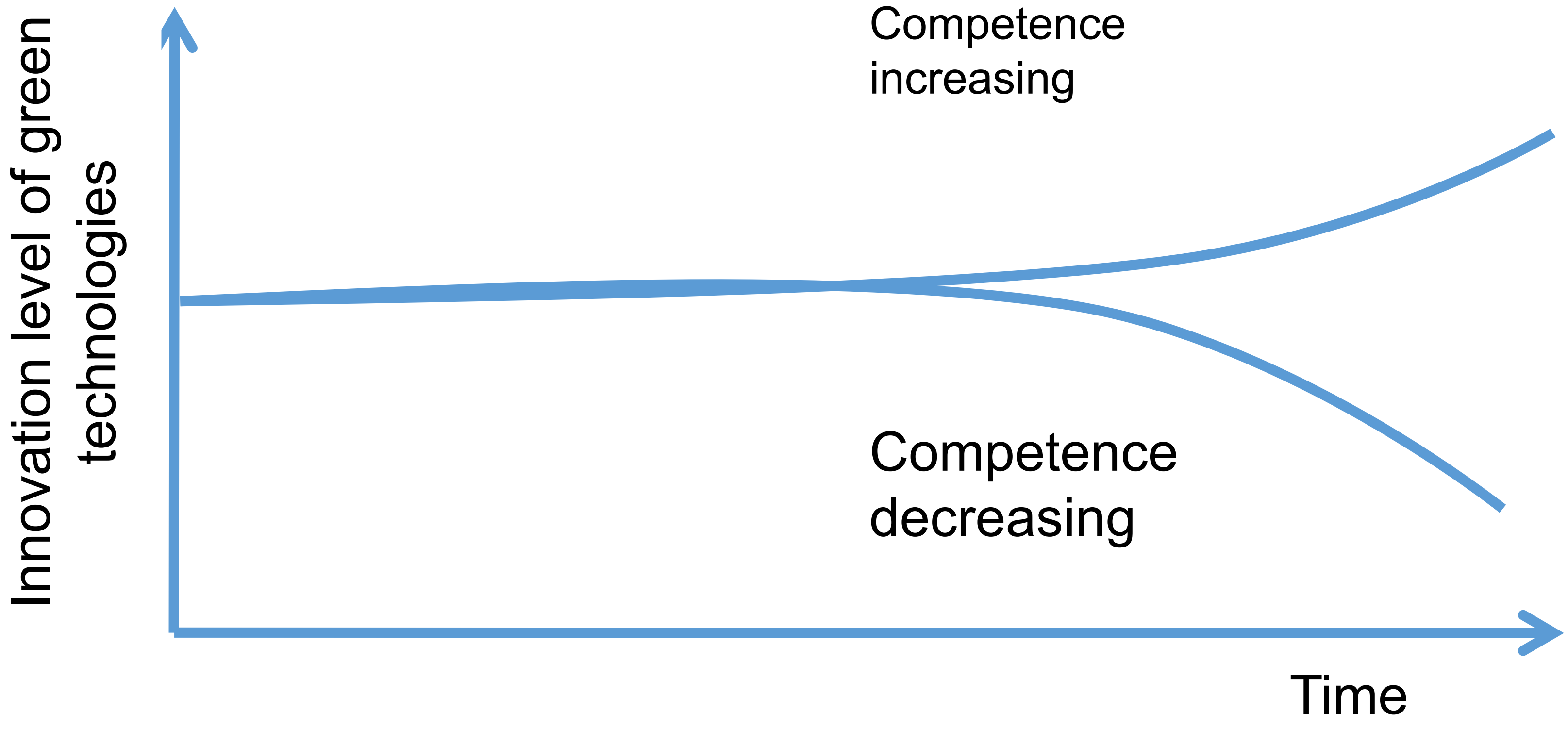
Relationship between the generated energy, and investment and depreciation flows



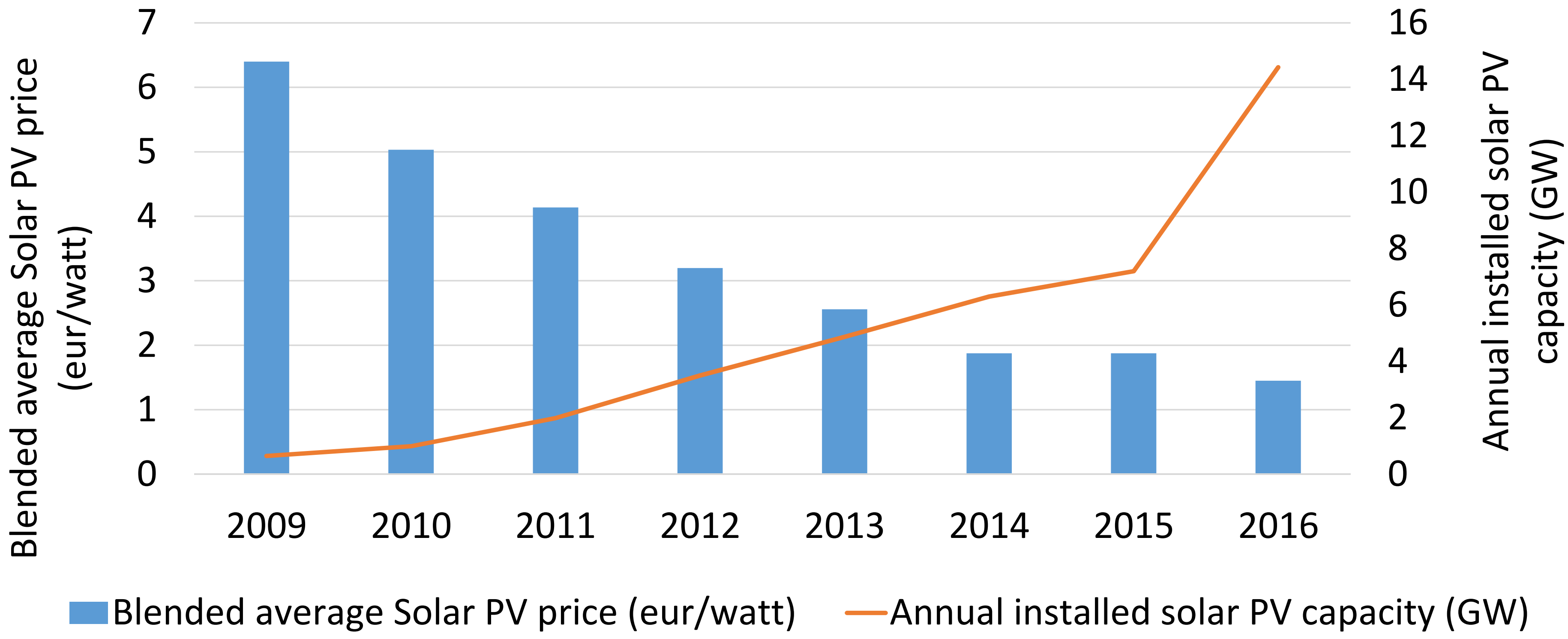
Hypothesis

- Investments in DH systems for solar energy installations are limited by economical, environmental and technological restrictions and …
- Balance between solar PV and solar collectors can be justified by results of LCA and LCIA

Innovation Diffusion



Innovative Technologies Development. Solar PV Case



Data source: Solar industry data. Solar Energy Industries Association (SEIA), available at: http://www.seia.org/research-resources/solar-industry-data

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Future of DH system – solar energy

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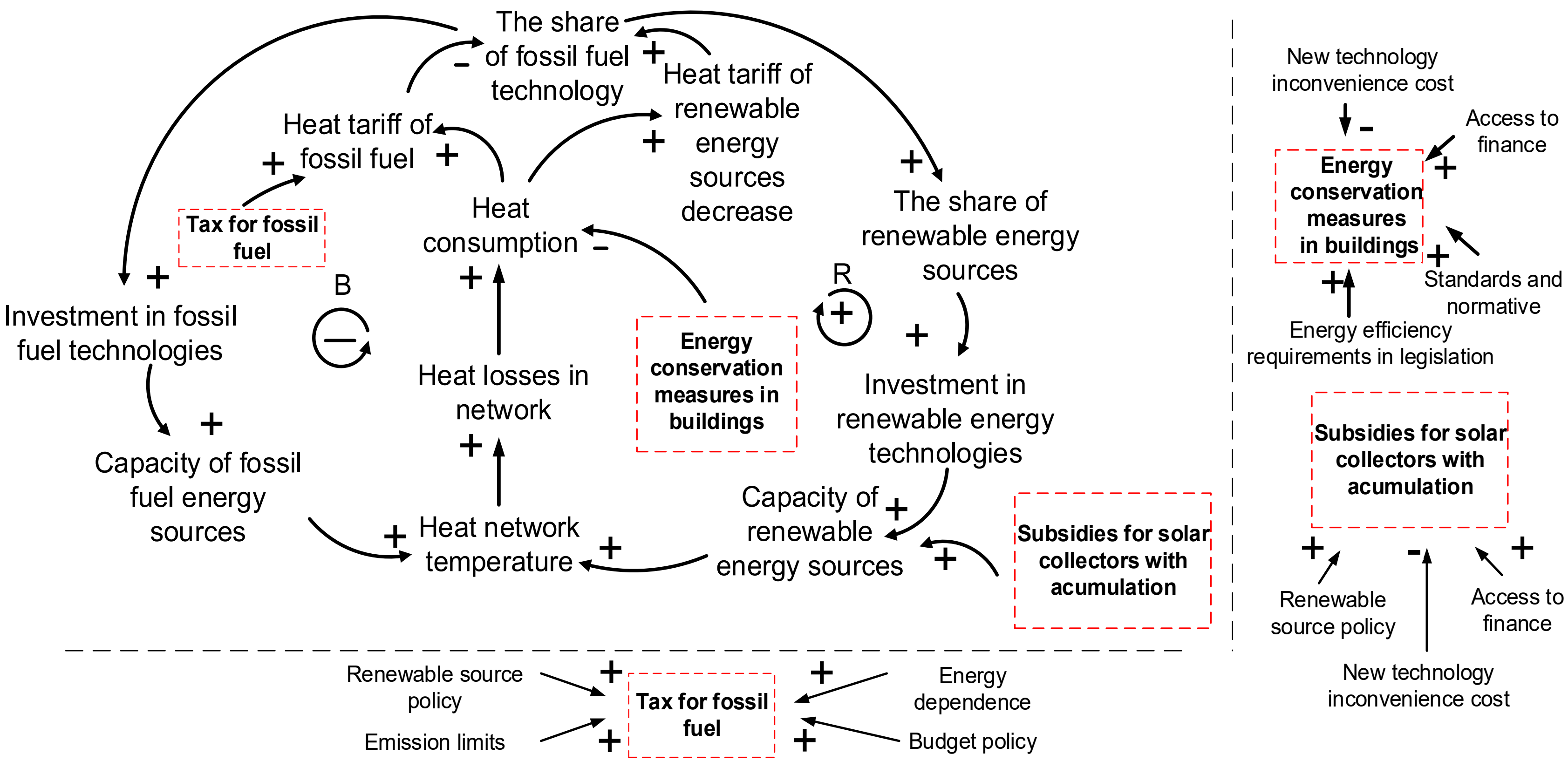
Causal loops diagram for non-ETS DH system

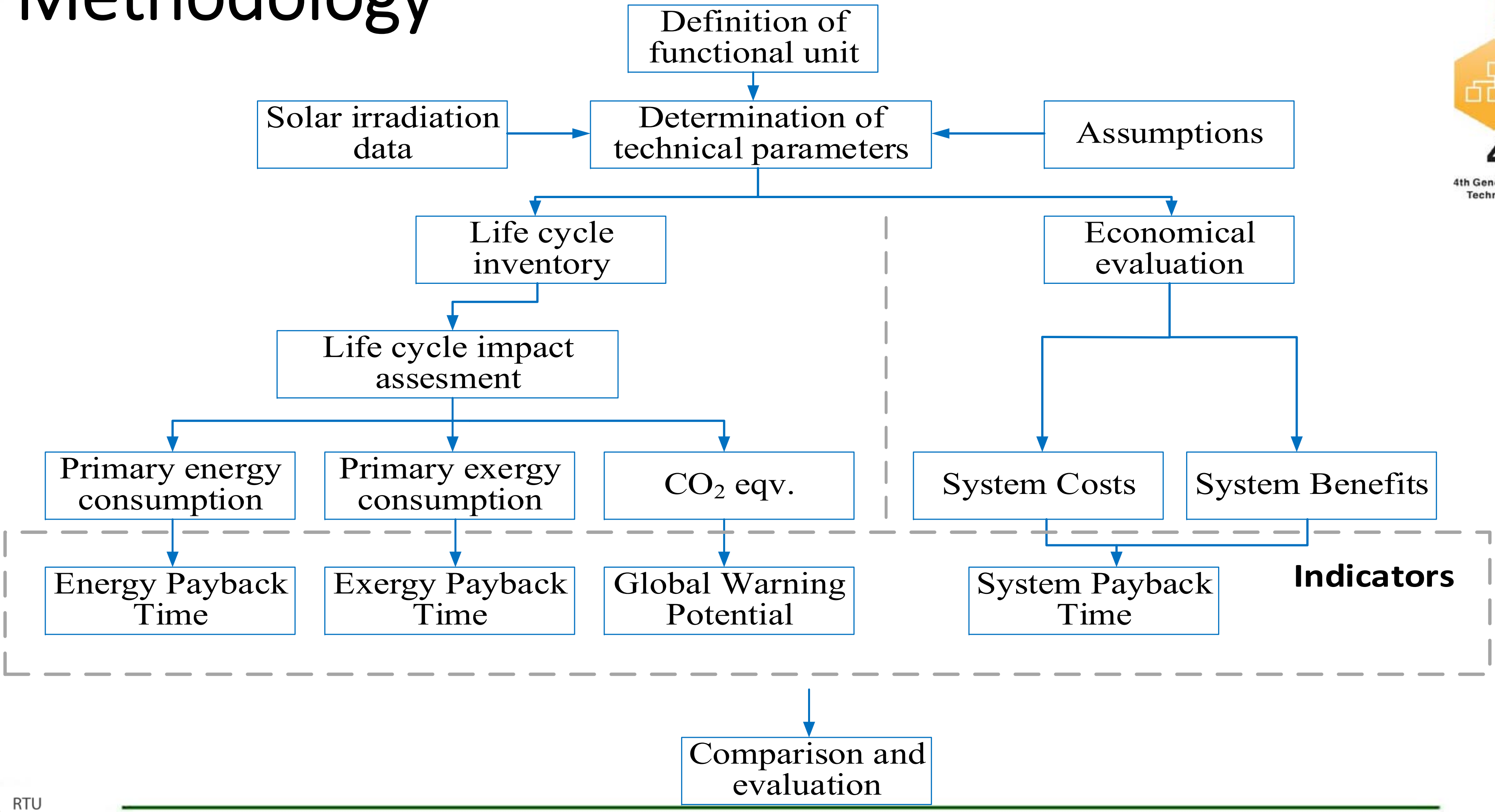


Cilinskis E., Ziemele J., BlumbergaA, Blumberga D. **Analysis of support measures for promoting energy efficiency and renewables for GHG emissions reduction in non-ETS sector. ICAE 2017, Energy Procedia 2017**

Goal of the study

- To determine optimal use of solar energy in district heating by comparing solar collector and solar photovoltaic panels from environmental and economical aspects

Methodology



LCA goal and scope definition

- Functional Unit - production of 1 MWh exergy;
- System Boundaries:
  - production of raw materials;
  - their processing and purification;
  - manufacture and balance of system (BOS) additional components;
  - the installation and use of the systems;
  - system decommissioning and disposal or recycling;
- LCA tool used - SimaPro;
- LCIA methods used - Cumulative Energy Demand, Cumulative Exergy Demand, IPCC 2013 GWP, IMPACT 2002

Case study. General parameters

System type	PV panels	Solar collectors
Type	Singlecrystalline cell PV panel	Cu flat plate solar collector
Installation	On flat roof	
Location	Riga, Latvia	
Annual solar irradiation, kWh/m^2	992* *(2015-2016 average)	
Efficiency (solar energy to power/thermal energy)	14 % (cell efficiency) 85% (performance ratio)	41 %
Exergy rate	1	0,27 (thermal energy to power)
Technical life time	30	25
Necessary area, m^2	9,32 m^2	8,90 m^2
Corrected area, m^2	-	10,68 m^2
BOS elements	Inverter, cabling, mounting system	Water storage tank, pump, heat transfer medium, expanssion vessels, pipes, mounting system

LCA inventory of solar collector

Element	Parameters
Flat plate solar collector, Cu absorber	Production and disposal of a flat plate collector with a copper absorber. Including materials, water and energy use of production. Empty weight of 52 kg
Additional system elements:	
Hot water tank	Volume 600 l, weight 283 kg
Pump	Capacity 40 W, gross weight 2,4 kg
Expanssion vessel	Volume 80 l, weight 15 kg
Heat transfer medium	35 % glycol, 65 % purified water. Exchanged every 10 years
Pipes	Chromium steel pipes (8,8 kg), EPDM foam insulation (7,6 kg) and poluethylene coating (0,7 kg)
Mounting	Flat roof mounting system based on zinc coated low-alloyed steel and concrete
Transportation	Transportation of solar collector and BOS from Western Europe by road transport
Operation	Electric energy for pumping, 396 MJ per year

Reference: *Stucki M., Jungblath M. Update of the Life Cycle Inventories of Solar Collectors, Report, 2012
**Jungbluth N. (2003) Sonnenkollektoranlagen. In: Sachbilanzen von Energiesystemen: Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz. Swiss Centre for Life Cycle Inventories, Dübendorf, CH

LCA inventory of PV panel

Element	Parameters
Photovoltaic panel, single-Si wafer	Investigated for the production of solar panel with 60 solar cells a 156*156 cm^2 with a capacity of 192 Wp. Production of the cell matrix, cutting of foils and washing of glass, production of laminate isolation. Disposal after end of life.
Additional system elements	
Inverter, 0,5 kW	Weight 1,6 kg, consists mainly of electronic components and the case (aluminium, polycarbonate, ABS). Included: materials, packaging, electricity use for the production, disposal of the product after use.
Cabling	Copper vires (0,77 kg) with thermoplastic elastomer coating (0,59 kg)
Mounting	Flat roof mounting system with isolation mats, aluminium profiles and smaller parts of the mounting system. Electricity for mounting 1 kWh
Transportation	Transportation of solar panel and BOS from Western Europe by road transport
Operation	Tap water for panel cleaning, transportation for maintenance team once in 10 years

Reference:
*Jungblath N., Tuchchmid. Photovoltaics. Ecoinvent report No.6-XII, Swiss Centre for Life Cycle Inventories, Dubendorf, 2007

Results

Parameter	Solar collector	Solar panel
Produced exergy, kWh/year	1000	
Primary exergy consumption	13 667	14 500
Specific annual exergy consumption kWh/kWh	13,7	14,5
Produced energy, kWh /year	4 375	1 000
Primary energy consumption, kWh	16917	12639
Specific annual energy consumption kWh/kWh	3,9	12,6
Energy Payback Time, years	4	13
Avoided CO_2 emissions, tons	28 875	3 270
Global Warning potential, kg CO_2 eq	4080	2900
CO_2 payback time, years	0,0035	0,03

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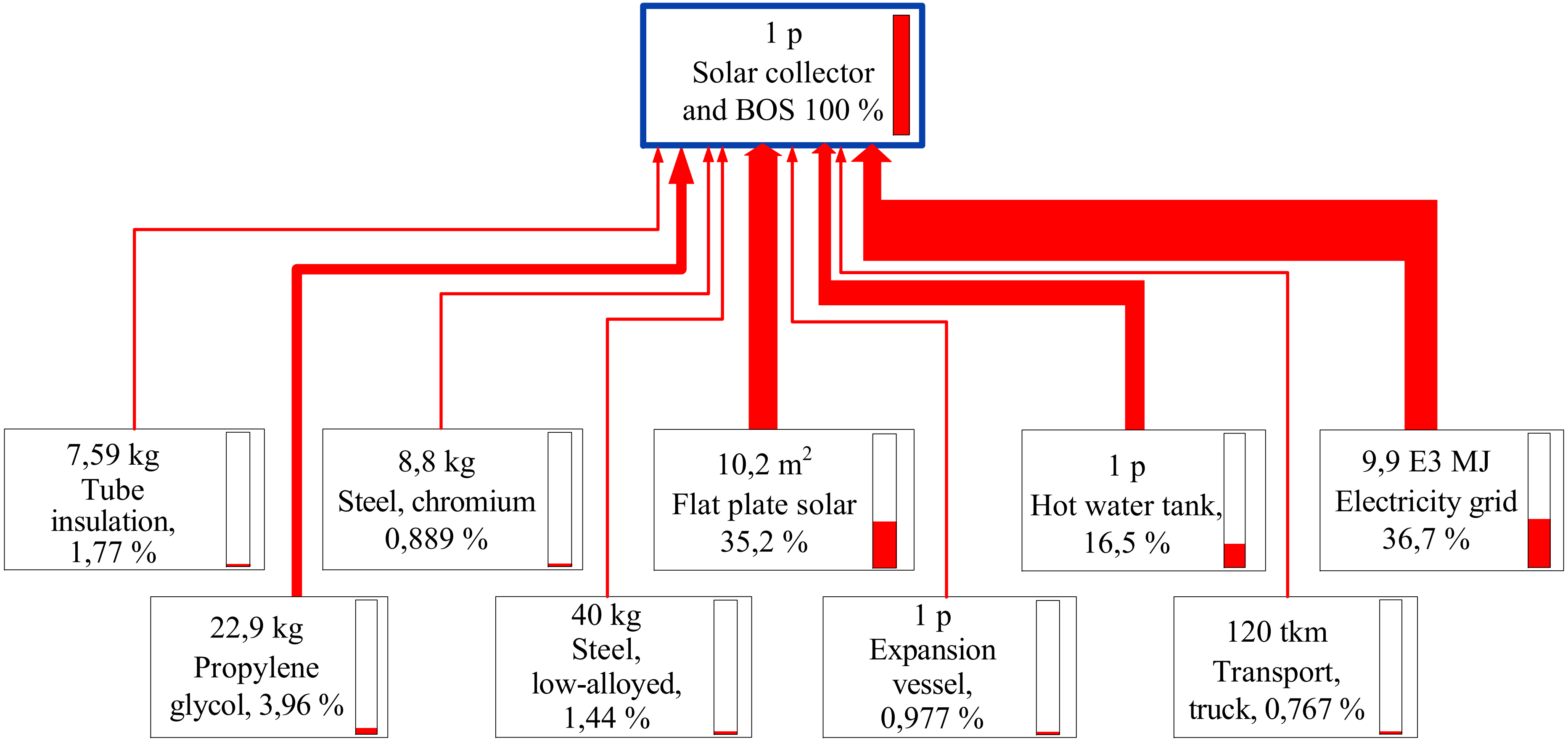
Primary energy demand, solar collector



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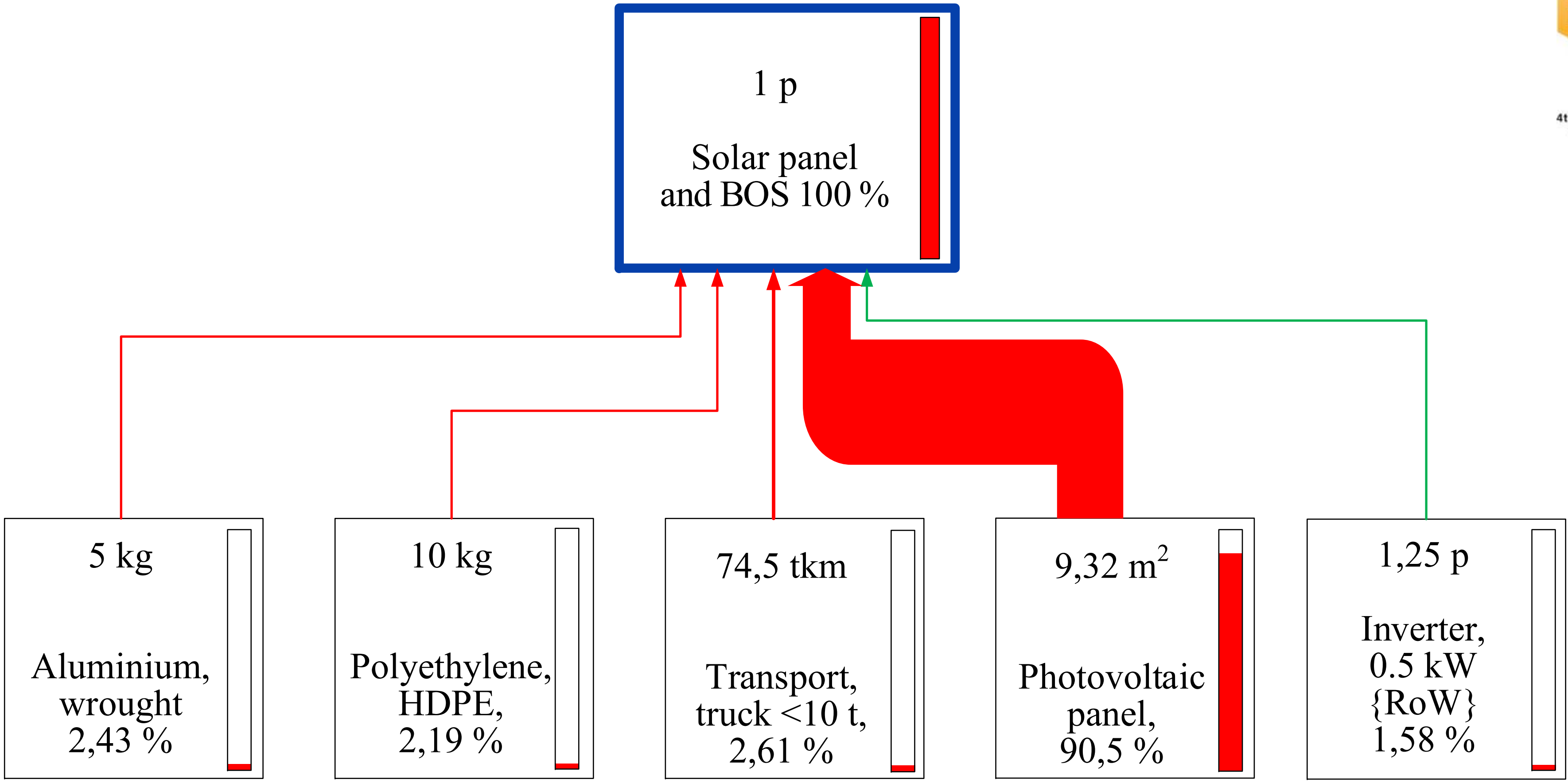
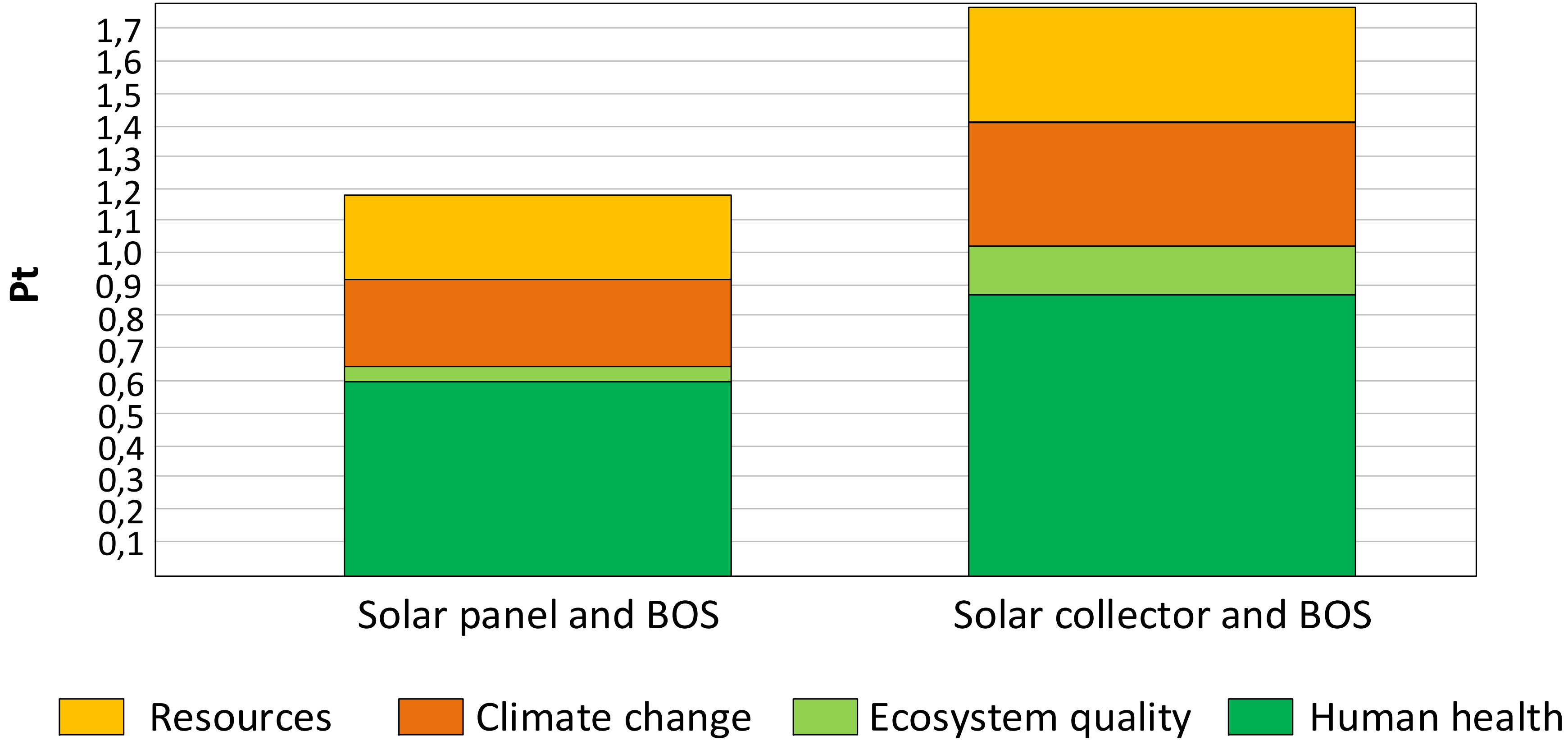
Primary energy demand, solar panel



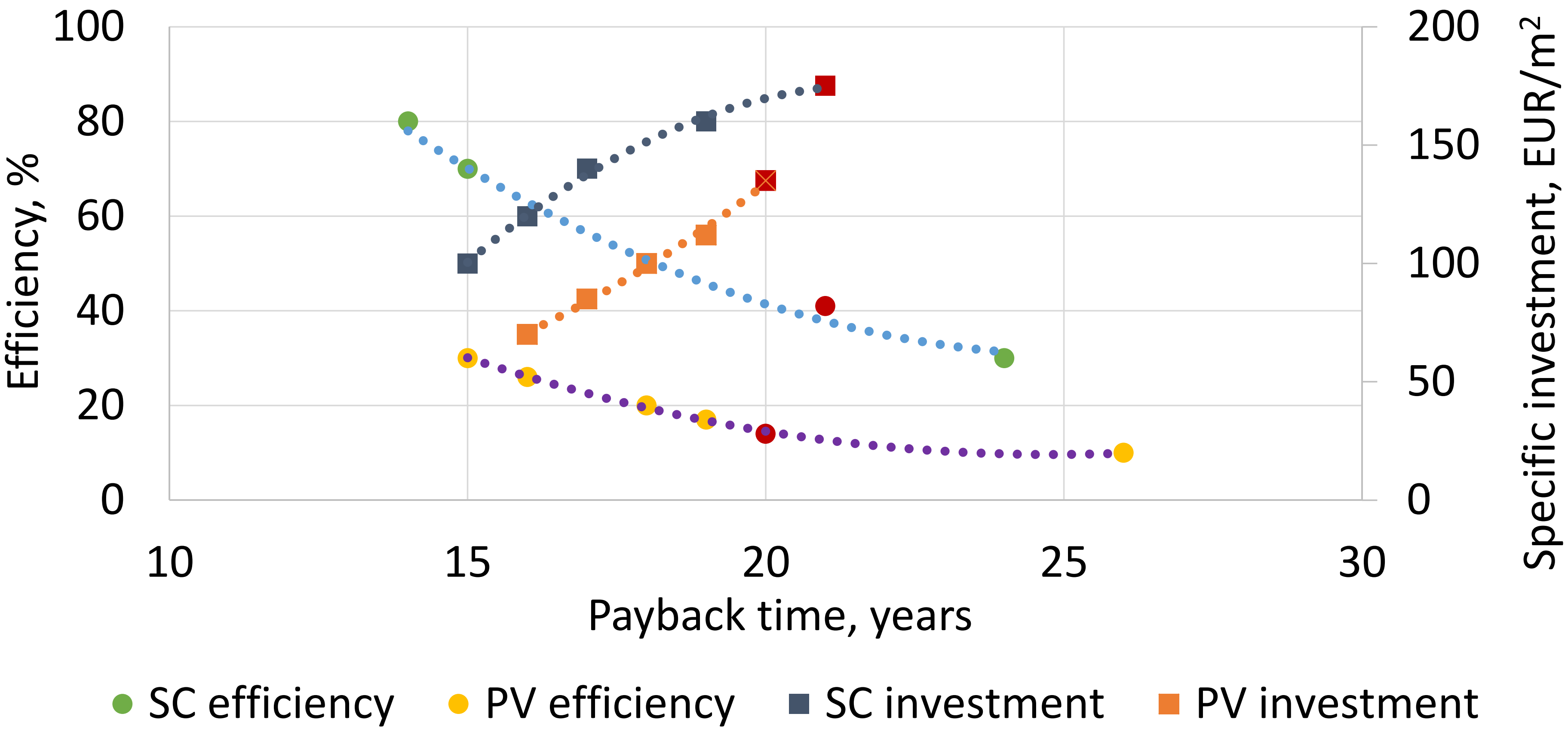
Life Cycle Impact comparison



Economical analyses input data

	Solar PV	Solar collectors (SC)
Area, m^2	8	11
Costs of main elements, EUR	1146	1868
Costs of BOS elements, EUR	1000	1300
Installation costs, EUR	429	634
Total costs, EUR	2575	3802
Specific costs, EUR/MWh per year	85,82	34,76
Natural gas price, EUR/MWh	44	
Electricity price, EUR/MWh	120	
Saving, EUR/year	120	193
Simple payback time, years	21	20

Sensitivity analyses

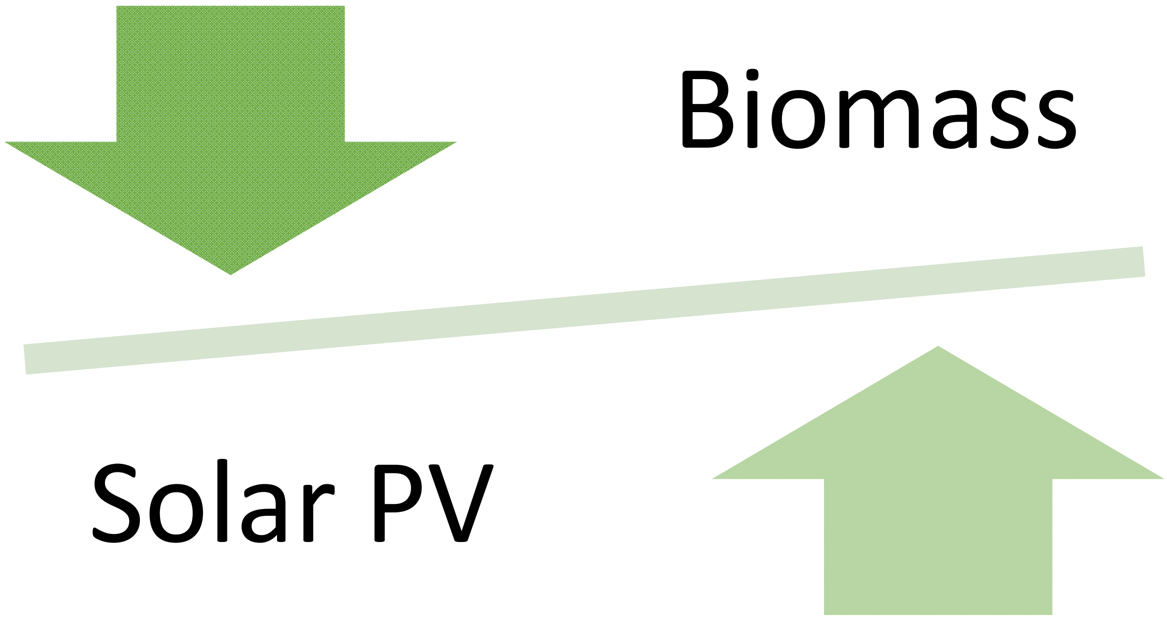


Conclusion (1)

- LCA results for 1 MWh exergy production shows:
  - primary energy consumption higher for solar collectors;
  - primary exergy consumption slightly higher for solar panels;
  - Global warming potential (CO_2 eqv) higher for solar collectors;
  - CO_2 payback time longer for solar panels.

Conclusion (2)

- Economical analyses results for 1 MWh exergy production shows similar payback time for both systems.
- Methodology can be used for evaluation of solar system alternatives and evaluation of policy tools.
- Further application for solar hybrid (PV thermal panels is planned).



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