Livscykelanalys och risker
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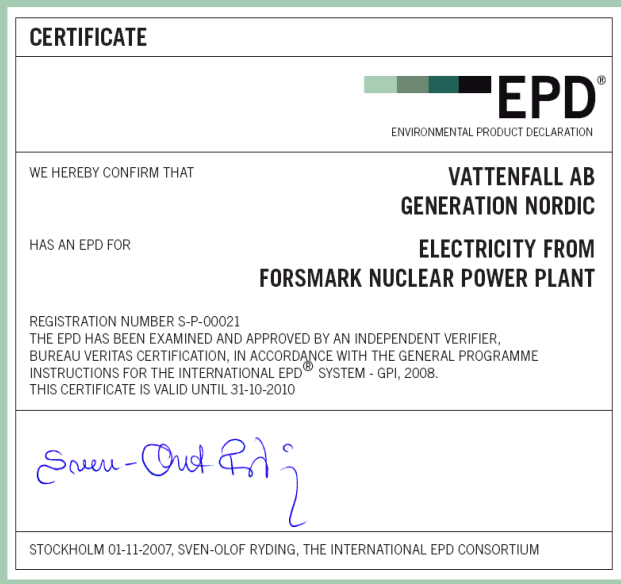
This presentation

- Basic explanation of used methods
  - Environmental Product Declaration, EPD
  - Lifecycle Assessment, LCA
  - Environmental Risk assessment, ERA
- Some results for the energy sector

Certified Environmental Product Declaration EPD® catches more than LCA

- **EPD® – Environmental Product Declaration – an information system to describe environmental properties of products and services based on facts**
- **Open for all products and services**
- **Based on ISO 14025**
- **Third party verified and certified**
- **Product Category Rules, PCRs, to be followed**
- **An EPD® for electricity and district heat contains**
  - Life Cycle Assessment (LCA), ISO 14040 series
  - Study of impacts on biodiversity
  - Environmental Risk Assessment (ERA)
  - Radiology



CERTIFICATE

EPD®
ENVIRONMENTAL PRODUCT DECLARATION

WE HEREBY CONFIRM THAT

VATTENFALL AB
GENERATION NORDIC

HAS AN EPD FOR

ELECTRICITY FROM
FORSMARK NUCLEAR POWER PLANT

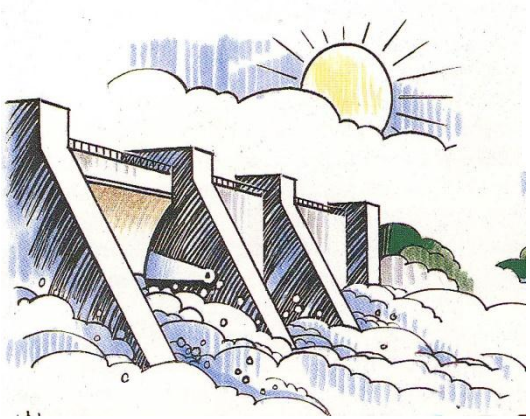
REGISTRATION NUMBER S-P-00021
THE EPD HAS BEEN EXAMINED AND APPROVED BY AN INDEPENDENT VERIFIER,
BUREAU VERITAS CERTIFICATION, IN ACCORDANCE WITH THE GENERAL PROGRAMME
INSTRUCTIONS FOR THE INTERNATIONAL EPD® SYSTEM - GPI, 2008.
THIS CERTIFICATE IS VALID UNTIL 31-10-2010

STOCKHOLM 01-11-2007, SVEN-OLOF RYDING, THE INTERNATIONAL EPD CONSORTIUM

Detailed documentation

- http://www.environdec.com/pageId.asp
  - Here details can be found for EPDs which are LCA studies with strict rules and verified by a third party
- http://www.environdec.com/pageID.asp?id=131&menu=3,7,0&pcrId=243
  - This is the address to the rules to follow to make an EPD for Electricity or heat
  - There is also a list of available EPDs for electricity

Base and peak

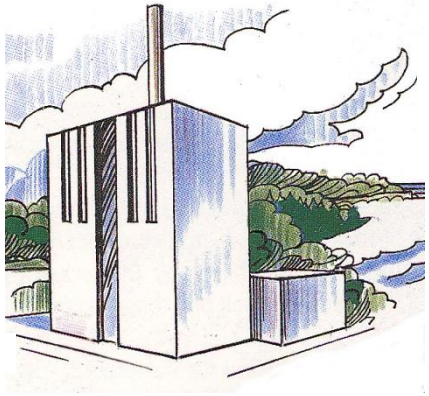


Change of landscape,
Biodiversity

Intermittent

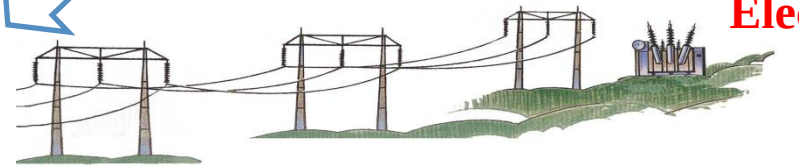
Noise, Visual impact

Base



Long lived radioactive waste,
Mining, Risks

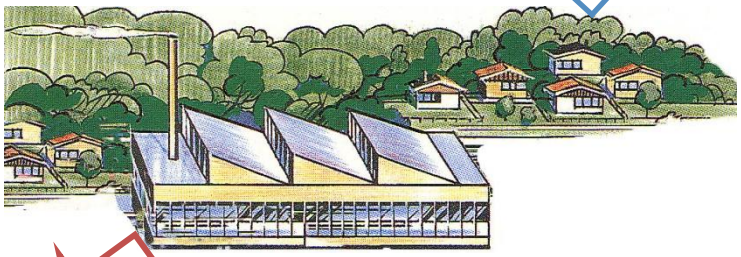
Electricity use



Electricity

New Sources?

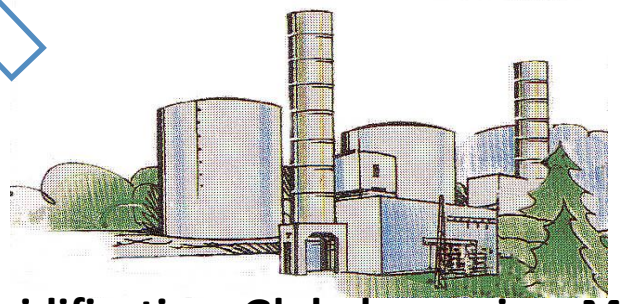
Base/intermittent



Heat

Change of landscape,
Biodiversity

Base/reserve/peak



Acidification, Global warming, Mining
Oil drilling and transportation

LCA standardized

- ISO 14040 Life Cycle Assessment –Principles and framework
- 14044 Life Cycle Assessment Requirements and guidelines
- 14025 Type III Environmental declarations

Environmental Risk Assessment

- Not standardized so far
- Vattenfall developed and documented a method
- Based on nuclear and hydro power experience
- Had the method peer reviewed and made public
- Verifiers then can check the procedure and calculations in the EPD
- http://www.vattenfall.se/sv/miljoriskinventering.htm

What is Risk, and what is studied in EPDs

- Risk is identified as the probability of an undesired event multiplied by the consequence of the event
- Dam breaks and big accident in nuclear power plants are excluded in EPDs

Procedure for risk assessment hydro

- From aviation, nuclear, offshore
- This method implies an inventory of undesired events, which can occur and bring about emissions to the surrounding environment
- Good general knowledge of the plants is a prerequisite.
- Acquire background data and material that describe the plant such as design drawings, pictures, lists of the chemicals present
- Data from operation of the plants, risk assessments , incident reporting etc
- A list of conceivable accident scenarios is compiled.
- Site visit to verify
- Interviews with staff
- Probabilities are always difficult to estimate
- But to try is better than doing nothing
- Result order of magnitude

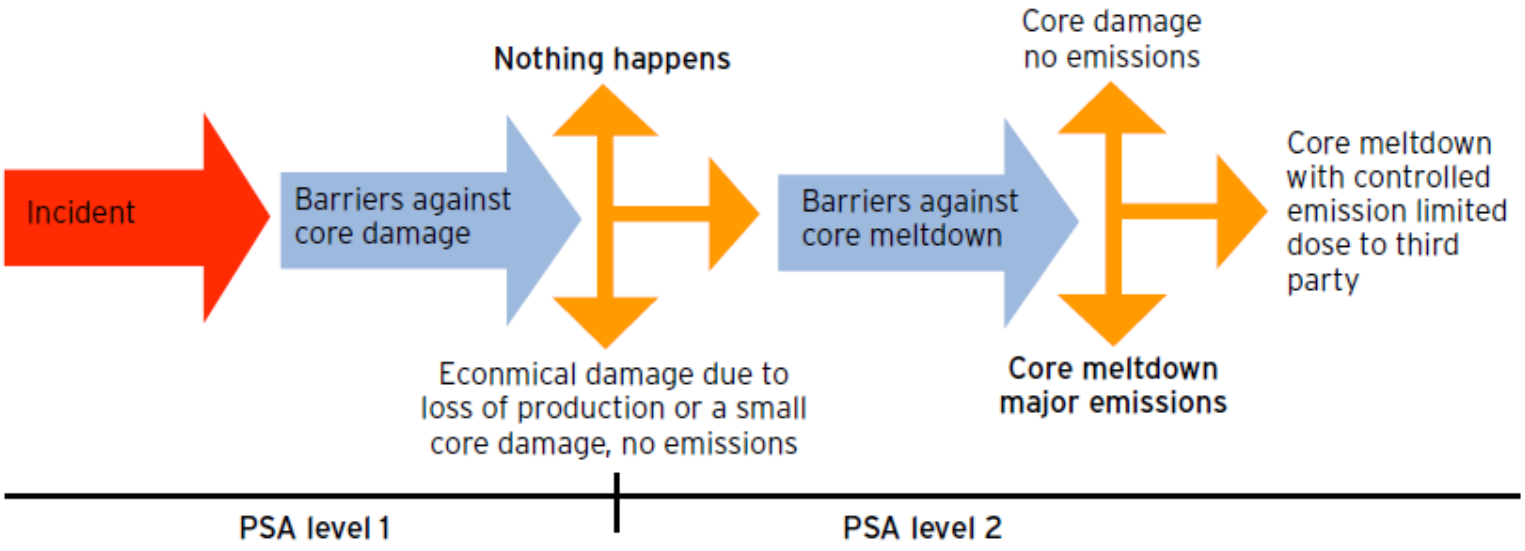
Emissions from potential incidents compared to normal operation

Dominating events causing emissions of respective substance	Substance to air	Substance to ground or water	Potential emissions due to accidents in the Core process	Potential emissions caused by accidents during construction of the Core process - infrastructure	Lifecycle emissions under normal conditions (excluding distribution of electricity)
			g/kWh	g/kWh	g/kWh
Fire in turbine, transformer, breaker and emission from carbon dioxide extinguishing	Carbon dioxide		10^{-5}	10^{-7}	4,4
	Carbon monoxide		10^{-7}	0	$8{,}8 \cdot 10^{-3}$
	Sulphur dioxide		10^{-6}	10^{-6}	$2{,}5 \cdot 10^{-3}$
	Dust		10^{-7}	10^{-7}	$1{,}0 \cdot 10^{-3}$
Breakdown of magnetic transformer or breaker (arc), cable fire	Gasified copper		10^{-6}	0	$2{,}5 \cdot 10^{-7}$
Breakdown of breaker, leakage or fire in breaker	SF_6		10^{-6}	0	$3{,}4 \cdot 10^{-7}$
Turbine breakdown, breaker breakdown, control system leakage		Oil/diesel/ petrol	10^{-4}	10^{-5}	$5{,}0 \cdot 10^{-4}$

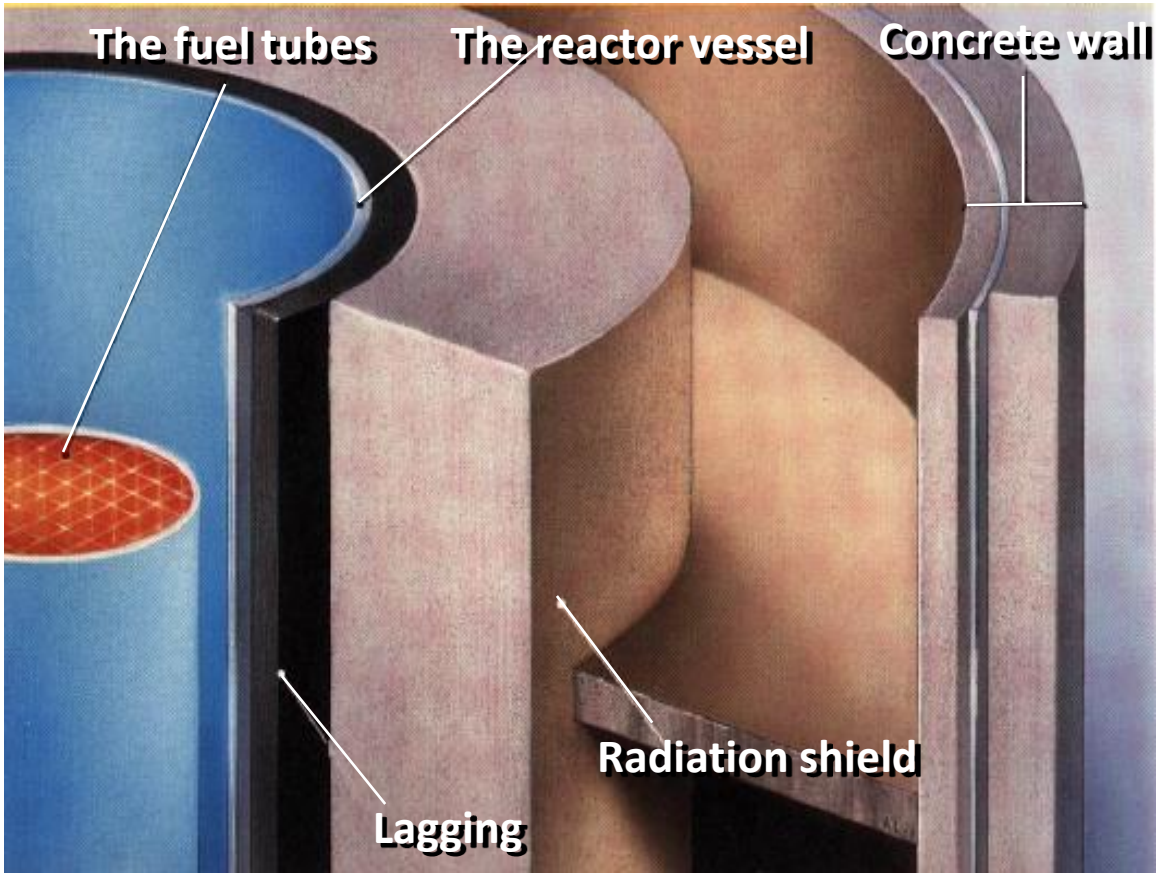
Procedure for risk assessment Nuclear

- Information about risks in the nuclear fuel cycle varies, from qualitative reasoning to quantitative assessments
- Before construction of a NPP, risk analyses are performed, deterministic risk analyses
- Since the 1970´s Probabilistic Safety Assessment (PSA) has been applied
  - What incidents may occur, and how frequently?
  - What barriers are required
- For conventional environmental risk the nuclear industry uses various methods

PSA flöde


Incident
Barriers against core damage
Nothing happens
Econmical damage due to loss of production or a small core damage, no emissions
Barriers against core meltdown
Core damage no emissions
Core meltdown major emissions
Core meltdown with controlled emission limited dose to third party
PSA level 1
PSA level 2

Barriers


The fuel tubes
The reactor vessel
Concrete wall
Radiation shield
Lagging

NPP focus on radioactivity

Dose to Personnel in Forsmark's lifecycle

	Facility	Average annual individual dose to personnel at respective facility (mSv in 2006)	Allocated average dose-to-personnel (mSv/kWh in 2006)
Mining	BHP Billiton, Olympic Dam Rössing Uranium Ltd	3,1 2,3	$2{,}0 \cdot 10^{-12}$ $6{,}4 \cdot 10^{-12}$
Conversion	Cameco, Blind River Cameco, Port Hope	3,5 1,5	$3{,}8 \cdot 10^{-12}$ $2{,}1 \cdot 10^{-12}$
Enrichment	Urenco, Capenhurst TENEX, UEIP, Novouralsk TENEX, ECP, Zelenogorsk	0,39 0,45 0,68	$1{,}1 \cdot 10^{-12}$ $1{,}0 \cdot 10^{-13}$ $9{,}1 \cdot 10^{-14}$
Fuel fabrication	Areva ANP, Lingen	0,1	$5{,}4 \cdot 10^{-13}$
Electricity generation	FKA, Forsmark	1,3	$5{,}6 \cdot 10^{-11}$
Waste	SKB-SFR, Forsmark SKB-CLAB, Oskarshamn SKB-Encapsulation plant, Sweden* SKB-Final Repository, Sweden	0 0,4 1 1,5	0 $7{,}2 \cdot 10^{-12}$ $1{,}5 \cdot 10^{-11}$ $2{,}2 \cdot 10^{-11}$

* *The Encapsulation Plant and the Final Repository are not yet in operation. The doses in the table are estimated.*

Ways to be exposed to annual dose of 1-3 mSv per year

- Annual dose for transatlantic aircraft personnel
- Average annual dose for a Swedish nuclear worker
- Annual dose from radon in homes (100 Bq/m^3 give about 2mSv per year)

Conventional incidents with environmental impact in FKA LCA

Incident	Probability ranking	Consequence ranking
Release of contaminated extinguisher	3	3
Ruptured tubing to turbine oil tank Tubing ruptured by collision during garbage collection during revision	3	3
Oil spill from tank truck in traffic accident	2	3
Oil spill from auxiliary transformer	2	3
Fuel oil spill (to ocean) from canal-side tanks	2	3
Shipwreck with ensuing oil spill	1	5
Fire in transformer with release of particles	1	3

Explanation to table on conventional risks for FKA

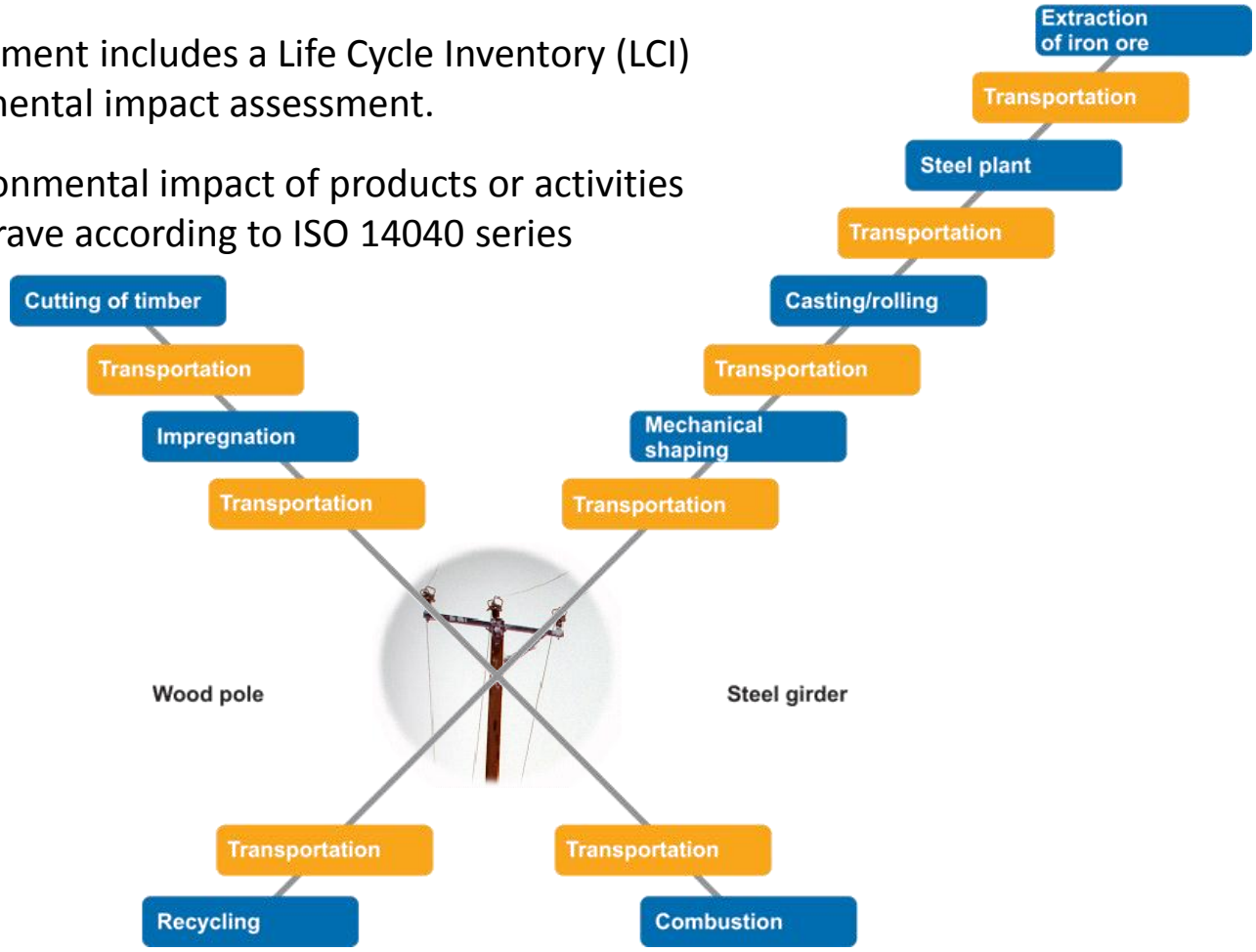
Consequence Rank	Life and Health	Cost, MSEK	Environmental impact
1 Minor	Minor discomfort	<0,1	Local impact within 1 km Short duration –approx. 1 month
3 Major	Major discomfort, few badly injured	1-5	Local impact Long duration – approx. 35 month
5 Catastrophic	Several fatalities, or Tens of badly injured	>20	Regional impact Medium duration – approx. 6 months

Frequency ranking	
1 - infrequent	< 1 per 1000 years
3 - probable	Aprox 1 per 10 – 100 years
5 - frequent	> 1 per year

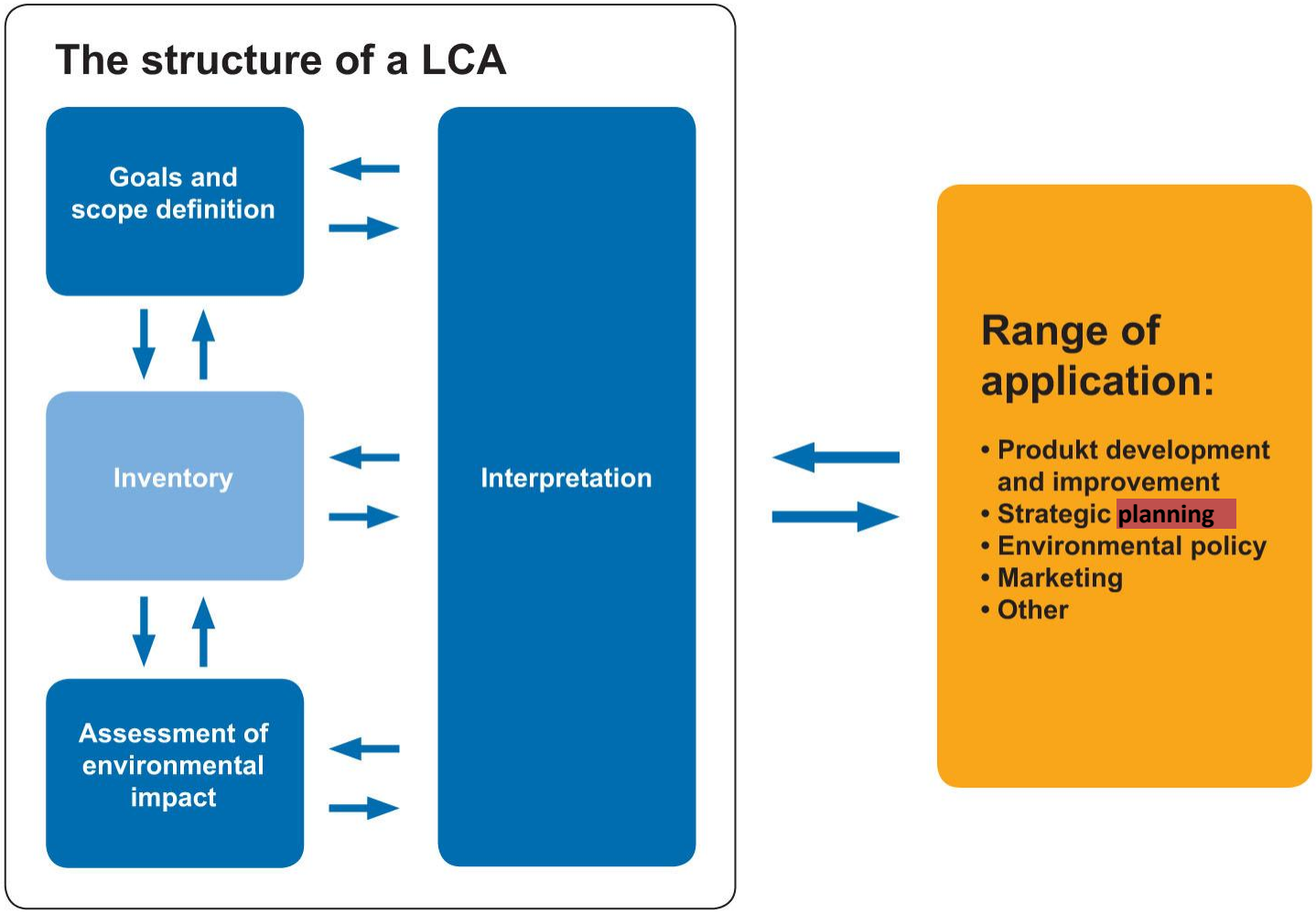
LCA

Life Cycle Assessment includes a Life Cycle Inventory (LCI) and an environmental impact assessment.

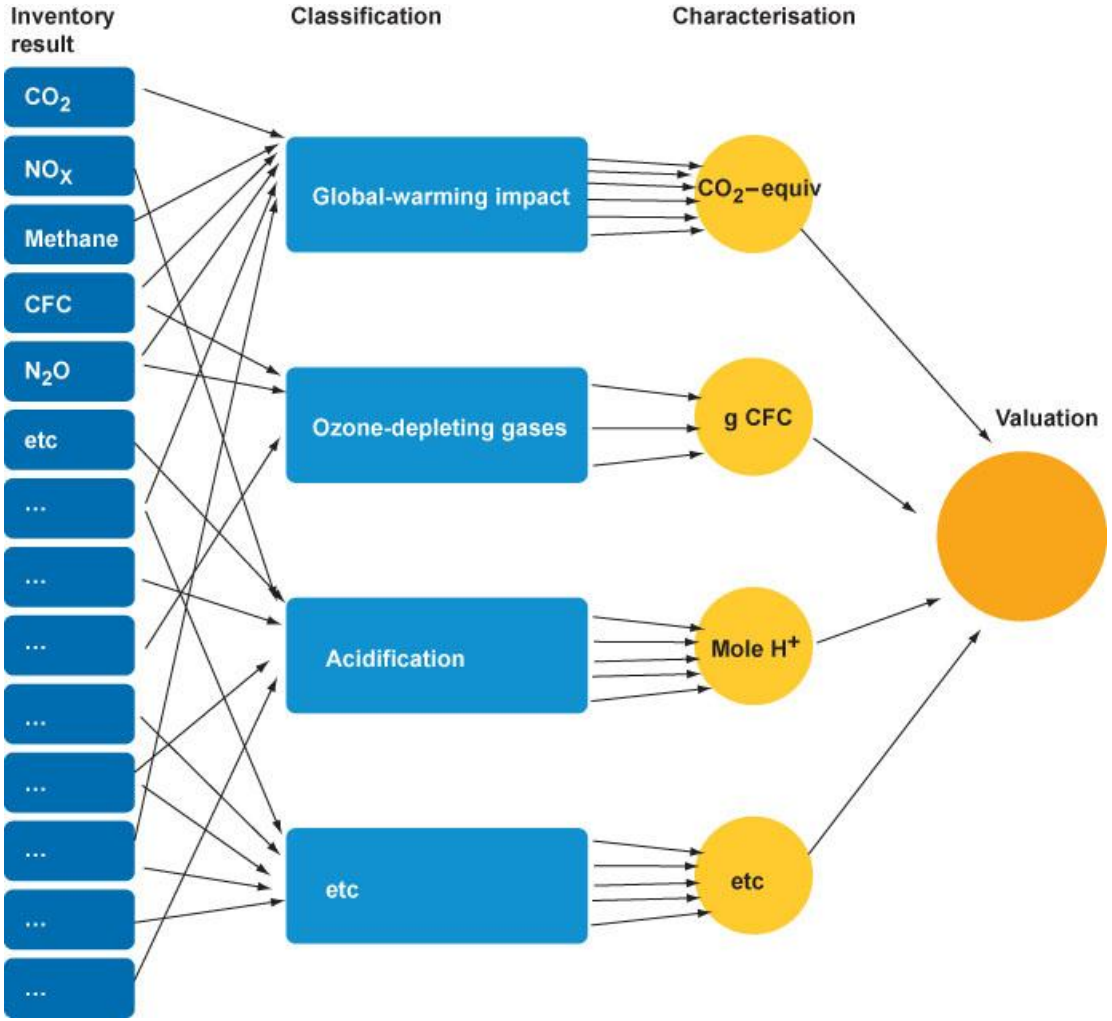
A study of environmental impact of products or activities from cradle to grave according to ISO 14040 series



Phases of Life Cycle Assessment



Environmental Impact Assessment



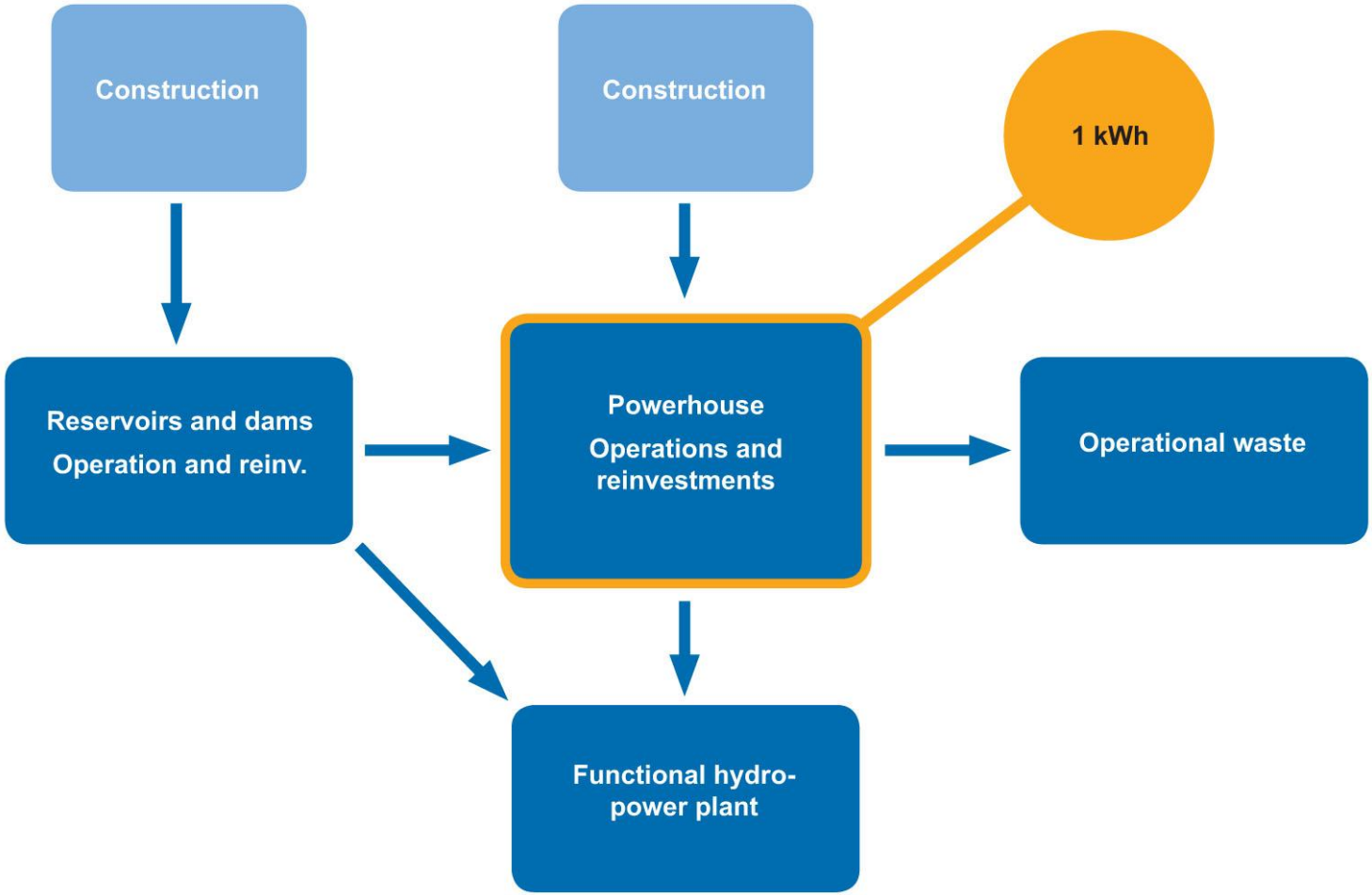
Important for comparability

- Standards
- PCR (Product Category Rules)
- System boundaries
- Functional unit
- Allocation principles
- Data quality - specific and generic

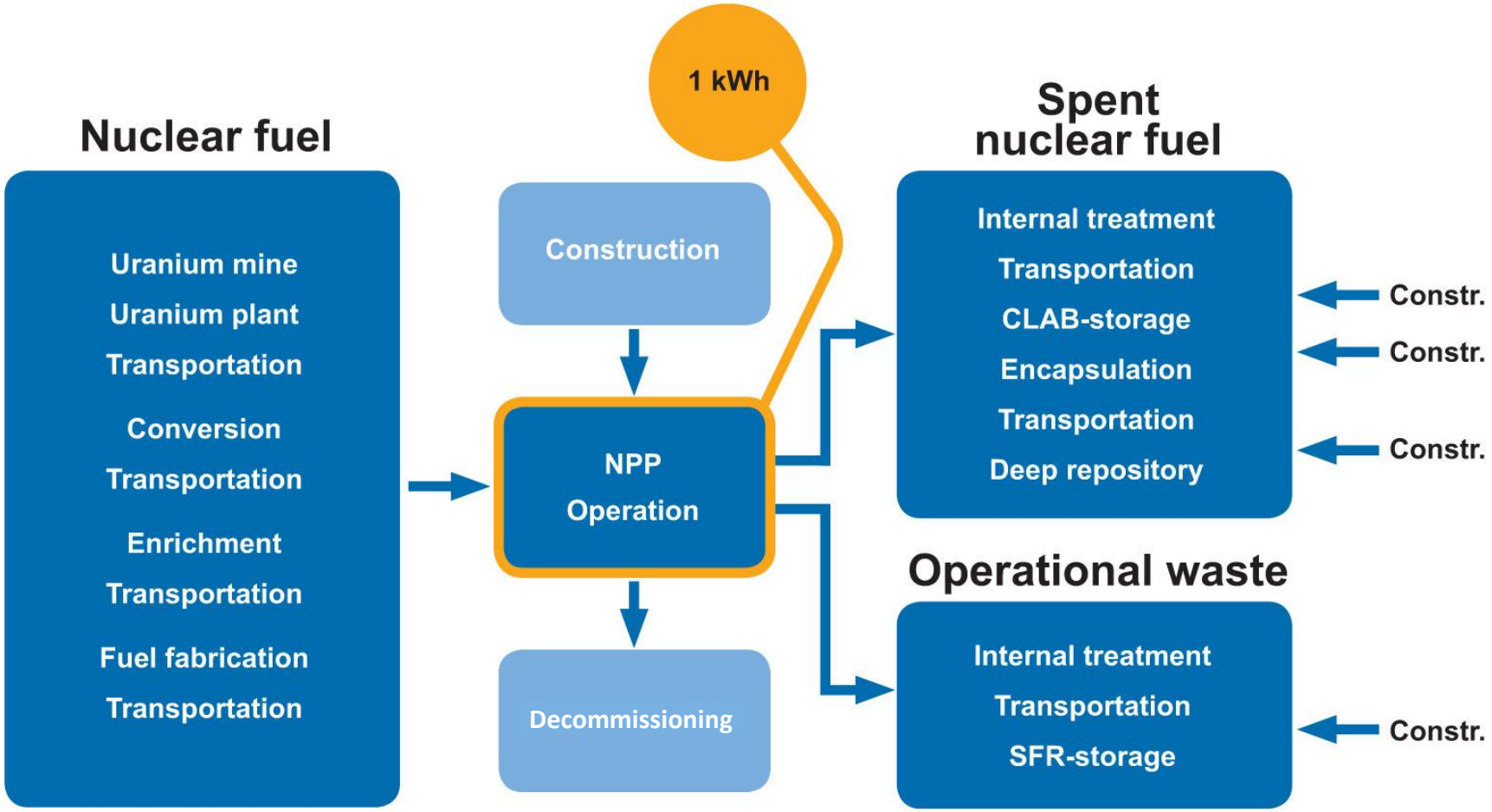
Different types of LCAs - different results

- Attributional –Bookkeeping
  - Specific processes and/or average data
- Consequential
  - Marginal approach
- System expansion
  - What if – somebody else – system boundary
- Verification
  - Possible for attributional and preferably without system expansion

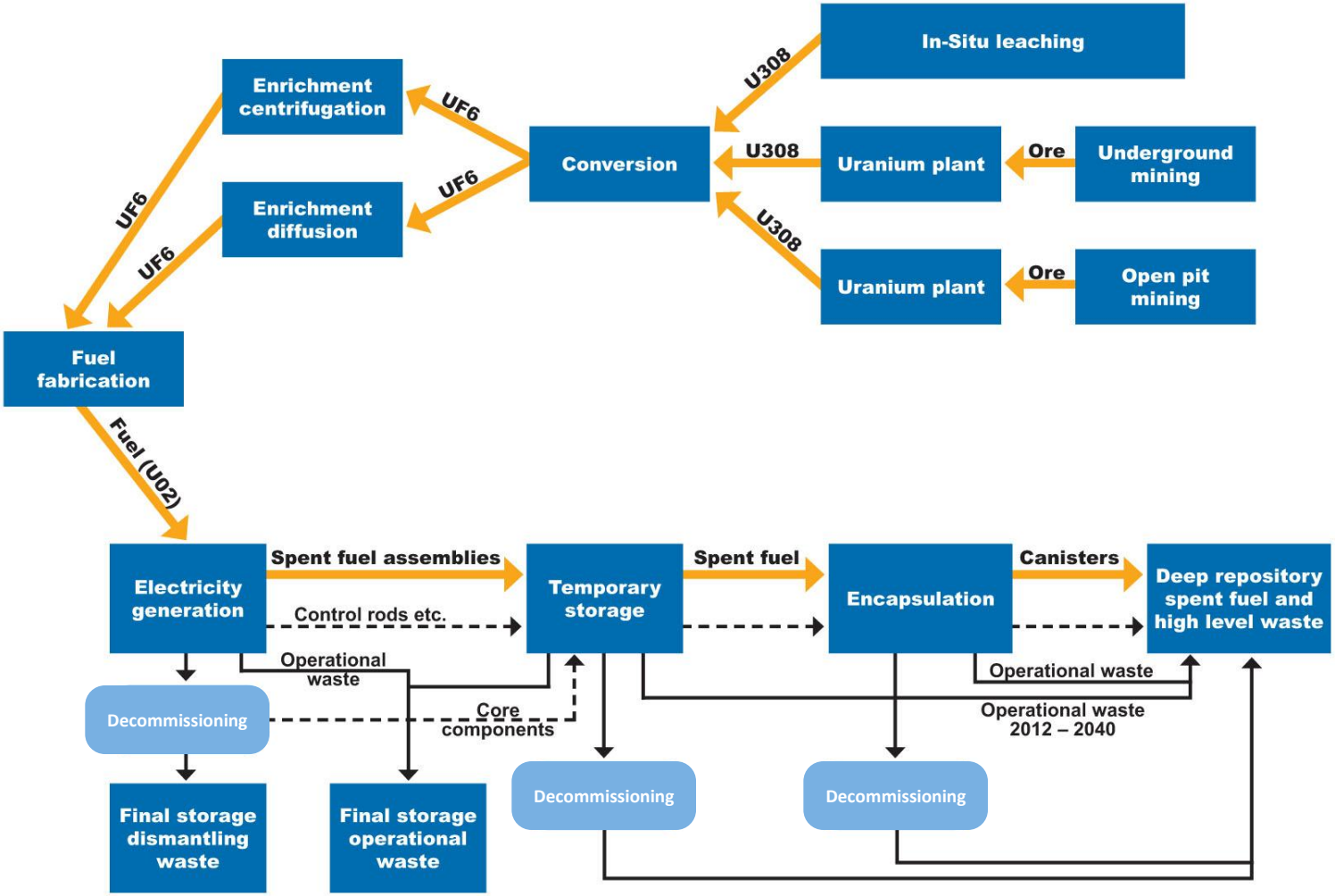
Included parts in the LCA of hydropower



Included parts in the LCA of nuclear power



Ringhals' nuclear fuel cycle

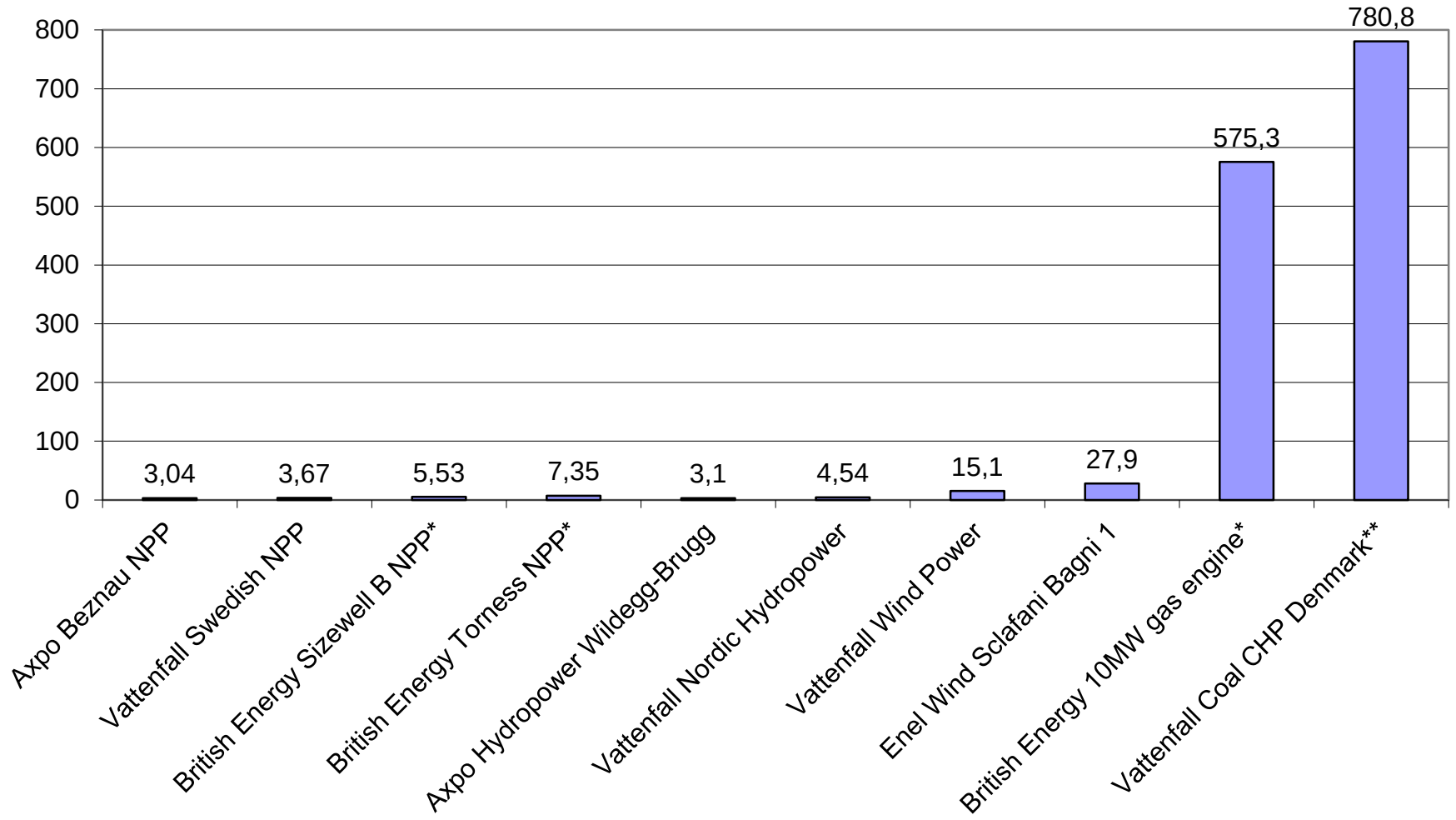


GHG is interesting for most people

- GHG is in focus but is not the only thing

- From the EPDs Climate declarations are presented for that single parameter
- Upcoming standard on Carbon footprint for products ISO 14067 will state:

It is a single issue and not proof of over all superiority for a product


g CO2-equivalents per kWh electricity at power plant (100 yr)
800
700
600
500
400
300
200
100
0
3,04
3,67
5,53
7,35
3,1
4,54
15,1
27,9
575,3
780,8
Axpo Beznau NPP
Vattenfall Swedish NPP
British Energy Sizewell B NPP*
British Energy Torness NPP*
Axpo Hydropower Wildegg-Brugg
Vattenfall Nordic Hydropower
Vattenfall Wind Power
Enel Wind Sclafani Bagni 1
British Energy 10MW gas engine*
Vattenfall Coal CHP Denmark**

This is connected to the graph

- * Not verified by third party
- ** CHP=Combined heat and power; a part of the emissions have been allocated to heat using the alternative generation method prescribed in the PCR.
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- Source: Homepage of the EPD® system managed by the International EPD Consortium (IEC) www.environdec.com
- Axpo Beznau NPP http://www.environdec.com/reg/epd144.pdf
- Vattenfall Forsmark NPP http://www.environdec.com/reg/021/dokument/EPDforsmark2007.pdf
- Vattenfall Ringhals NPP http://www.environdec.com/reg/026/dokument/EPD-ringhals2007.pdf
- Axpo Wildegg-Brugg run-of-river Power Plant http://www.environdec.com/reg/epd205.pdf
- Vattenfall Hydropower http://www.environdec.com/reg/epd88.pdf
- Vattenfall Wind Power http://www.environdec.com/reg/epd183full.pdf
- Enel Wind Power http://www.environdec.com/reg/epd66.pdf
- Vattenfall Coal CHP http://www.environdec.com/reg/152/dokument/EPD-coal.pdf
-
- and British Energy
- http://www.british-energy.com/documents/Sizewell_B_EPD_Technical_Report.pdf
- http://www.british-energy.com/documents/Torness_EPD_Report_Final.pdf
- http://www.british-energy.com/documents/EPD_District_Energy_Tech_Report_-_FINAL_(25-11-08).pdf
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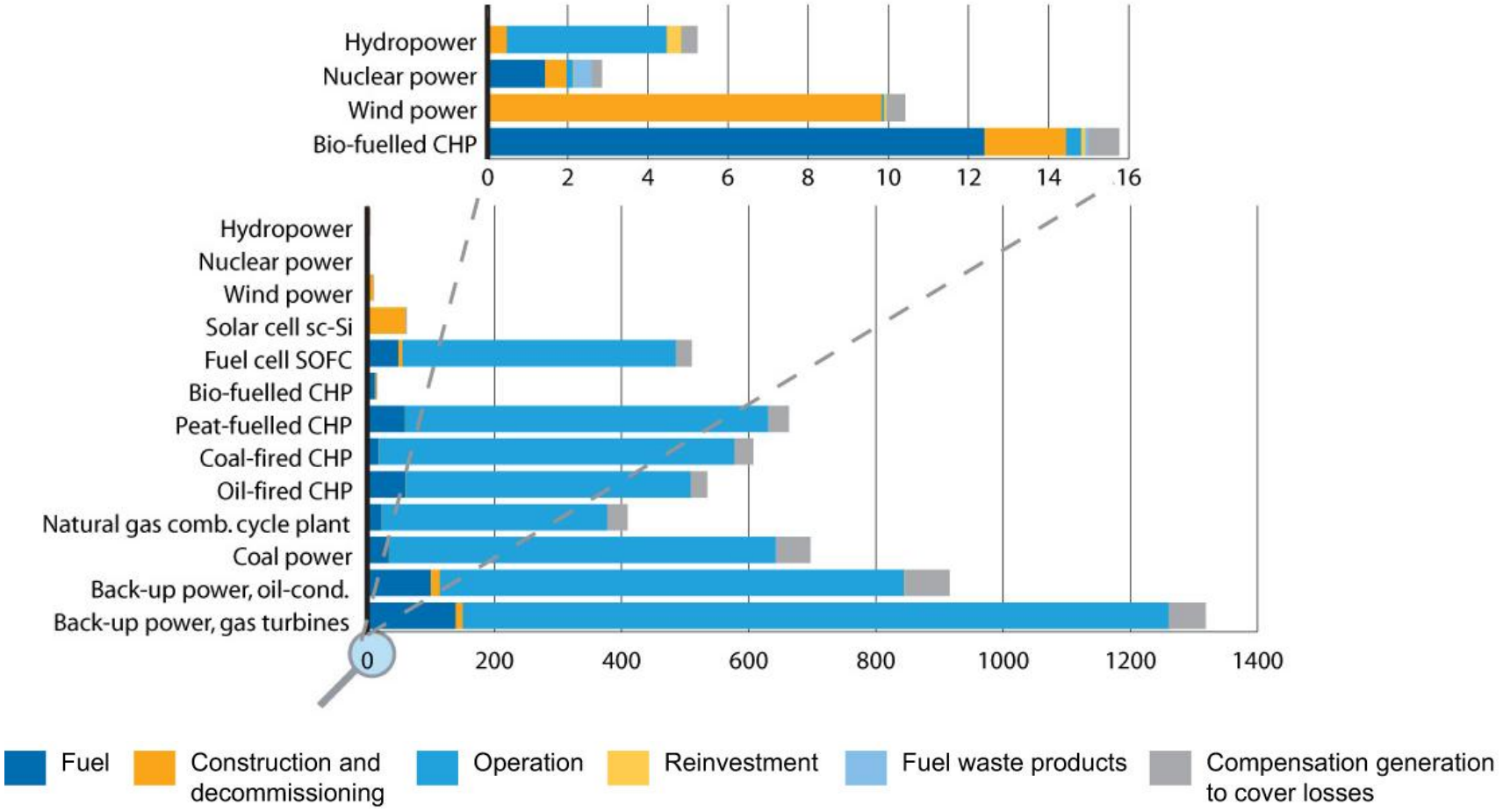
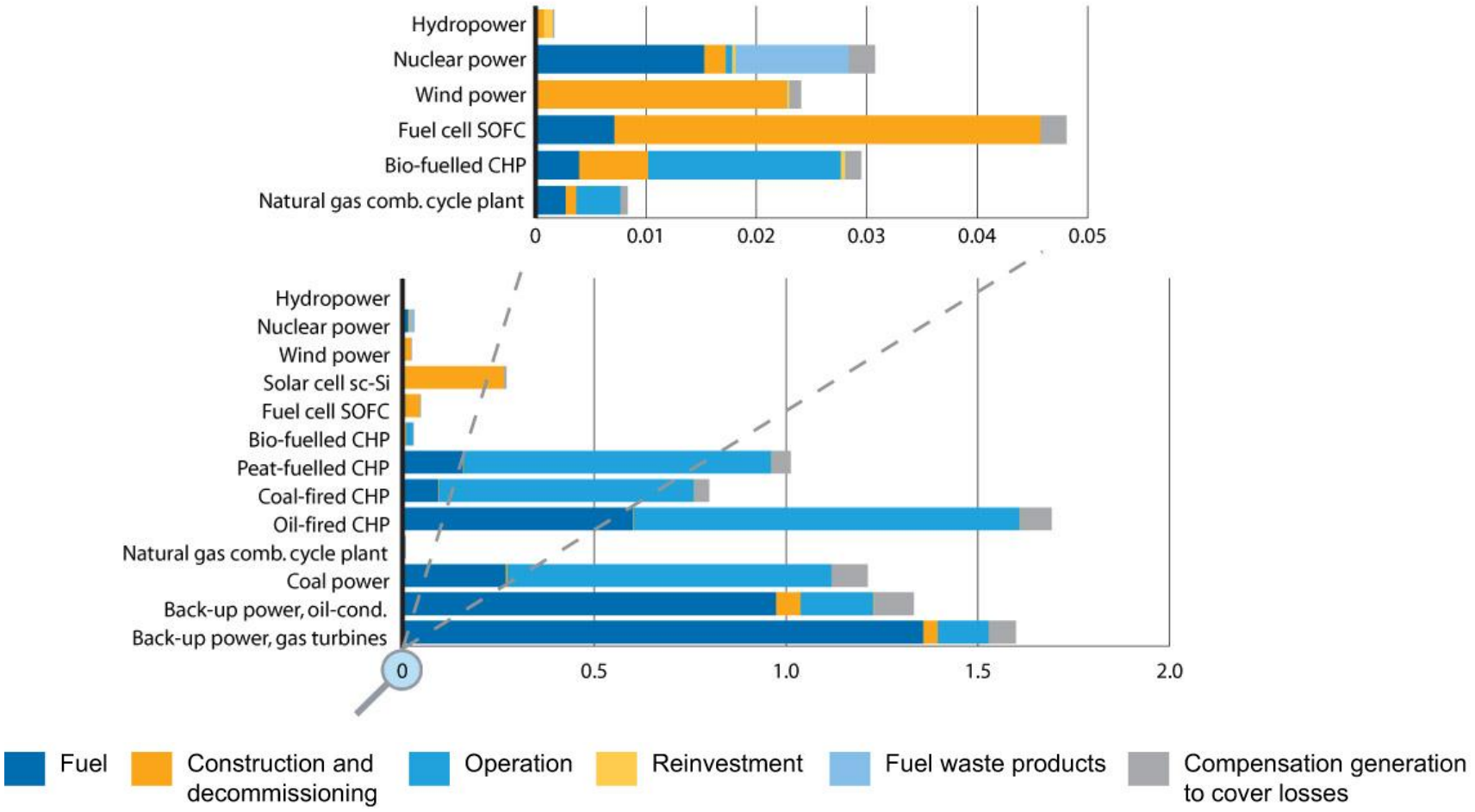
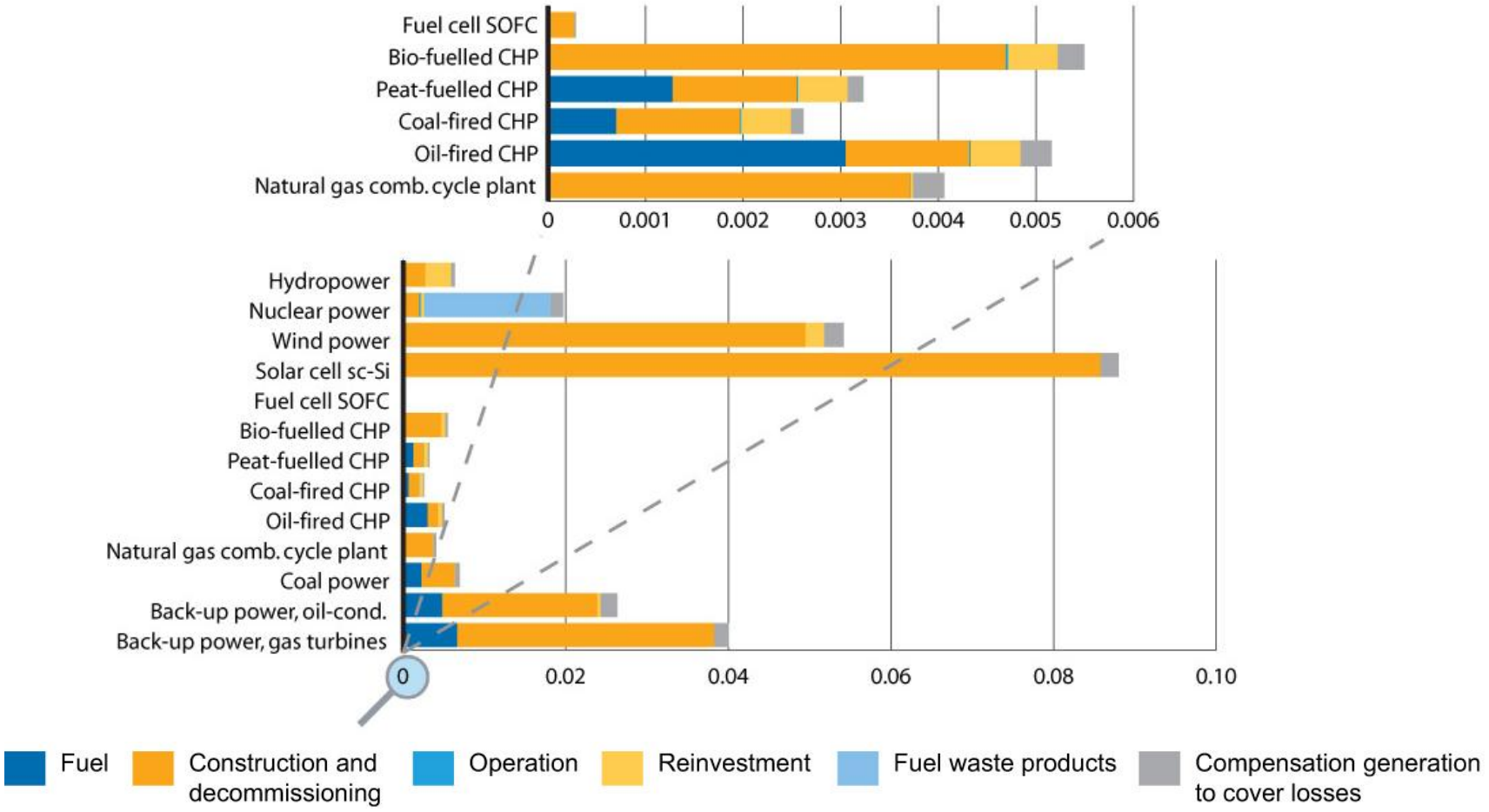
Emissions of fossil CO_2, g/kWh electricity delivered to household customer



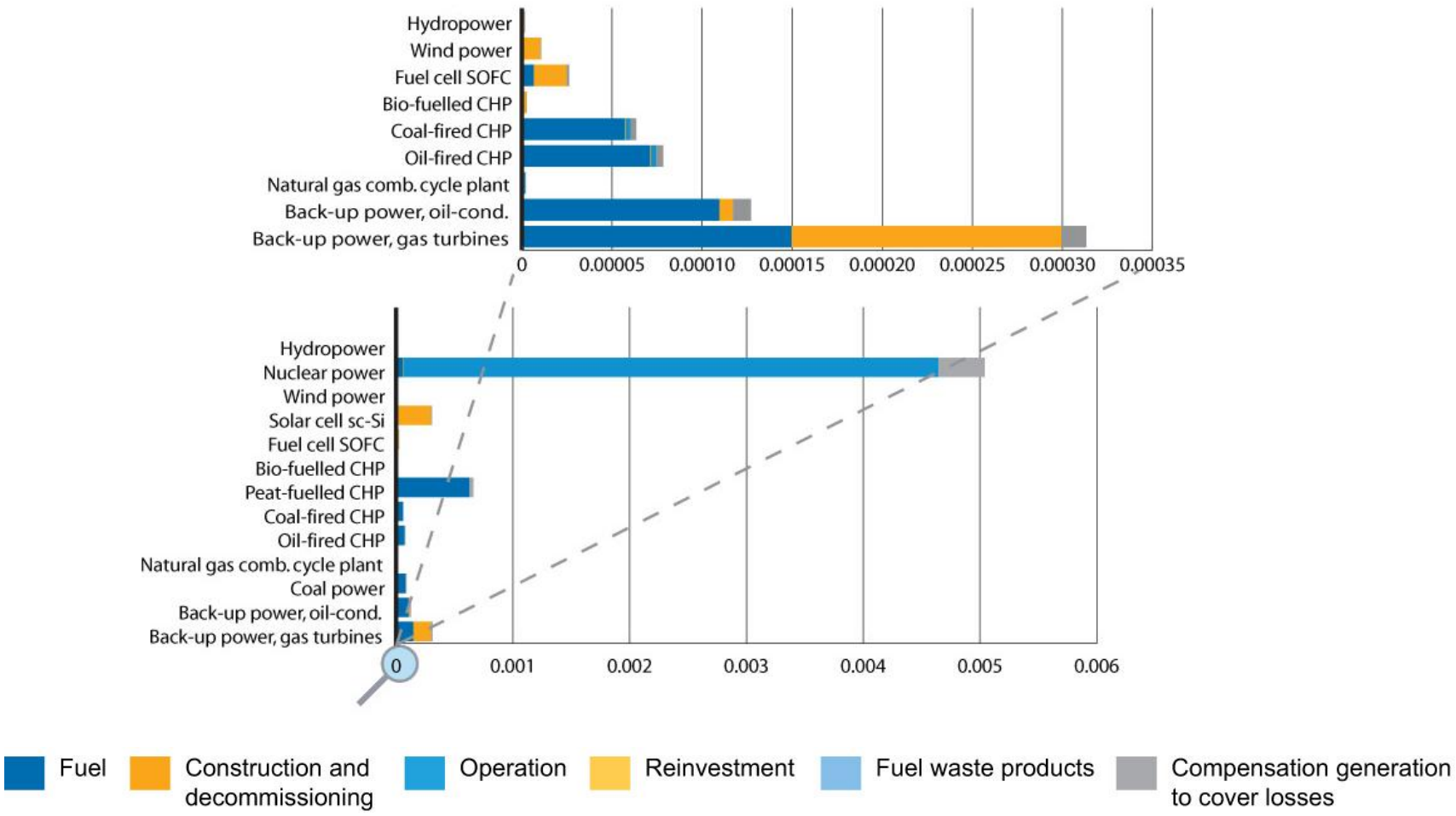
Emissions of SO_2, g/kWh electricity delivered to household customer



Use of copper from mine, g/kWh electricity delivered to household customer



High-active radio-active waste, g/kWh electricity delivered to household customer



Conclusions

- There are many energy options
- Some have more environmental problems than others
- Some have the problems in the normal operations
- Some have the problems in the accidents and the risks
- Some create global problems others local
- Some are site specific like hydro, tidal and geothermal
- Some are more promising than others
- We need to develop them all
- A world with insufficient supply of electricity is a dangerous world