Sustainability approach at DESY

A sustainable accelerator and high research performance? How can we manage it?

Concepts and first steps taken

Sustainable HEP 2024 - 3rd edition
11.06.2024 Andrea Klumpp

What is Sustainability at DESY

Broad approach with focus on energy efficiency

Science

- Science case supports sustainability goals
- High number of beamlines
- Innovation and technology transfer

Infrastructure
- Reuse of infrastructure
- Energy saving technologies
- New building concepts and materials

Supporting processes
- Key infrastructure of Science City Bahrenfeld: cooperation in campus security, safety, enviromental protection and mobility

Personnel
- Sustainable career development
- Keep knowledge on campus and attract best talents

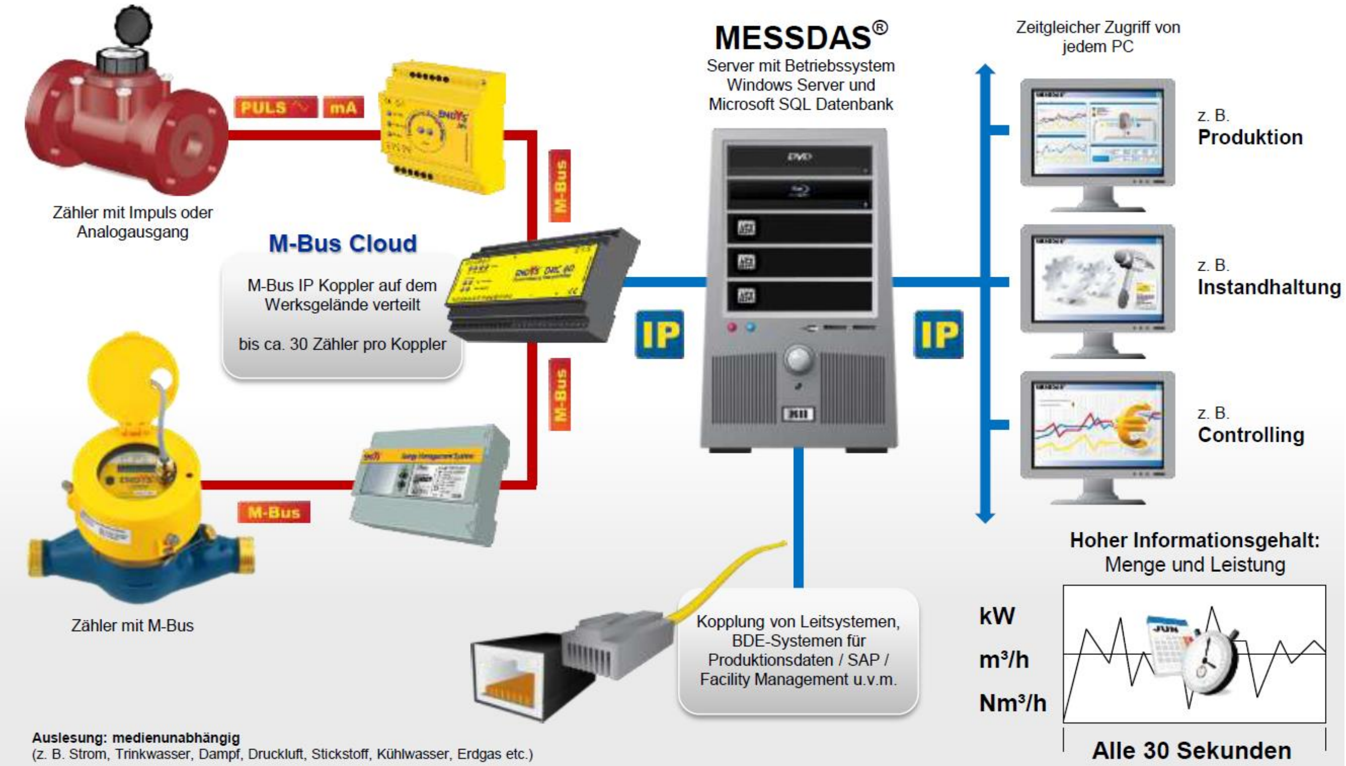
Management
- Transparent to employees and stakeholders
- Documentation of processes and decisions
- Boost socio-economic impact (education, employment, …)

DESY Energy approach

Energy Monitoring System

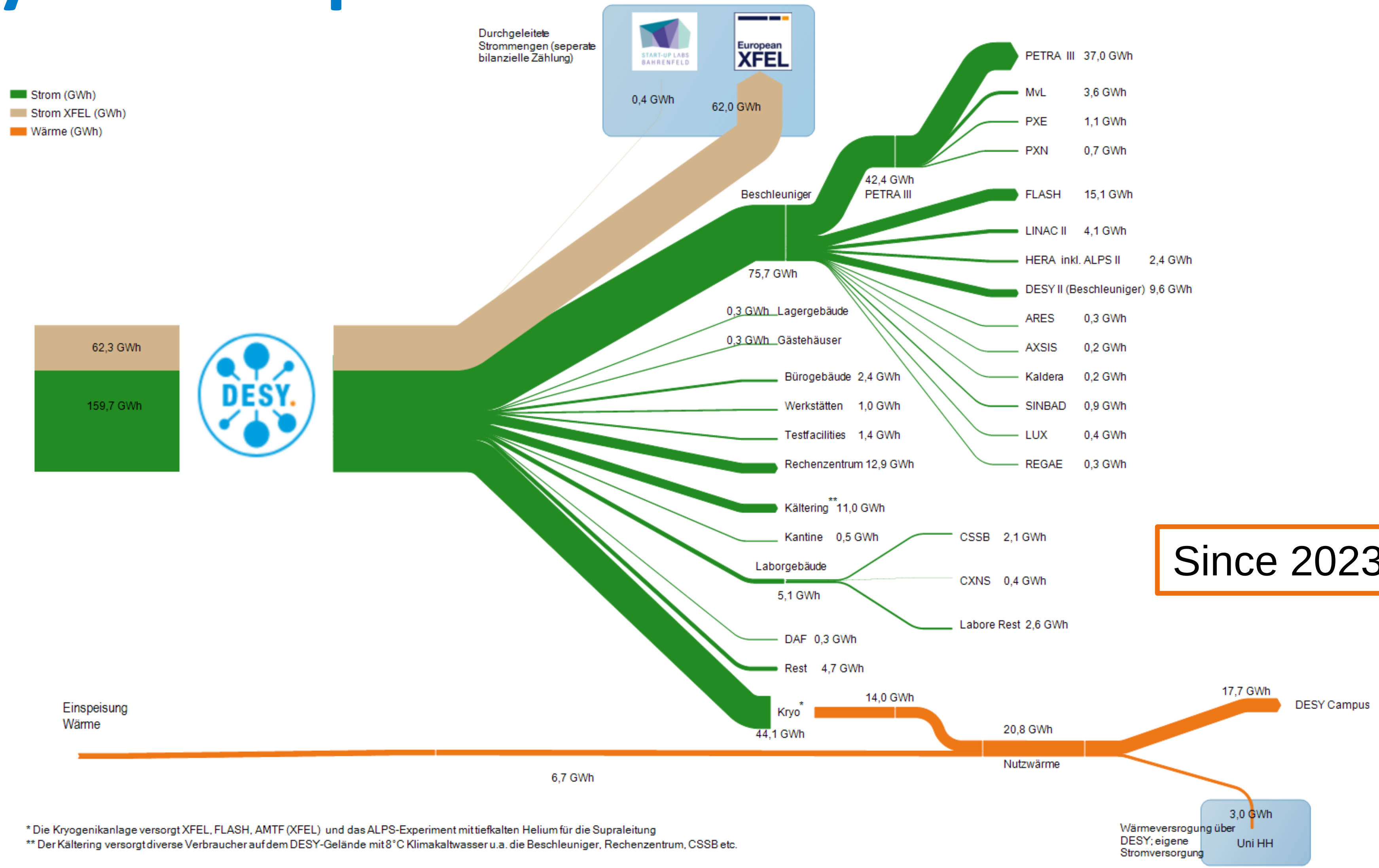
- Detailed, unified meter marking, centralized data collection and analysis, meters directly connected to database
- For Electricity, Water, Heat, Cooling

→ Enables for user-based/source-related accounting, identification of efficiency potentials and therefore more awareness



Energy consumption DESY 2023

SUSTAINABLE DESY.



* Die Kryogenikanlage versorgt XFEL, FLASH, AMTF (XFEL) und das ALPS-Experiment mit tiefkalten Helium für die Supraleitung

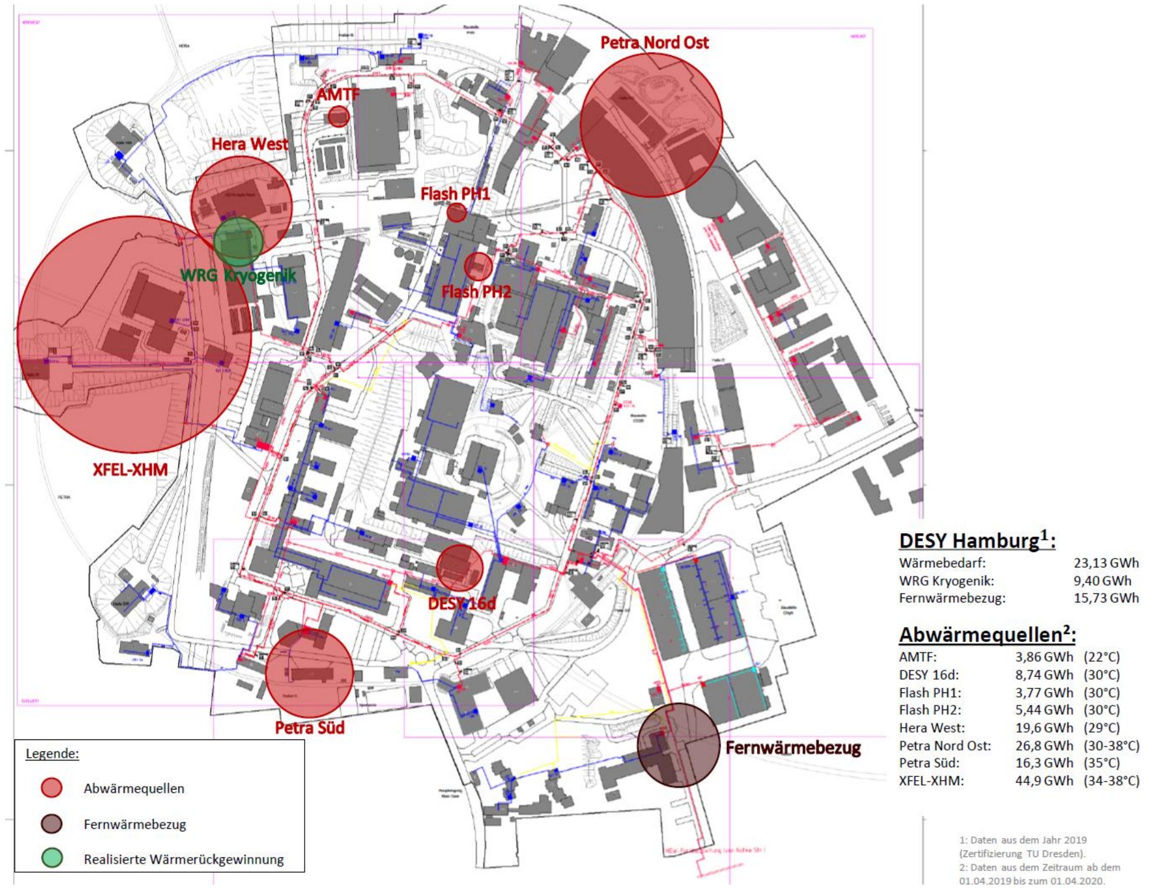
** Der Kältering versorgt diverse Verbraucher auf dem DESY-Gelände mit 8°C Klimakaltwasser u.a. die Beschleuniger, Rechenzentrum, CSSB etc.

Since 2023 renewable energy.

Waste Heat Usage

Potential at DESY Campus in Hamburg

- Project with University of applied science in Hamburg (HAW) to identify potential
- Result: 129 GWh/y of waste heat available at a temperature level of 30°C - 40°C
- Possible CO_2 savings at DESY campus of about 4.000 tons/y
- Surplus can be used in neighborhood; if we get the 129GWh in use saving will be up to 40.000 tons CO_2/y

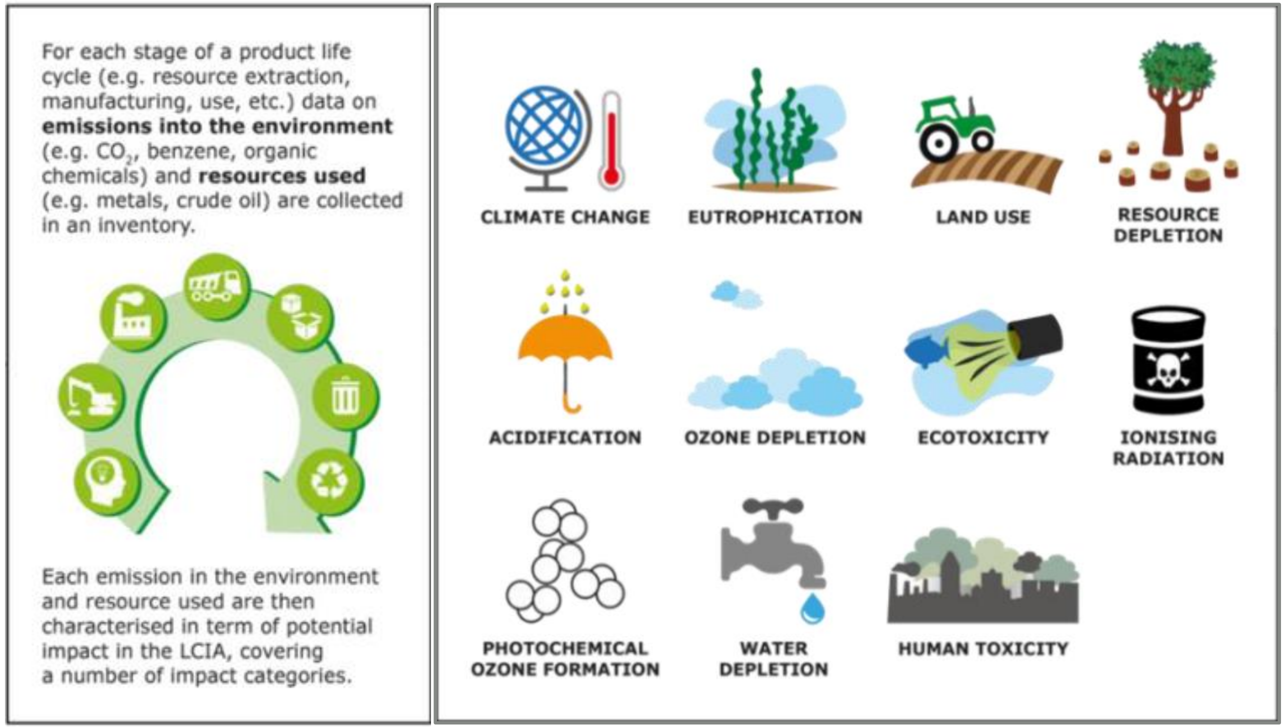


Life cycle assessment

Life Cycle Assessment (LCA)

- Consider entire life meaning:
  from the cradle to the cradle/grave
- LCA contains:
  - Life Cycle Inventory (LCI)
  - Life Cycle Impact Assessment (LCIA)
  - Life Cycle Interpretation phase
- Cost analysis
  - Lower operation cost justify higher investment cost, not to forget costs for decommissioning
  - To lose high level materials is not only an ecological but also an economical problem

Life Cycle Inventory (LCI) Life Cycle Impact Assessment (LCIA)



Example: Content of a Life Cycle Inventory
Source: https://eplca.jrc.ec.europa.eu/lifecycleassessment.html

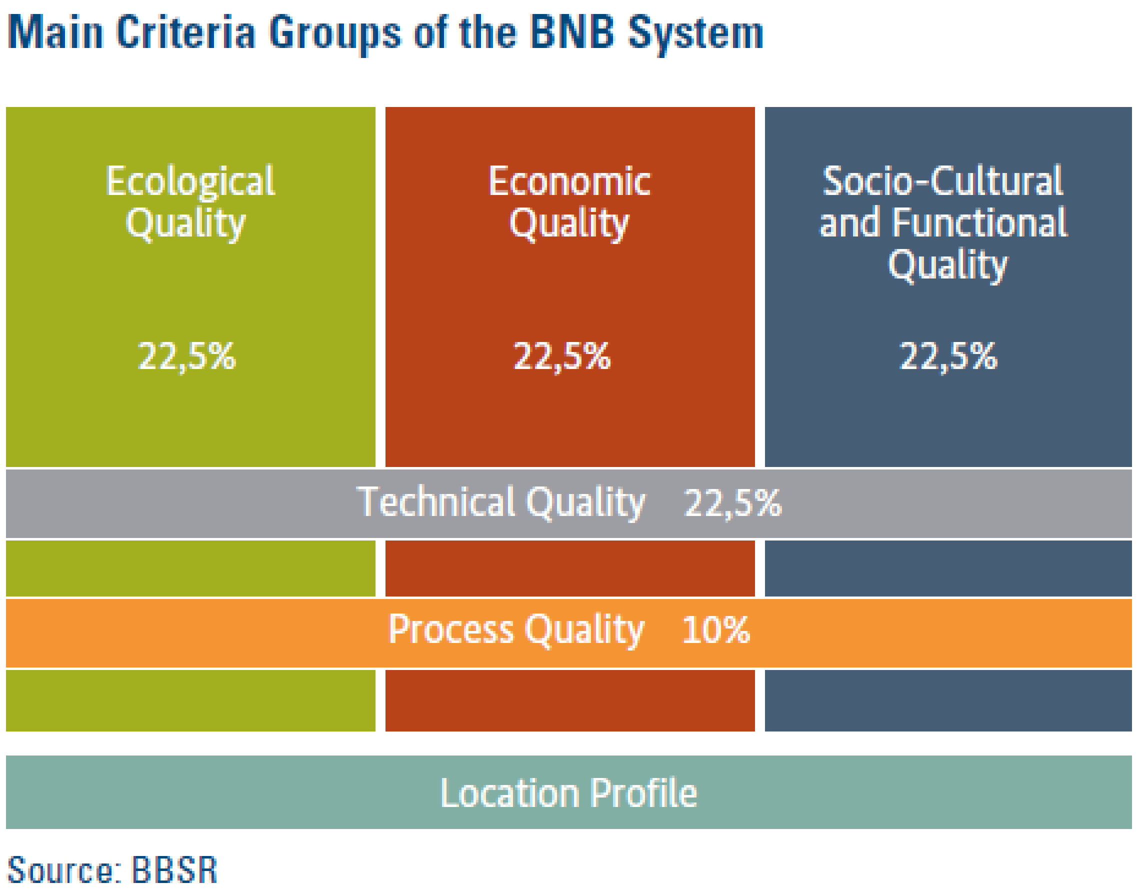
PETRA IV.
NEW DIMENSIONS

PETRA IV and Sustainability

Andrea Klumpp

Civil Construction

LCA for building

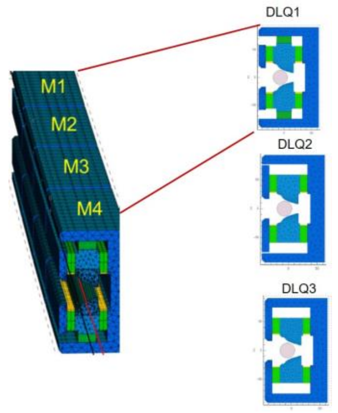


National certification system for sustainable building (BNB):

- Consideration of the whole life cycle of the building (LCA)
- Ecological, economic, socio-cultural and technical qualities are rated equally
- End of life and recycling are included

LCA for bending magnets

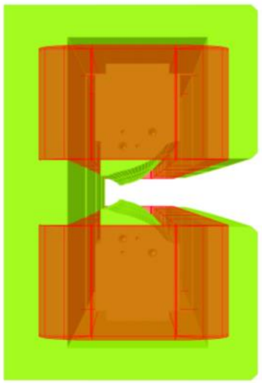
Permanent magnetic design



- 3 types DQ1, DQ2, DQ3
- DQ 1+ 2 made of 4 moduls
  DQ3 6 moduls
- Soft iron poles and yoke;
  SmCo magnets
- Thermal shims FeNi

Material	DLQ1	DLQ2	DLQ3
Al	20 kg	20 kg	30 kg
Fe	112 kg	112 kg	168 kg
Sm_5Co_{17}	16.5 kg	16.5 kg	24.7 kg
Steel	2.4 kg	2.4 kg	3.6 kg
FeNi	1.2 kg	1.2 kg	1.8 kg
Total	152 kg	152 kg	228 kg

Electromagnetic design

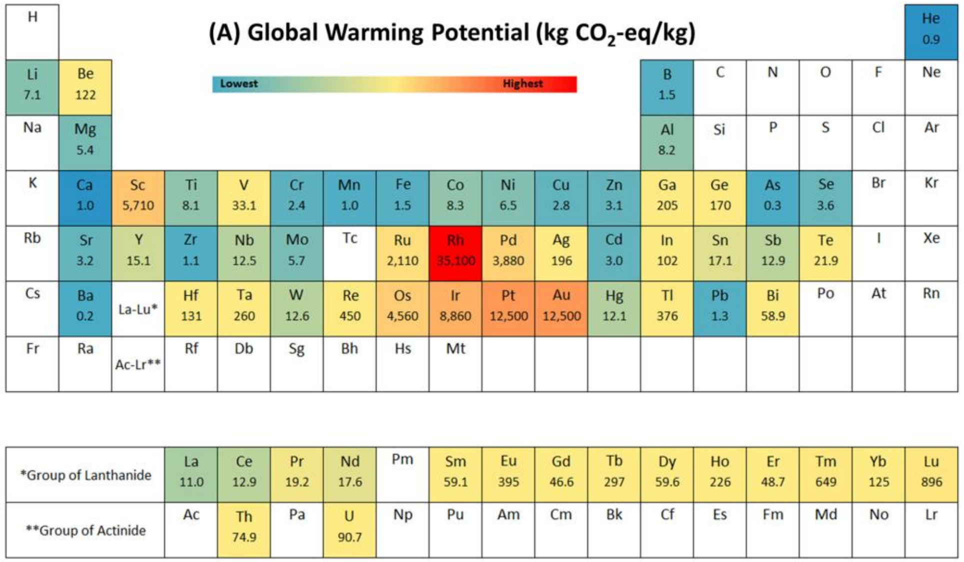


- Only calculated in order to compare with the permanent magnetic design
- Soft iron poles and yoke; Copper

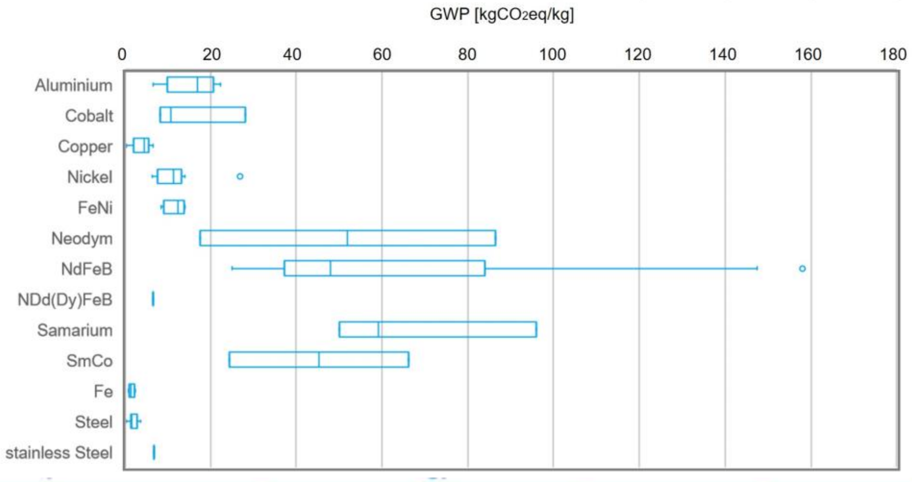
Material	DLQ1	DQL2	DLQ3
Cu	34,07 kg	30,97 kg	50,12 kg
Fe	189,60 kg	170,64 kg	287,56 kg
Energy	1,27 kW	0,67 kW	1,11 kW

Only material for the magnets and operation of the magnets includes!

Global warming potential



Life Cycle Assessment of Metals: A Scientific Synthesis
Philip Nuss1*, Matthew J. Eckelman
www.plosone.org 1 July 2014 | Volume 9 | Issue 7 | e101298



Material	Min	Max	Mean value	Chosen value (partly weighted mean)
Aluminium	6,7	22,4	15,872	16
Cobalt (Co)	8,38	28,2	15,77	16
Copper (Cu)	0,4	6,05	4,173	4
Iron (Fe)	0,86	2,46	1,61	2
Nickel (Ni)	6,5	26,9	12,754	12
Nickelferrit (FeNi)	8,53	14	10,933	11
Samarium (Sm)	50	96	68,367	70
Samarium Cobalt (Sm_2Co_{17})	24,414	66,176	45,295	27[1]
Steel	0,359	6,8	2,187	2
energy (normal mix in Germany)				0,410
energy (renewable in Germany)				0,03

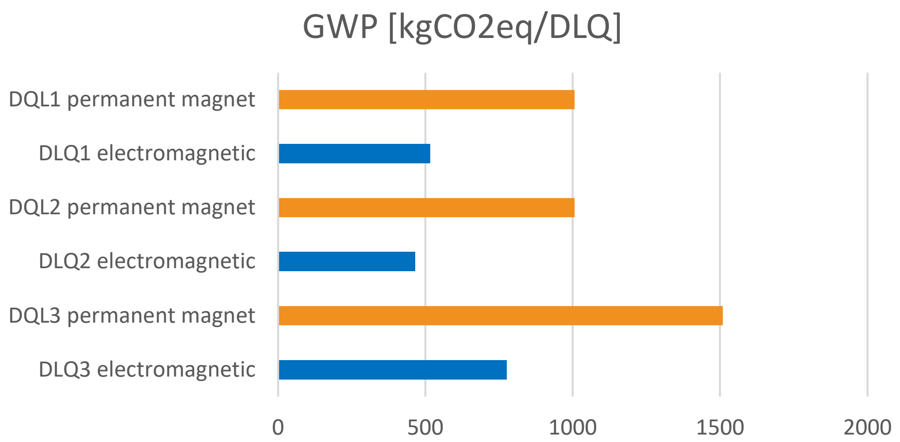
[1] calculated

GWP for energy: UBA reports

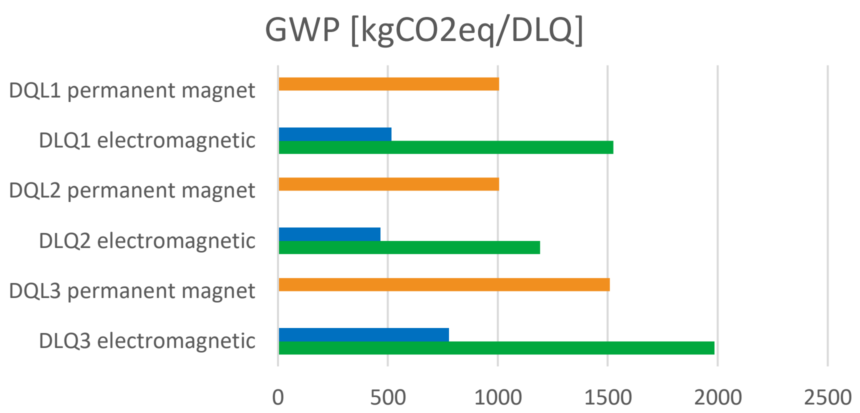
- Normal electricity mix 0.375 kgCO2eq/kWh (2020),
  0.410 kgCO2eq/kWh (2021)
  Strom- und Wärmeversorgung in Zahlen | Umweltbundesamt
- From renewable sources 0,03 kgCO2eq/kWh
  Emissionsbilanz erneuerbarer Energieträger 2021 (umweltbundesamt.de)

Results of the LCA

(a)



(b)



GWP for (a) material (electromagnets- blue and permanent magnets – orange)

(b) including estimated energy consumption (material + renewable electricity for 2 years – green)

Energy savings

1. Operation of magnets

- Per cell 2 magnets from each kind, 72 cells in the ring
- $P=72x2x(P_{DQ1}+P_{DQ2}+P_{DQ3})$~440kW
- Per year (6500 h operation time per year):

2.86GWh/year

2. Cable losses

- Each magnet needs an average cable length of 20m to the media shaft and 70m to the power supply
- Cable losses per magnet: DQ1~ 331,29W ; DQ2 ~ 195,23W; DQ3 ~ 200,4W
- $P=72x2 (P_{DQ1cable}+P_{DQ2cable}+P_{DQ3cable})$~ 104,98kW
- Per year (6500 h operation time per year):

0.68GWh/year

Heritage from PETRA I

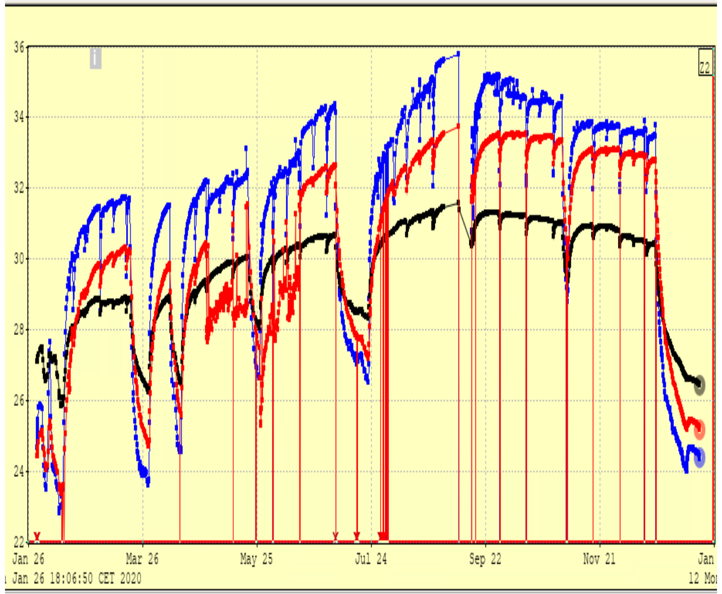
PETRA I Tunnel reused for PETRA IV

Constructional conditions

- 6 old sections, 100 – 300 m long, in total ~1 km
- The old sections of the tunnel are below streets, buildings, a park.
- The tunnel is covered by 3 – 10 m of soil.

Temperature over one year

- Temperature difference between positions **up to 5°C**
- Operating schedule of PETRA clearly visible
- Summer and winter time visible



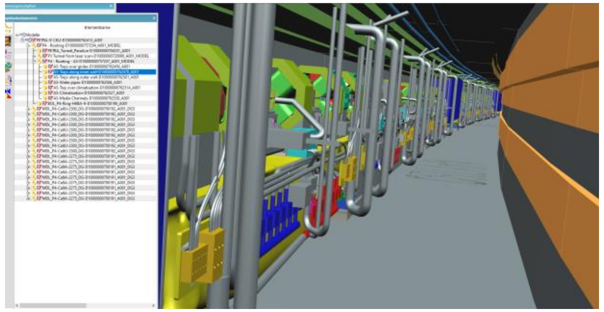
Black curve, 26º – 31º C: Concrete floor, OR59, air temperature regulated (30º C)
Red curve, 23º – 34º C: Concrete floor, SOR87, air temperature unregulated
Blue curve, 23º – 36º C: Air temperature, SOR85, air temperature unregulated

|Temp.Calc.Kickoff| PETRA IV
Michael Bieler

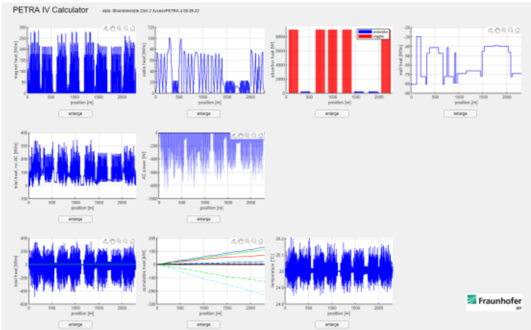
Calculations for the tunnel

Cooperation with Fraunhofer Magdeburg for a CFD- simulation (fluid dynamic)

- Digital Twin of the tunnel in CAD (not yet completed)
- List with all consumer of electricity with their heat input
- Including the cooling capacity and the position of air conditioners
- Fluid dynamical simulations:
  - Heat distribution also for corners and hidden places
  - Optimization for cooling and heating (in shutdowns)
  - Optimization of cabeling

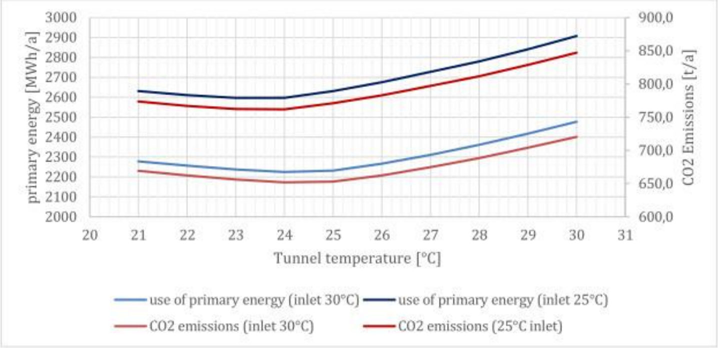


(Cedric Kula TAC)



screenshot of the app and first test results
(R. Zimmermann)

Optimal tunnel temperature and operation schedule



Primary energy consumption and CO_2 emission for different tunnel temperatures and cooling water inlet temperatures with reference PETRA IV operation
(T. Warnecke „Report on thermal parameters of PETRA IV”)

Including shutdowns, when we have to heat for a constant temperature.

optimal temperature

Water:	**30°C**
Air:	**25°C**

Long summer shutdown and short winter shutdown for energy savings

operation mode
1: beam time
2: machine studies
0: shutdown

Reference and alternative operation schedule and outdoor air temperature (T. Warnecke „Report on thermal parameters of PETRA IV”)

New automized processes

Reliability in operation:
Use of Robotics & Telepresence of Experts:

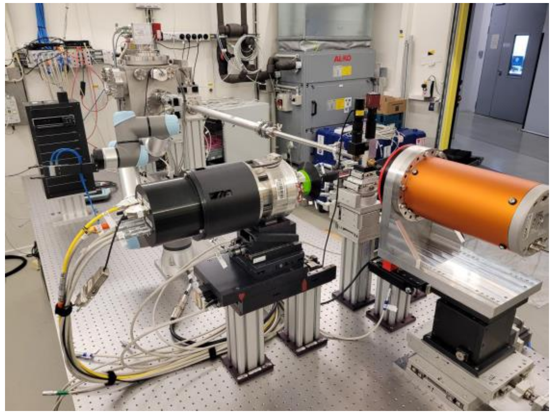
MARWIN3

KAI Kooperation für Anwendung und Innovation der HAW Hamburg und DESY

(Reinhard Bacher)

- Versatile platform based provides
    - Multiple sensors
    - Multi-axis manipulators
- Immersive remote control interface using mixed reality technologies
- Project partners: Hochschule21, HAW, UHH, DESY

HiPhax: Highly automated pharmaceutical screening beamline for room temperature measurements



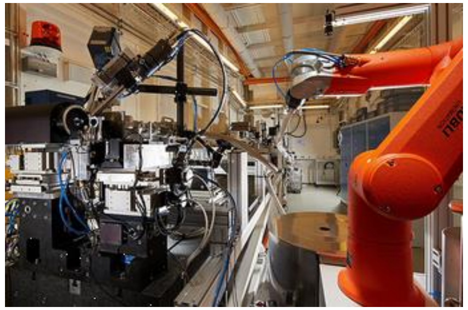
First successful test experiments in June/July 2022 at beamline P09 at PETRA III

- Designed for high-throughput pharmaceutical screening at cryogenic temperatures and room temperature
- >1000 samples/24 h

SLAC HIR³X

(Alke Meents ,Pontus Fischer Massive X-ray screening)

Remote Access – High-throughput MX

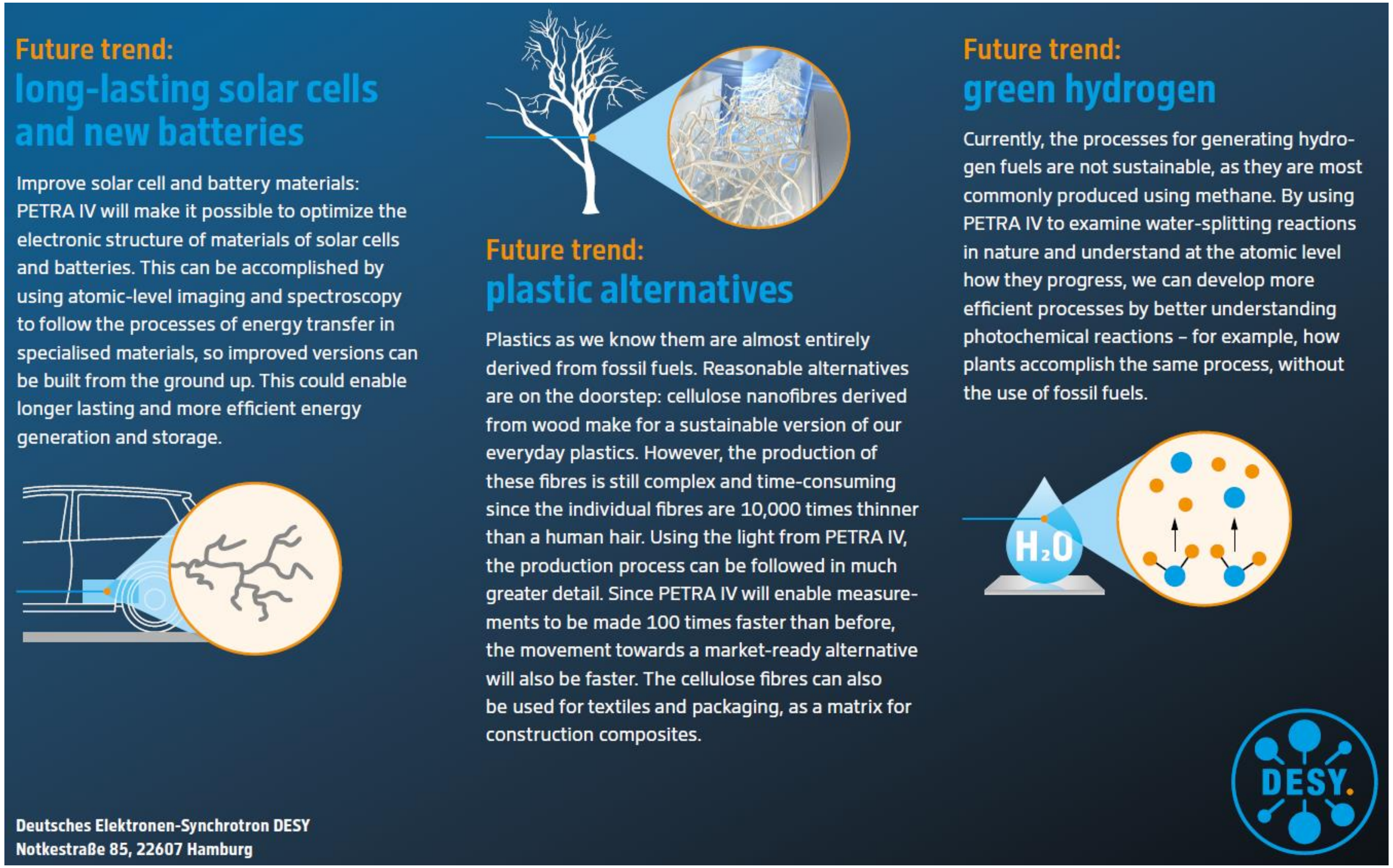


- The technical equipment at PETRA III's P11 beamline includes a robotic arm that can execute fully automated sample changes
- Experienced users have the possibility to collect data remotely

(Johanna Hakanpää)

PETRA IV – Research for Sustainability

PETRA IV enables research to tackle sustainability challenges and develop global solutions



Thank you for your attention!