

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 \geq sustainability goals
- High number of beamlines \succ
- Innovation and technology transfer

Personnel

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

\geq

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

Management

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



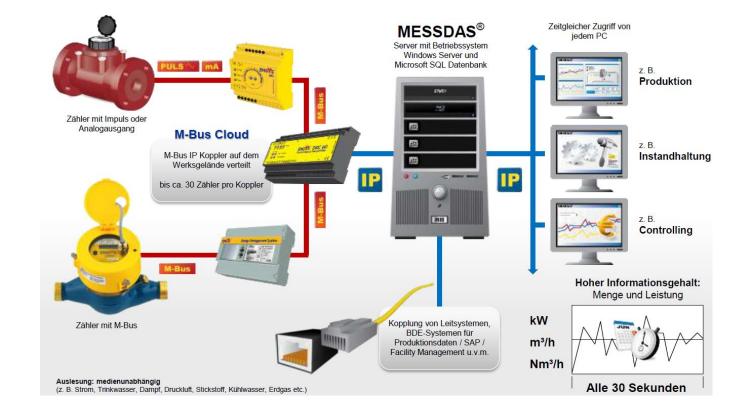
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DESY Energy approach

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

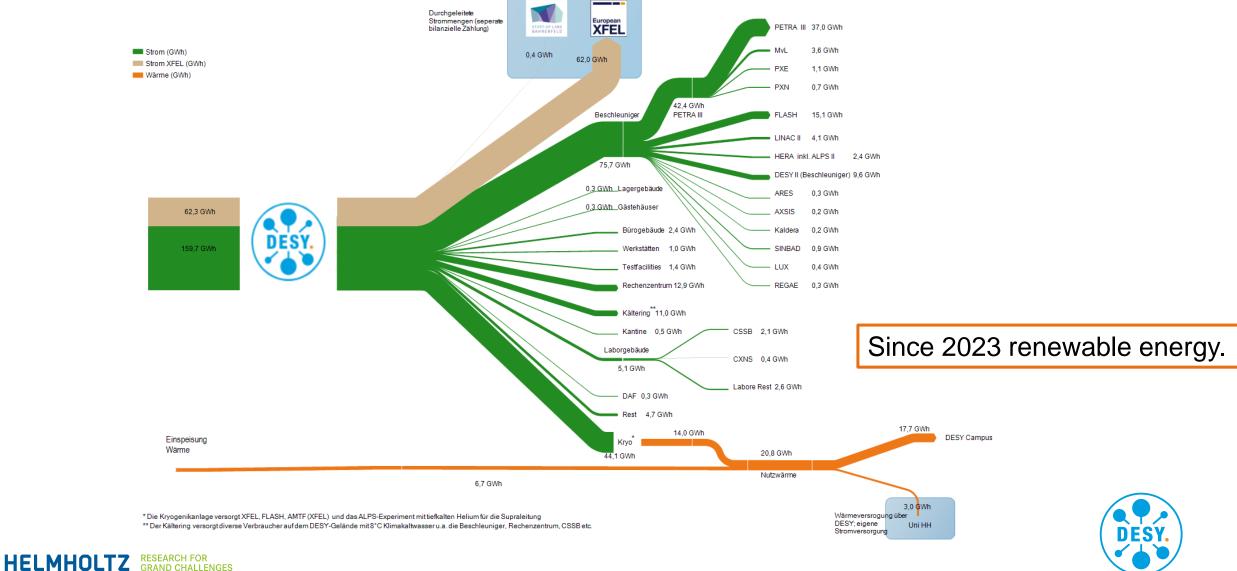




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Energy consumption DESY 2023

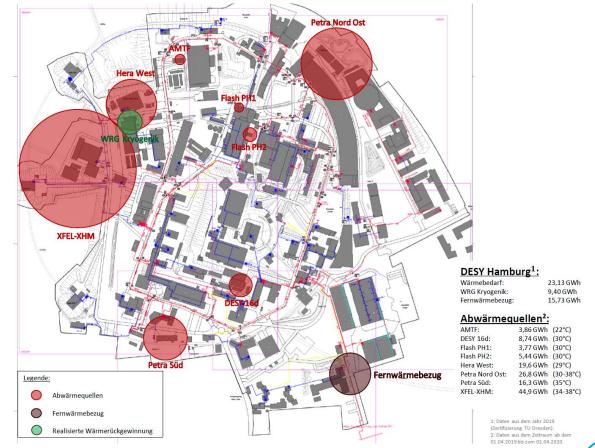




Waste Heat Usage

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 CO₂ 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





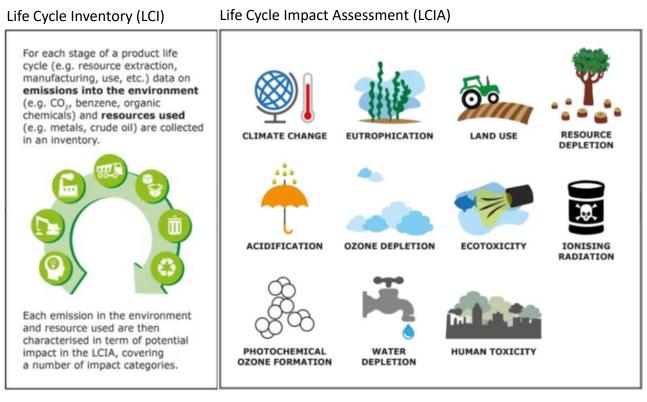
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Life cycle assessment

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



Example: Content of a Life Cycle Inventory

Source: https://eplca.jrc.ec.europa.eu/lifecycleassessment.html



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PETRAIV. NEW DIMENSIONS

PETRA IV and Sustainability

Andrea Klumpp

DESY.



Civil Construction

LCA for building

Main Criteria Groups of the BNB System



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



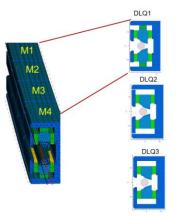
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LCA for bending magnets

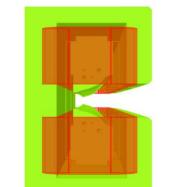
Permanent magnetic design

Electromagnetic 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 ₅ Co 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



- 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!



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Global warming potential

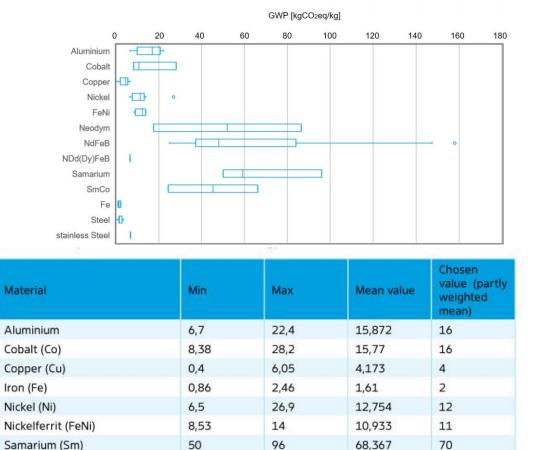
н		(A) Global Warming Potential (kg CO ₂ -eq/kg)									He 0.9						
Li 7.1	Be 122		1	Lowest					Highe	st		B 1.5	С	N	0	F	N
Na	Mg 5.4											Al 8.2	Si	Р	S	Cl	A
К	Ca 1.0	Sc 5,710	Ti 8.1	V 33.1	Cr 2.4	Mn 1.0	Fe 1.5	Co 8.3	Ni 6.5	Cu 2.8	Zn 3.1	Ga 205	Ge 170	As 0.3	Se 3.6	Br	K
Rb	Sr 3.2	ү 15.1	Zr 1.1	Nb 12.5	Mo 5.7	Тс	Ru 2,110	Rh 35,100	Pd 3,880	Ag 196	Cd 3.0	In 102	Sn 17.1	Sb 12.9	Te 21.9	I	>
Cs	Ba 0.2	La-Lu*	Hf 131	Ta 260	W 12.6	Re 450	Os 4,560	lr 8,860	Pt 12,500	Au 12,500	Hg 12.1	TI 376	Pb 1.3	Bi 58.9	Ро	At	R
Fr	Ra	Ac-Lr**	Rf	Db	Sg	Bh	Hs	Mt									

*Group of Lanthanide	La 11.0	Ce 12.9	Pr 19.2	Nd 17.6	Pm	Sm 59.1	Eu 395	Gd 46.6	Tb 297	Dy 59.6	Ho 226	Er 48.7	Tm 649	Yb 125	Lu 896
**Group of Actinide	Ac	Th 74.9	Ра	U 90.7	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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

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)



66,176

6,8

24,414

0,359

Samarium Cobalt (Sm₂Co₁₇)

energy (normal mix in Germany)

energy (renewable in Germany)

Steel

0,03

0,410

271

2

45,295

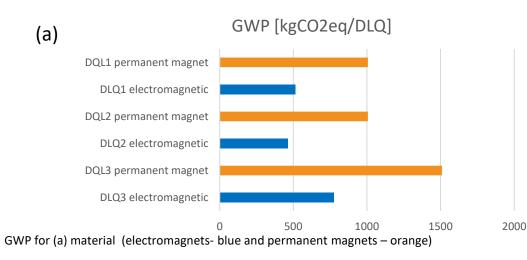
2,187



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Results of the LCA



(b) GWP [kgCO2eq/DLQ] DQL1 permanent magnet DLQ1 electromagnetic DQL2 permanent magnet DLQ2 electromagnetic DQL3 permanent magnet DLQ3 electromagnetic 0 500 1000 1500 2000 2500

(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

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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.

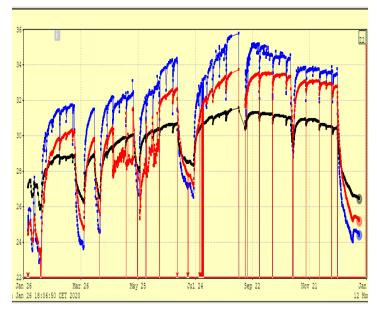


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Temperature over one year

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



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

|Temp.Calc.Kickoff| PETRA IV Michael Bieler



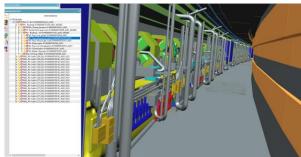




Calculations for the tunnel

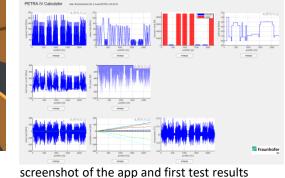
Cooperation with Fraunhofer Magdeburg for a CFD- simulation (fluid dynamic)

- 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

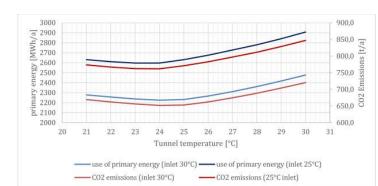


(Cedric Kula TAC)

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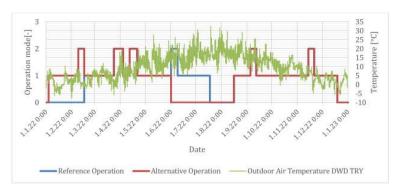
screenshot of the app and first test result: (R. Zimmermann)



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")

Warnecke "Report on thermal parameters of PETRA IV")



Reference and alternative operation schedule and outdoor air temperature (T.

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



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Optimal tunnel temperature and operation schedule



New automized processes

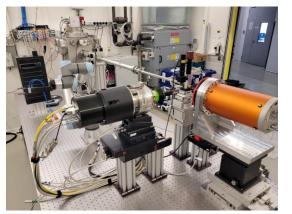
Reliability in operation: Use of Robotics & Telepresence of Experts:



MARWIN3

- 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 highthroughput pharmaceutical screening at cryogenic temperatures and room temperature
- >1000 samples/24 h

SLAC HIR³X

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

(Reinhard Bacher)

Kooperation I Anwendung s der HAW Harr

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



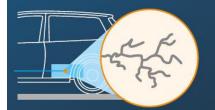


PETRA IV – Research for Sustainability

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

Future trend: long-lasting solar cells and new batteries

Improve solar cell and battery materials: PETRA IV will make it possible to optimize the electronic structure of materials of solar cells and batteries. This can be accomplished by using atomic-level imaging and spectroscopy to follow the processes of energy transfer in specialised materials, so improved versions can be built from the ground up. This could enable longer lasting and more efficient energy generation and storage.





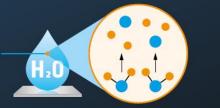
Future trend: plastic alternatives

Plastics as we know them are almost entirely derived from fossil fuels. Reasonable alternatives are on the doorstep: cellulose nanofibres derived from wood make for a sustainable version of our everyday plastics. However, the production of these fibres is still complex and time-consuming since the individual fibres are 10,000 times thinner than a human hair. Using the light from PETRA IV, the production process can be followed in much greater detail. Since PETRA IV will enable measurements to be made 100 times faster than before, the movement towards a market-ready alternative will also be faster. The cellulose fibres can also be used for textiles and packaging, as a matrix for construction composites.

Deutsches Elektronen-Synchrotron DESY Notkestraße 85, 22607 Hamburg

Future trend: green hydrogen

Currently, the processes for generating hydrogen fuels are not sustainable, as they are most commonly produced using methane. By using PETRA IV to examine water-splitting reactions in nature and understand at the atomic level how they progress, we can develop more efficient processes by better understanding photochemical reactions – for example, how plants accomplish the same process, without the use of fossil fuels.







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Thank you for your attention!



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