iFAST Open Steering Committee, Nov 16, 2021

Mike Seidel, PSI/EPFL

WP11 Overview

task 1: **Sustainable Concepts for RIs**: networking, workshops on selected topics
deliverable: report

1) System Efficiency of Accelerator Concepts (N.Catalan Lasheras, CERN)
2) Key Technologies and Components for High Efficiency (C.Martins ESS)
3) Cross Linking Accelerator R&D with Industrial Approaches (P.Spiller GSI)
4) Ecological Concepts (D. Voelker DESY)

task 2: **High Efficiency Klystron** (O.Brunner CERN, THALES, ULANC)

- deliverable: industrial prototype
- replacing klystrons in LHC

task 3: **Permanent Combined Function Magnets for Light Sources** (B.Shepherd, UKRI, DLS, KYMA, DESY)

- deliverable: magnet prototype, applicable for Diamond upgrade,PETRA-4
- several advantages of permanent magnets, not just power consumption

Task 1.1: System Efficiency of Accelerator Concepts

Nuria Catalan Lasheras (CERN) overtook from Erk Jensen (CERN)

- **Workshop on Efficient RF Sources** to be held the first week of **July 2022 in Switzerland** (TBC).
- Around 50 participants expected
- aim of the workshop and rough program (still under discussion)
  - Set the RF sources in perspective against the global accelerator energy consumption
  - world efforts towards system efficiency for
    - Pulse generation
    - Klystrons
    - Solid state amplifiers
    - Magnetrons
    - IOTs
    - Distribution system losses
    - …

Build a power usage model for a “generic” accelerator.

- differentiate energy consumption per system: (RF power, Cryogenics, Magnets, Cooling and ventilation, other infrastructure)
- Mine data from existing machines and different operating conditions

- Design a parametric model based on realistic efficiency of (AC/CD conversion, Klystron, cryogenics, etc)
- Systems weight will depend on actual accelerator (Linac, synchrotron, RCS, ERL, etc)

- Final figure of merit is different depending on the application (Beam power on target, luminosity, synchrotron radiation power, etc)
- Optimization can be done for future machines

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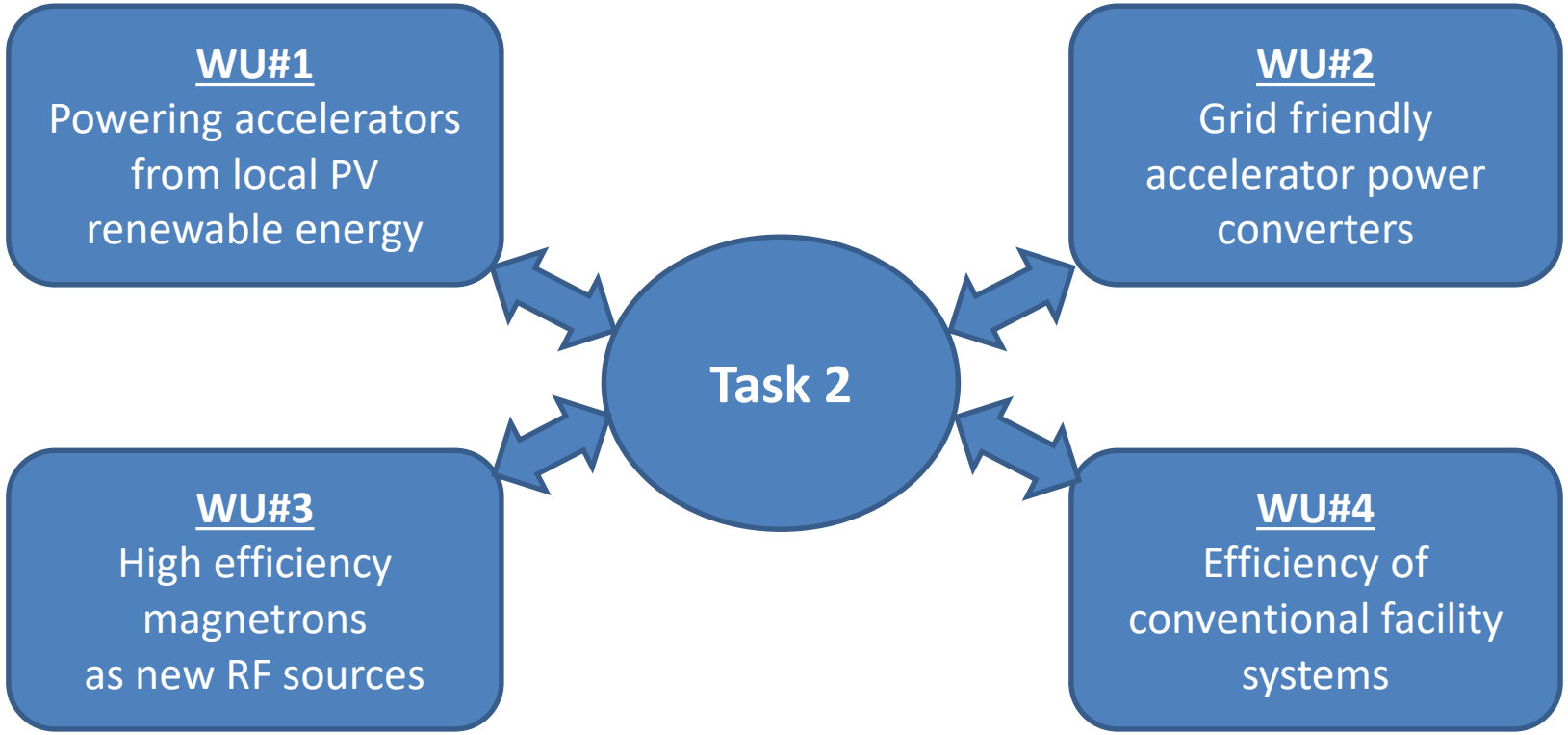
[Nuria Catalan Lasheras]

Task 1.2: Key Technologies and Components for High Efficiency (Carlos Martins, ESS)

- Assess the relevance of particular technologies in typical applications
- Identify important R&D directions together with their challenges and opportunities
- Quantitative assessment of the achievable gains for certain technologies
- Review of state of the art and best practices from different accelerator facilities



Workshop "Key technologies and concepts for high efficiency" in Spring 2024

Powering accelerators from local PV renewable energy

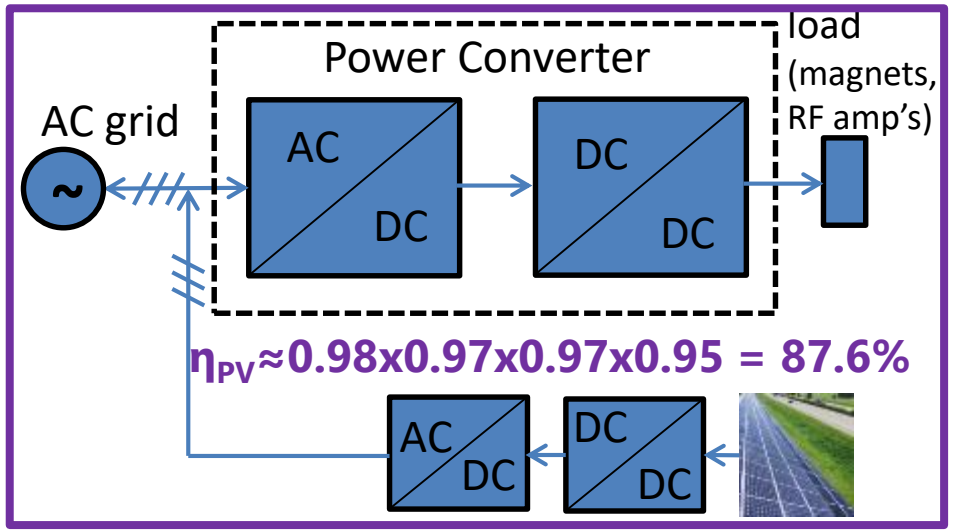
Concept:

- Install PV panels near accelerators' "wasted land";
- Connect them to main power converters for accelerator magnets or RF amplifiers, using high efficiency DC/DC converters;
- AFE's can redirect the PV energy back to the AC grid when accelerator not running;
- Up to 15-20% renewable energy utilization possible with no transmission losses and high conversion efficiency;
- Lower capital cost & lower payback time;

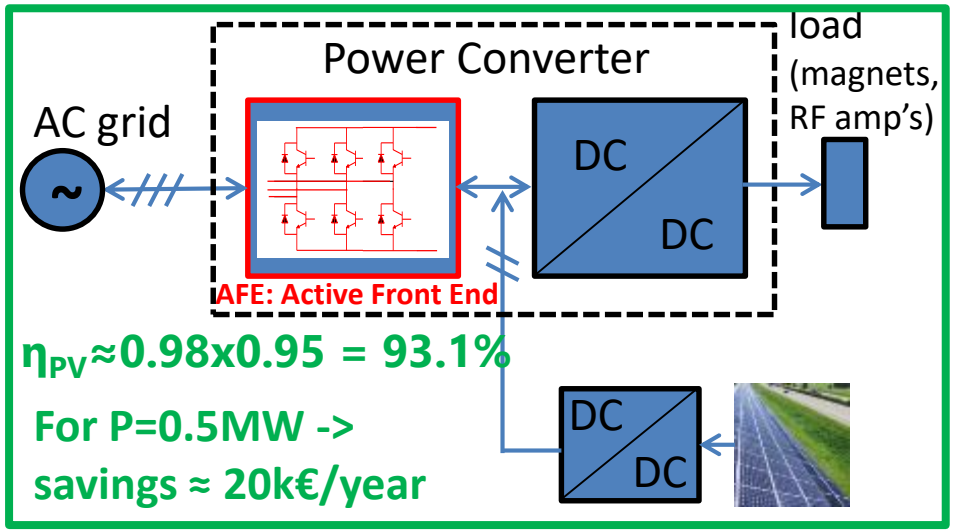
Objectives:

- Feasibility study for ESS case: up-to 2MW installed PV injected into the Linac RF klystron modulators;
- MSc thesis with Lund University (starting Feb. 2022);

Conventional scheme:
PV injected into the AC grid (4 stages)



New scheme:
PV injected into power converters (2 stages)



[C. Martins]

Task 1.3: Cross Linking of Accelerator Facilities and Technologies with Industrial Approaches (GSI, P.Spiller)

Fostering “Dual-Use”: Developments for Accelerators applied to Energy Systems. Strengthening the communication with industry to evaluate potential collaborations, support developments and to attract interest.

Accelerator Technologies	Energy Systems
Development of (intermediate) **energy storage technologies** (e.g. fly wheels, capacitive or s.c. magnetic energy storage systems) for e.g. cheaper accelerator power converters.	Technologies for minimizing power grid interaction (disturbance) by energy intensive industries. Vice versa: Increasing independence of accelerator facilities and energy intensive industry from power grid fluctuations.
Development of a improved **HTS tapes and new s.c. cables** for next generation of fast ramped s.c. magnets.	Application of new HTS tapes in new s.c. cables for s.c. transmission lines or s.c. magnetic energy storage.
Protection of superconducting magnet strings by **DC circuit breakers**.	Protection of superconducting energy systems, e.g. s.c. transmission lines, s.c. magnetic energy storage or photo voltaic energy systems.
Development of diagnostic **technology for detecting defects** (synthetic TDR) in s.c. bus bar systems and in long accelerator cables.	Detection of defects in km long underground power cables.
Control of electrical power of large IT infrastructures in reasearch centers and operation of cryogenic plants	Provision of controlling power/balancing power for damping fast fluctuations in power grids.

DC ciruit breaker for s.c. magnet strings

HTS Energy Applications Study (GSI)

- GSI and IEE have been investigating use cases for HTS CORT cables (from WP8.6) beyond the the use in fast-ramped magnets
- The two-step study is ongoing:
  - A broad “brainstorming” has been conducted based on available literature
  - Investigation of 1-2 applications in detail

Applications have been split into broad categories:

- Science
- Energy
- Industry
- Transport
- Medicine

As a first indication for market potential, applications have been evaluated by their estimated conductor requirements

Application	Application field	Tape use in typical single unit [km]	Potential request [units/year]	Potential for HTS tape use [km/year]
Current Leads/Magnet Feeders	Science	0.1	100	10
Fault Current Limiters	Sciece/Energy	10	20	200
High Field/Fusion	Energy	100000	0.25	25000
Induction Billet Heaters/ Magnetic Separation	Industry	10	5	50
Magnetic Energy Storage	Energy	200	1	200
Particle Accelerators/ Particle Therapy	Science, Medicine	10	100	1000
Power transmission cables	Energy	100	5	500
Rotating Machines	Energy, Transport	20	50	1000
Transformers	Energy	5	5	25
Wireless Energy Transfer	Transport	5	100?	500?
MRI/NMR	Medicine	50	100	5000

[P. Spiller, T.Winkler]

Task 1.4: Ecological Concepts (DESY, Denise Voelker)

Focus 1: Materials for high-tech components

- i.e. rare earths for permanent magnets (PM)
- Pro: PM save energy
- Contra: rare earths needed for PM mined and processed under destructive social and environmental conditions
- no alternative sources or certified mining and processing available
- industry has same challenge ahead (i.e. wind power stations)
- Idea: combine forces and push for EU/global certification system

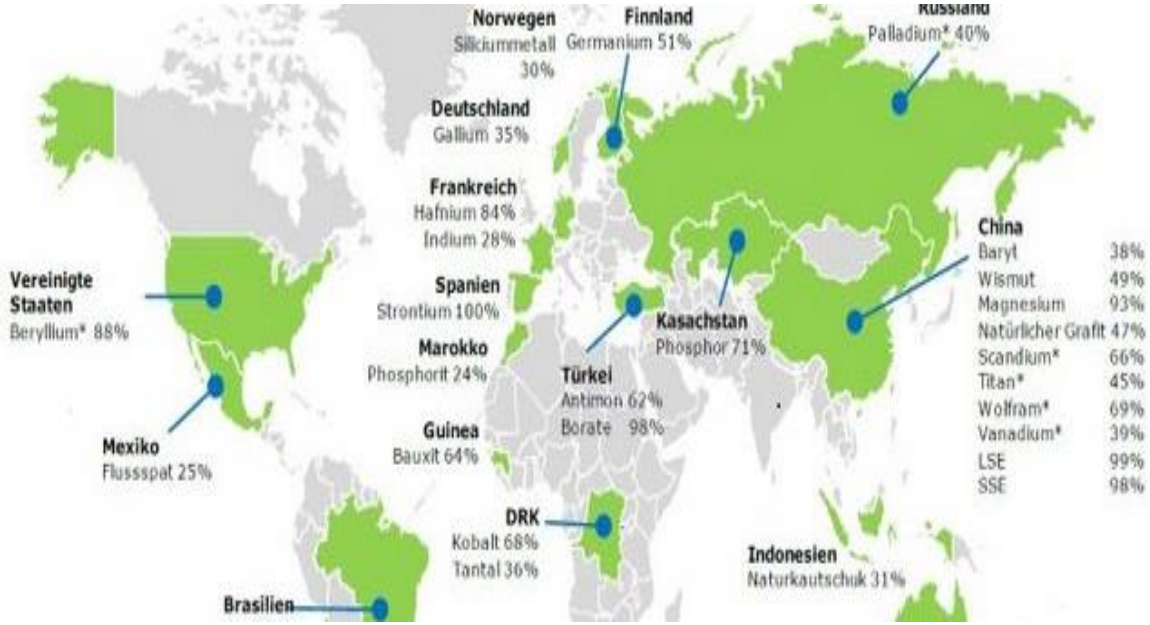
→ Currently investigation on social and environmental impacts of mining and processing for the specific materials needed for PM in close cooperation with NGOs

→ Next step: approach industry

→ Workshop planned for Nov/Dec 2022

Source countries for rare elements

https://www.springerprofessional.de/rohstoffe/ressourceneinsatz/eu-will-kritische-rohstoffe-fuer-die-industrie-sichern/18628620



Task 1.4: Ecological Concepts (DESY, Denise Voelker)

- Focus 2: Life cycle management
  - Consider entire life cycle of machines and components meaning construction – running – deconstruction
  - lower operation cost justify higher investment cost, not to forget costs for decommissioning
  - Currently questions of deconstruction are not enough considered in accelerator development
  - To lose high level materials is not only an ecological but also an economical problem
  - Idea: find best practice for recycling of these materials and save money
  - implement life cycle management already in planning phase of new RIs

  → Currently identification and contact of experts on technical life cycle thinking

  → **Workshop planned for Nov/Dec 2022**

Example: Old shielding stones being shredded and used again for foundation of new buildings on campus (DESY)

Appendix: Milestones & Deliverables

Schedule of relevant Milestones

Milestone number[18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification	
MS50	Workshop on energy for sustainable science at research infrastructures, at ESRF	41 - PSI	6	Web site (task 11.1)	ESSRI Grenoble, J.P. Revol et al, prep ongoing! 17/18 March , 2022; [Link, reserve the date]
MS51	Workshop on efficient RF sources	1 - CERN	13	Web site (task 11.1)	July 2022
MS52	Workshop on efficient magnet- and RF power supplies	2 - ESS	22	Web site (task 11.1)	April 2023
MS53	Workshop on sustainable materials and lifecycle management for accelerators	12 - DESY	18	Web site (task 11.1)	December 2022
MS54	Workshop on industrial approaches for sustainable accelerators	13 - GSI	42	Web site (task 11.1)	December 2024
MS55	Design review	1 - CERN	12	Web site (task 11.2)	June 2022
MS56	Magnets constructed and tested	25 - KYMA	25	Magnetic measurements completed (task 11.3)	July 2023

Deliverables related to WP11	
D11.1: Sustainable Accelerators Report. *Report on strategies to improve sustainability and reduce environmental impact of accelerators.*	M45
D11.2: Klystron prototype completed and validated. *Report on the construction of the klystron prototype and on the test results.*	M36
D11.3: Prototype adjustable PM quadrupole and combined function magnets. *Two prototype PM-based magnets one quadrupole and one combined-function magnet designed, built and measured.*	M28