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Greening for Bosons

Thomas Parker

Head of Energy Division

European Spallation Source

The 55th ICFA Advanced Beam Dynamics Workshop

on High Luminosity Circular e+e- Colliders – “The Higgs Factory”

Beijing, October 9-12, 2014

WG10 Green Higgs factory

Science - Technology - Energy

New levels of scientific knowledge
have often been reached
as a result of technological breakthrough.

Telescopes and accelerators
are examples of
Research Infrastructure.

For each level of scientific breakthrough,
the requisite infrastructure
tends to need more and more energy.

Galileo’s telescope

Society's decision to invest in science

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Value of Science

Knowledge

Applications

Externalities, e.g. clusters

Cost of Science

Investment

Operations

Externalities, e.g. environmental impact

Each new accelerator project must show that it will contribute more good (sustainability) than it will cost.

World sustainability challenges

Population growth in the world combined with higher living standards and a changing climate put increasing pressure on equitable access to life essentials such food, water, energy and an acceptable living environment.

Energy use has adverse environmental effects, contributes to energy poverty, and competes with food production.

Sustainability for accelerators

Accelerators and energy are connected in all three aspects of sustainability.

Environmentally

Financially

Socially

Negative effects on the environment from the increased energy production.

Accelerator facilities may need to secure the research activities from negative effects of energy price fluctuations.

Accelerators may compete for space and energy and other resources with sustainable food production, marginally exacerbating scarcity and price volatility.

Greening at ESS

Spallation Source of Neutrons

17 partner countries in Europe

First cornerstone today!

World's brightest neutron source,
at full capacity 2025

5 MW linear proton accelerator

Rotating tungsten target

Long pulse

Online 2019

Example of an argument of the sustainability value of an accelerator

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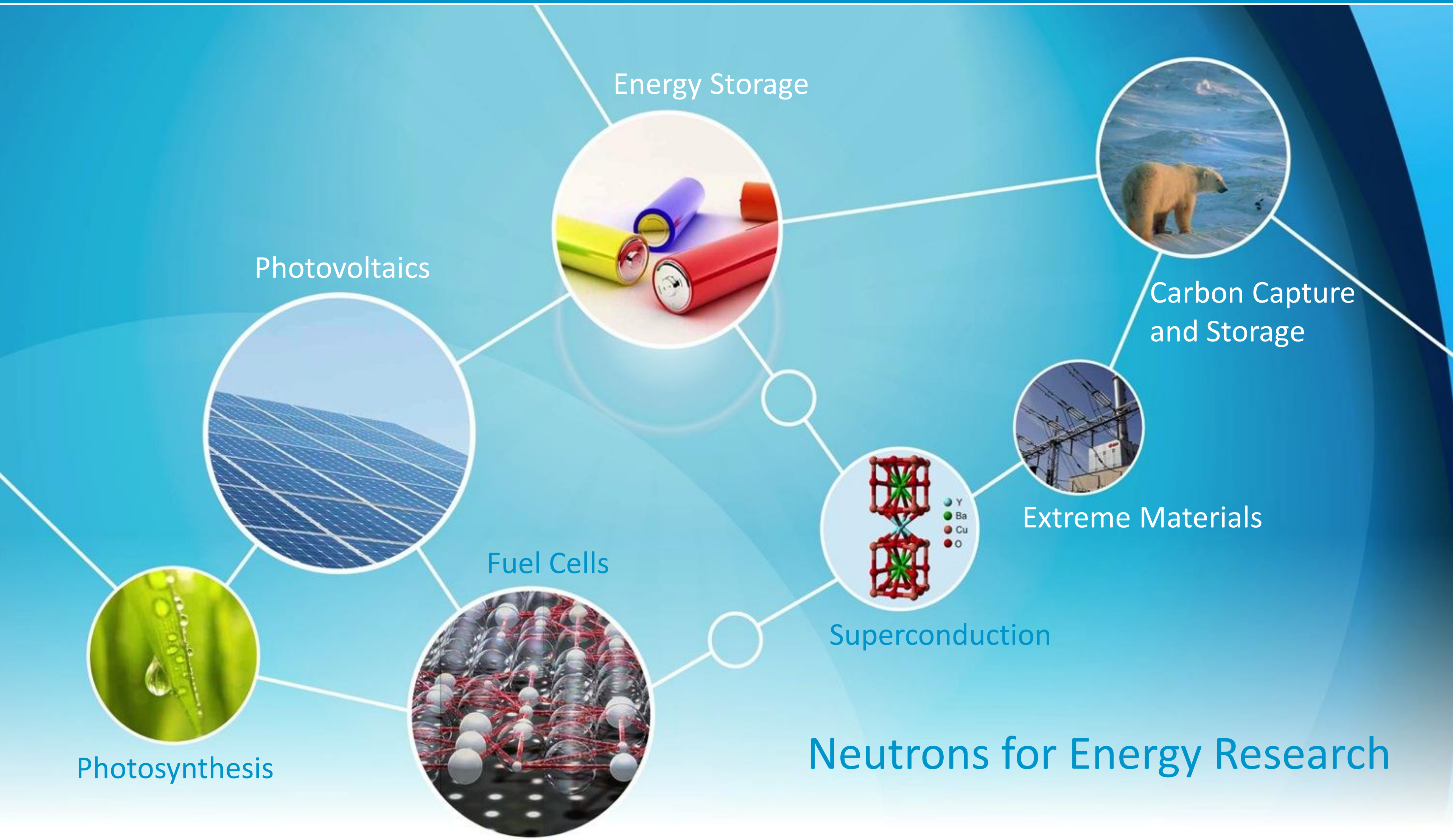
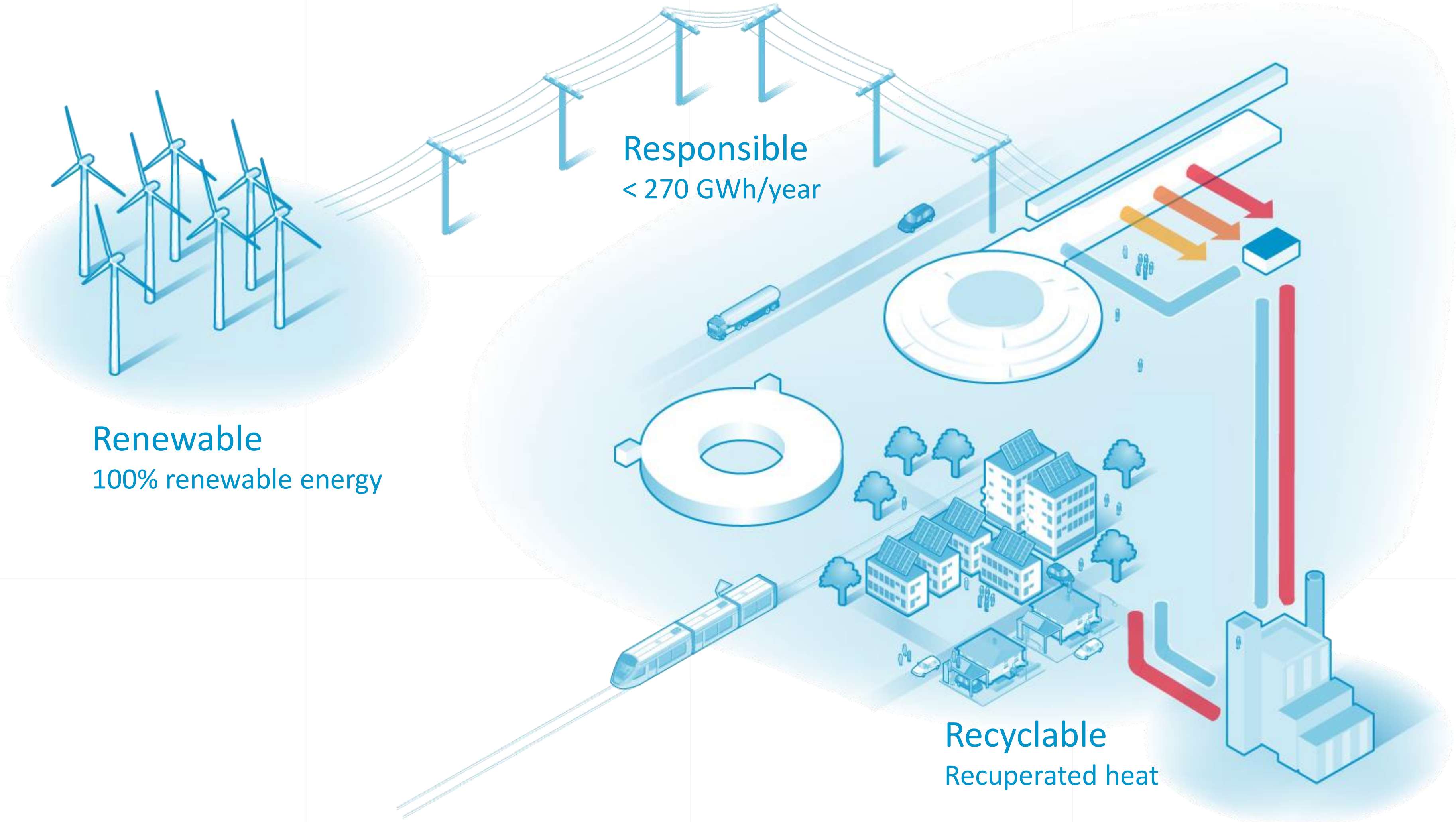


Responsible – Renewable – Recyclable



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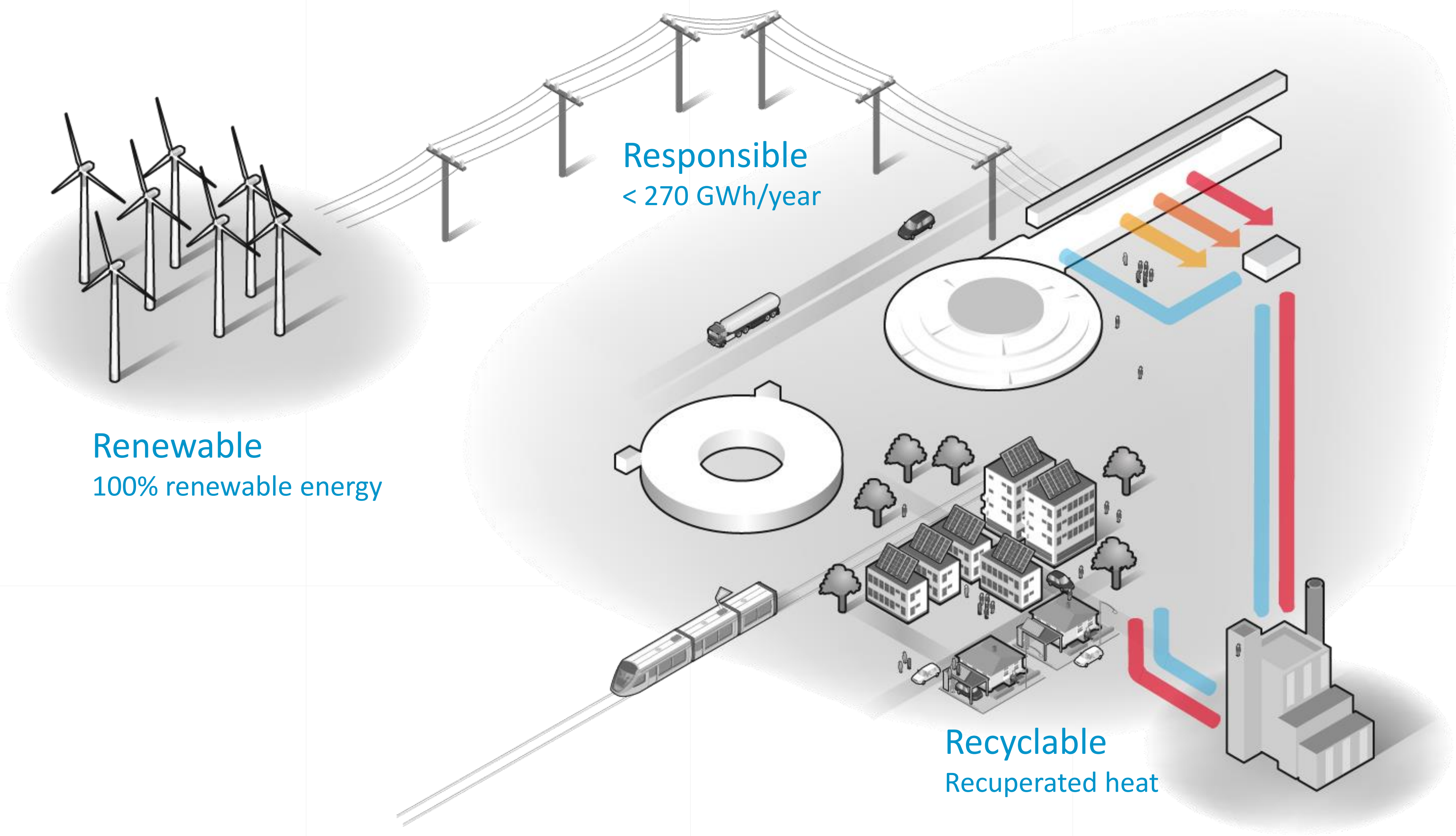

Responsible

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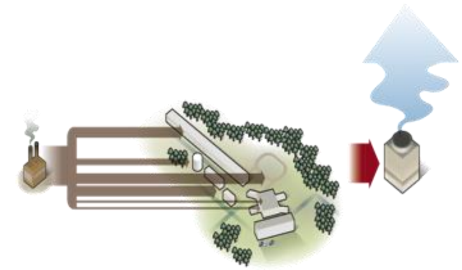
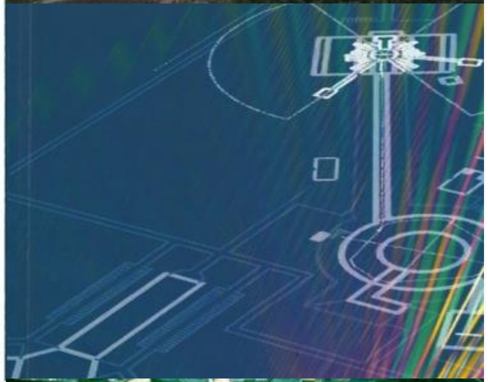
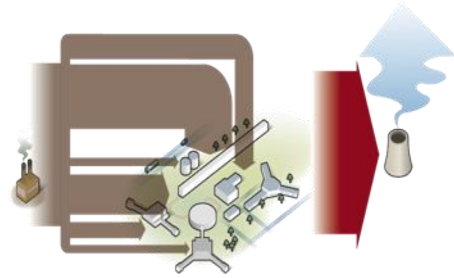
Spallation Neutron Source, USA,
1 MW beam on target, 150 GWh in,
140 GWh out, cooling towers

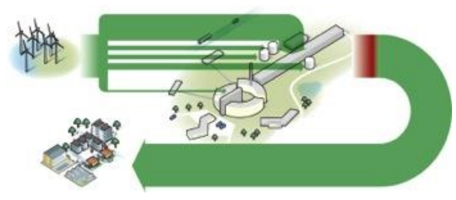


ESS Pan-European Project 2002,
5 MW beam on target, 610 GWh in,
580 out through cooling towers





ESS 2014, 5 MW,
265 GWh in 253 GWh
recycled to district heating



Responsible

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Electricity	GWh	MW max power
Accelerator	119	18
Target	21	3
Cryo	44	6
Buildings	7	1
Instruments	11	1
Control systems	3	0
Heat Pumps	60	8
TOTAL	265	

Heat	GWh	Electricity needed to cool with district heating (GWh)
Low	73,5	35 = 16 (low to medium) + 19 (medium to high)
Medium	91	25 (medium to high)
High	88,5	0
Total	253	60

265 GWh corresponds to the annual electricity consumption of

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40 769 apartments

10 600 houses

3 312 500 smartphones

664 234 washing machines

46% of the annual consumption of the Smurfit Kappa paper mill in Piteå

Renewable

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100% renewable energy

Electricity only,
all heating demand with recuperated heat,
district heating as back-up

Worlds most liberalized energy market,
choose from hundreds of suppliers

Power purchase

Public procurement

Google model

Long-term purchase,
done sufficiently in advance to allow new,
dedicated production to compete

Market mechanisms and regulation
steer towards the right choice

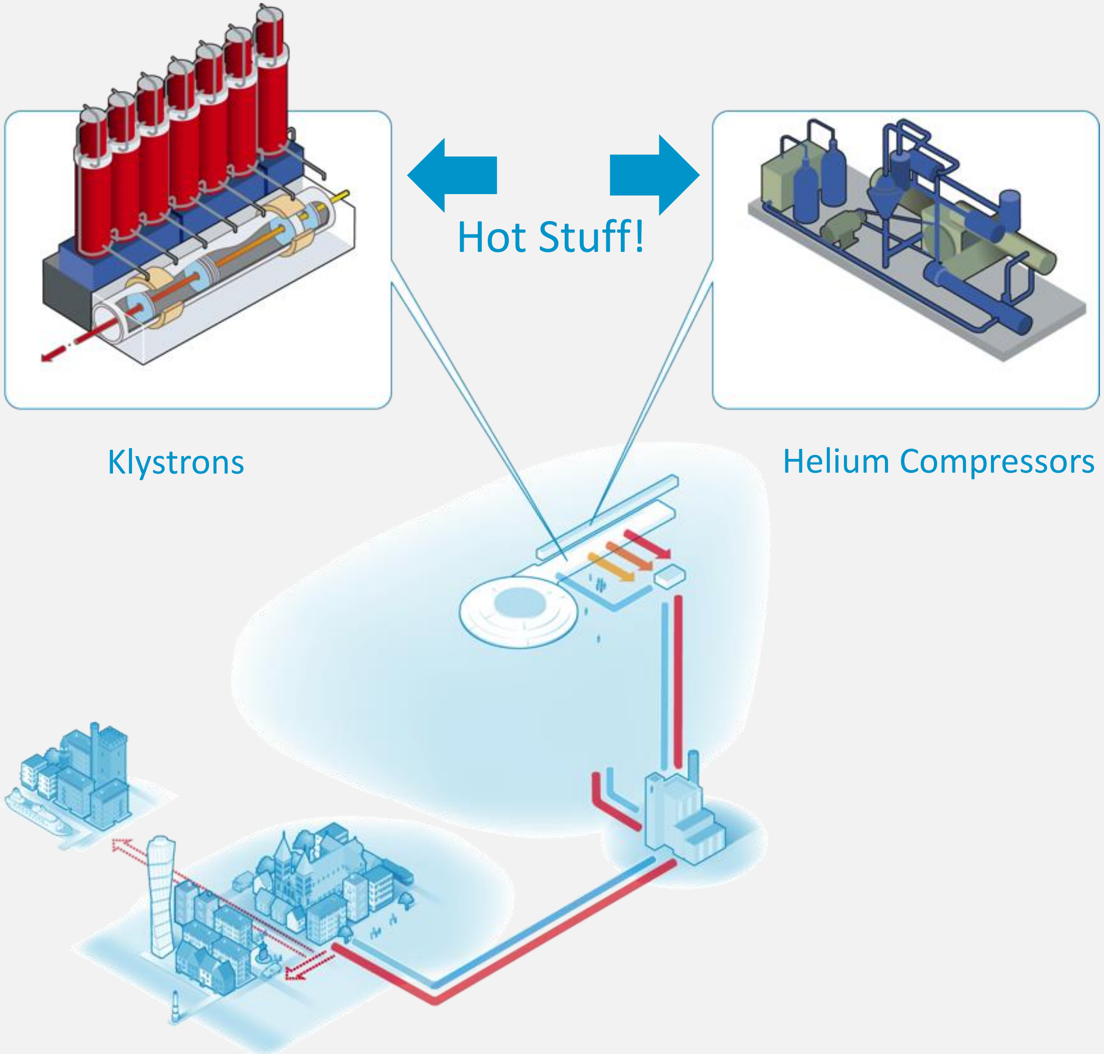
Recyclable

Science gives heat

Temperature is Money

(2nd law of thermodynamics for managers)

Money gives science



Recyclable

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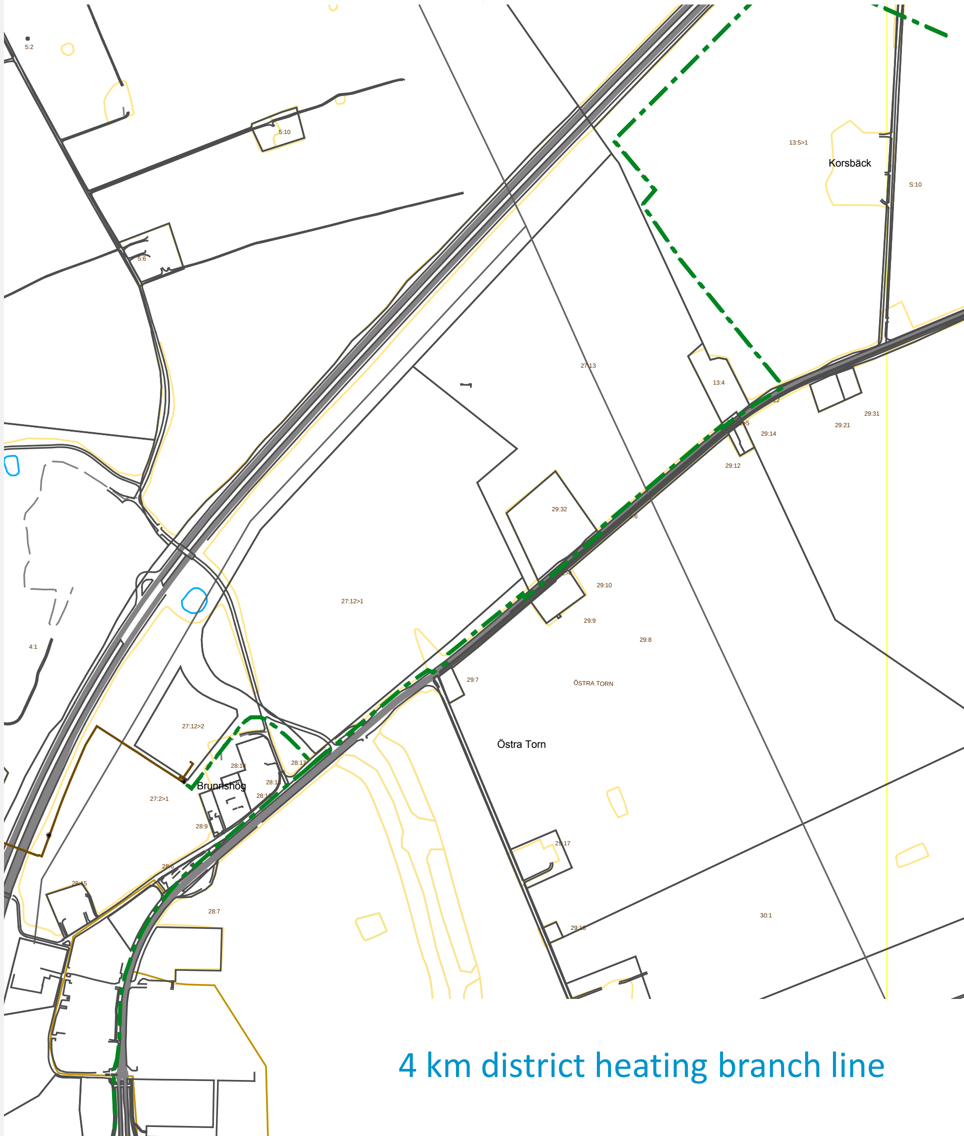
Agreement
with the local district heating company Kraftringen for connection to the district heating system, purchase of surplus heat, and back-up heat supply.

5 M€
investment to connect.

Commitment
from Kraftringen to accept all generated heat.

Full recycling
to district heating would at full operation mean a revenue of up to 5 M€ per year to ESS.

Cooling
with district heating requires 80° C heat and gives 50°C back. Heat pumps are needed for lower-temperature cooling.



4 km district heating branch line

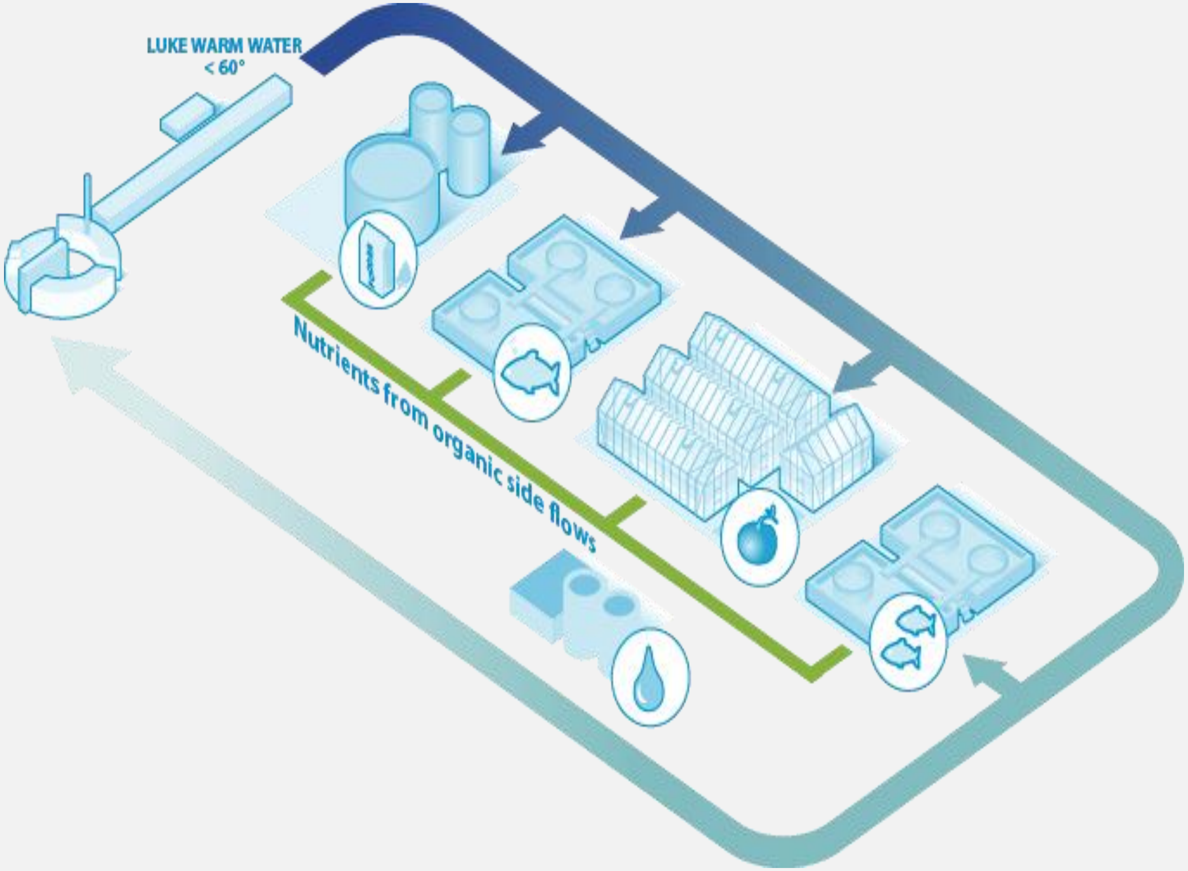
Recyclable

Low temperatures

can be used for food production with greenhouses fish farming and fermentation with microbes.

Similar revenue to ESS,

lower costs, lower energy use, increased food security and quality, improved land and sea environment.



Remarkable yet Replicable

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Contribute to sustainable development

Save and earn money

Comparable to power-intensive industry, such as pulp and paper, which is common in the Nordic region

Open for study

Industrial symbiosis

Low-temp heat enables solar and geothermal

Energy leadership

Industry and Science

Additionality

Dependent on local conditions

W o r l d w i d e   a t t e n t i o n

Solar and geoheat next

Energy for Sustainable Science Workshops

CERN

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ERF European Association of National Research Facilities
Open to International Access

2nd Workshop
Energy for Sustainable Science
at Research Infrastructures

CERN, GENEVA, SWITZERLAND 23-25 OCTOBER 2013

Main findings of the first joint workshop on Energy management for large-scale research infrastructures

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"Research Infrastructures (RIs) are at the centre of science-driven technological, educational and managerial **innovation**. They are instrumental for R&D in the energy field, for instance through **development** of advanced materials and energy efficient processes and products (e.g. photovoltaic, fuel cells, catalysers);

Despite severe budget constraints, the operation of RIs demonstrates that more **exchange** of best practices, more **cooperation** in joint projects and training are possible and can be started on technical as well as on administrative levels, especially **new business models** in close interaction with providers e.g. on grouped procurement or grid connection;

…

RIs can particularly **train** young researchers, operators and managers to face the upcoming energy challenges in order to cooperate on R&D, exchange on best practices and provide know-how; a program similar to the RAMIRI2 scheme could further foster cooperation and **education** on energy themes among the European RIs;

The workshop has shown that several RIs are able to mobilize their unique resources and technical skills to respond to the Energy Grand Challenge and can already act as a **test bed** for implementing appropriate energy supply and procurement schemes as well as efficient energy use. There is a strong consensus that this can be expanded to help further develop and demonstrate methods and techniques for the sustainable use of energy. "

Proposals

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Continued and intensified interactions

between laboratories and projects both in dedicated fora like the “Energy for Sustainable Science” workshop series and in conjunction with other interaction, such as this conference.

Development of benchmarks

such as energy delivered / energy used
to show progress in accelerators.

Worldwide collaboration

on accelerator efficiency.

Showcase successful projects

in laboratories across the world.

intensified interactions

“Energy for Sustainable Science”

benchmarks

workshop series

w o r l d w i d e c o l l a b o r a t i o n

accelerator
efficiency

Conclusions for the Higgs Factory

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An energy program is now expected.

"Responsible, Renewable, Responsible"
is neither perfect nor universal, but a benchmark
for future development and may be useful to showcase.

Energy efficiency must be the primary objective.
The total efficiency of accelerators is not impressive.

Major improvements
can usually only be made before the facility is built,
with the combined strength of design flexibility and buying power.

How to do heat recycling

- Don't. Efficiency – avoid creating the heat.
- 2nd law. High temperature cooling.
- Create uses of low grade heat.

Energy for Sustainable Science

Join the movement for sustainable science

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Time for comments and questions.

Thomas Parker
Head of Energy Division
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