Summary: Energy Management at RIs

- Summary of sessions A1 and A2 (subjective?)
- Many technical details were treated in other sessions

- Highlights of talks
  - Examples to follow
  - Specific for an RI
  - Global for the field
- (personal) Conclusions

2nd Workshop
Energy for Sustainable Science
at Research Infrastructures

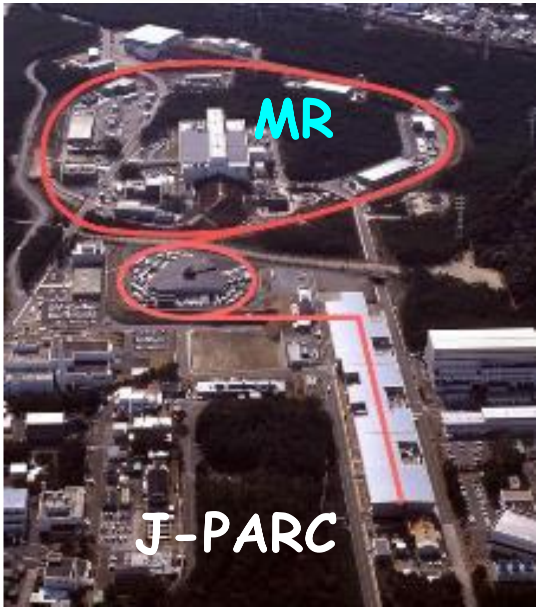
CERN, GENEVA, SWITZERLAND, 23-25 OCTOBER 2013

Energy Management at KEK, Strategy on Energy Management, Efficiency, Sustainability

Atsuto Suzuki (KEK)

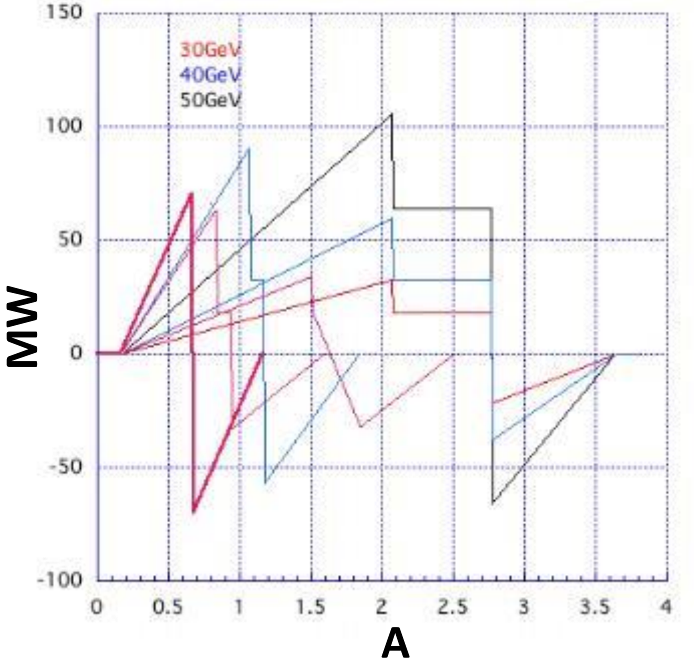
INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

Energy Storage for Power Fluctuation Compensation at J-PARC MR



Power Amplitude of J-PARC-MR Operation Cycle

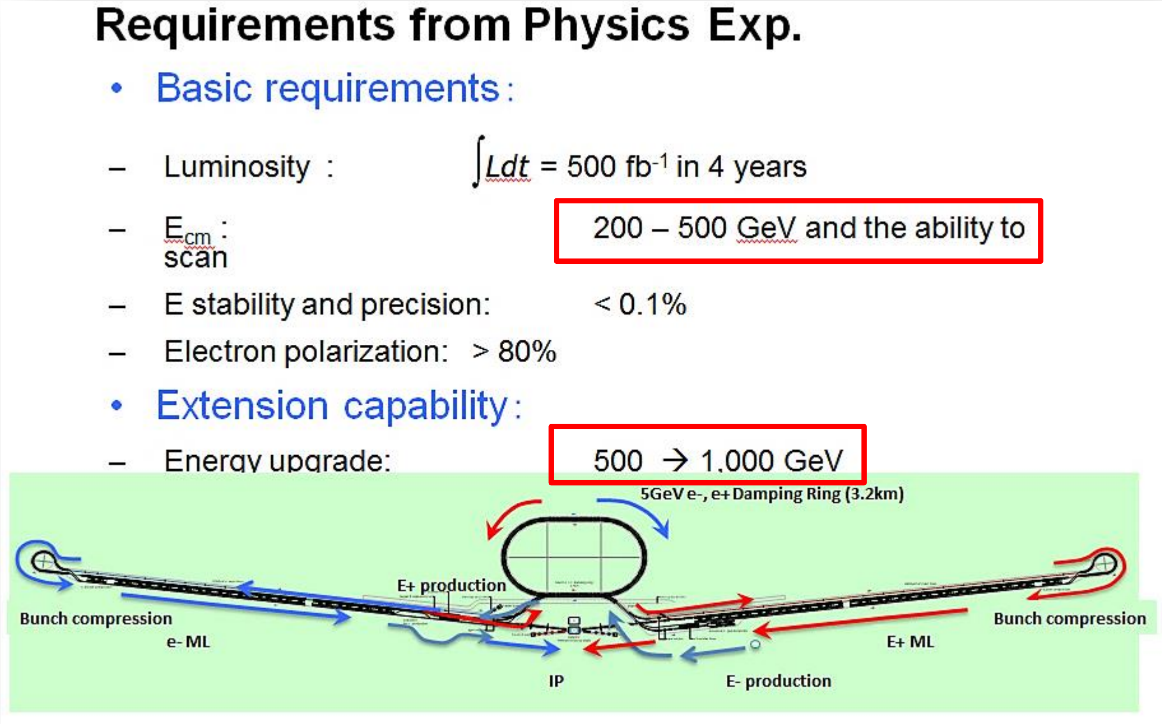
(1 – 4 sec. cycle)



	J-PARC MR
Reputation (sec.)	3.64
Power (MW)	105
Line Voltage (kV)	66/22/6.6
Compensation Type	Fly Wheel : 51 MVA
	SMES : 90 MVA

Developing new MGs with large capacitor energy storage: F. Kurimoto's talk

Power Balance of Consumption and Loss in ILC



Requirements from Physics Exp.

- Basic requirements :
  - Luminosity : $\int Ldt = 500\ \mathrm{fb}^{-1}$ in 4 years
  - E_{cm} : 200 – 500 GeV and the ability to scan
  - E stability and precision: < 0.1%
  - Electron polarization: > 80%
- Extension capability :
  - Energy upgrade: 500 → 1,000 GeV

ILC 500 GeV Total Power : ～200 MW

Improve efficiency

	loss rate
Infrastructure : 50 MW	50 % : 25 MW
RF System : 70 MW	50 % : 35 MW
Cryogenics : 70 MW	90 % : 60 MW
Beam Dump : 10 MW	100 % : 10 MW
200 MW	～ 130 MW

Obligation to Us

Increase recovery

Present Status of R&D

Target

proof-of-principle of CPD in the unsaturated region (a maximum rf power of 500 kW) using a KEKB 1.2MW-klystron

R&D Schedule

2013.3: Modification of an existing klystron to CPD klystron (already done)

2014.3: until then, preparation and commissioning of the test station

~2014: Verification of klystron operation without CPD

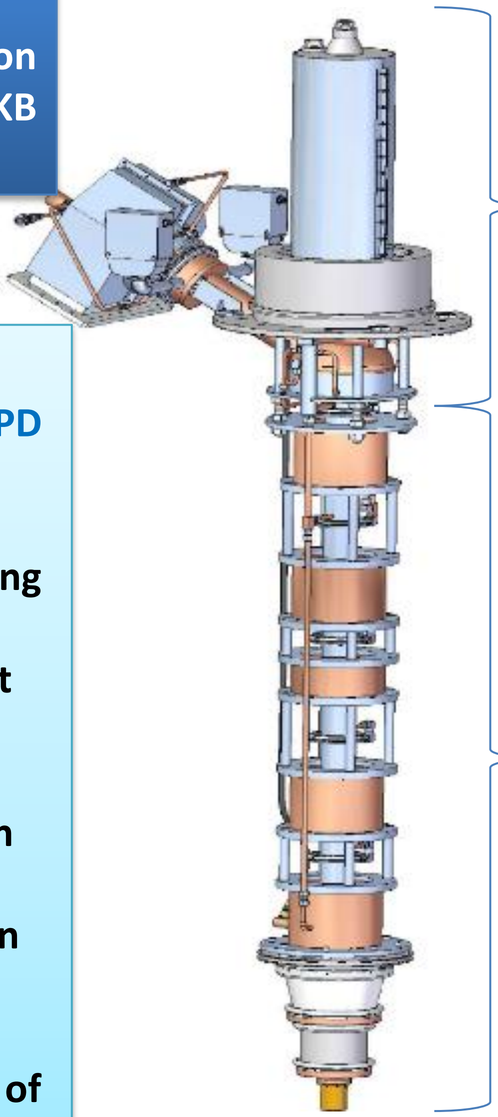
~2015: Measurement of rf leakage from the gap between the body column and the collector (with no CPD voltage applied)

Measurement of induced pulse voltage on the collector with CPD

~2017: Test of rectification by Marx circuit

Integration test of the proof-of-principle of CPD operation

80 % efficiency



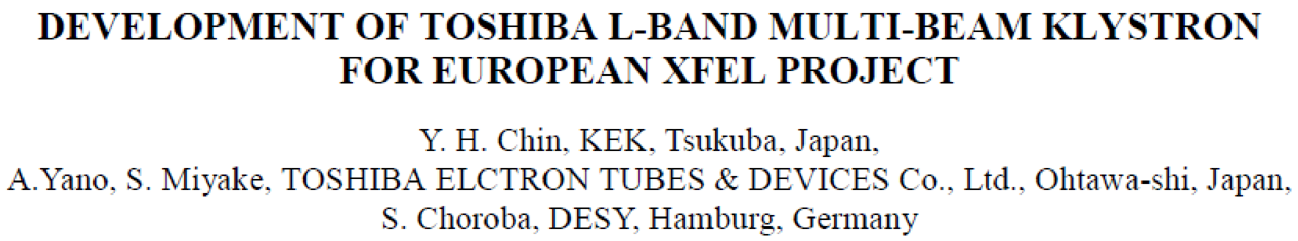
Newly fabricated components

- collector
- ceramic insulator
- output cavity
- output coupler

Recycled components

- electron gun
- input cavity
- intemediate cavities

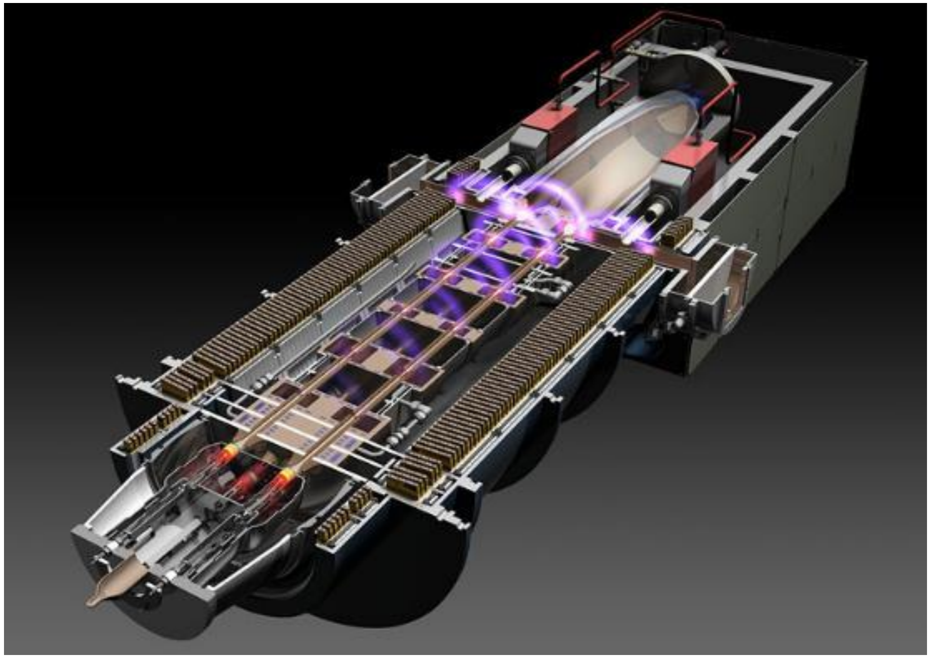
Multi(6) – Beam Klystron (MBK) for 26 Cavities for ILC



DEVELOPMENT OF TOSHIBA L-BAND MULTI-BEAM KLYSTRON
FOR EUROPEAN XFEL PROJECT

Y. H. Chin, KEK, Tsukuba, Japan,
A.Yano, S. Miyake, TOSHIBA ELCTRON TUBES & DEVICES Co., Ltd., Ohtawa-shi, Japan,
S. Choroba, DESY, Hamburg, Germany

- **The design goal is to achieve 10 MW peak power with 65 % efficiency at 1.5 ms pulse length at 10 Hz repetition rates.**
- **MBK has 6 low-perveance beams operated at low voltage of 115 kV for 10 MW to enable a higher efficiency than a single-beam klystron.**



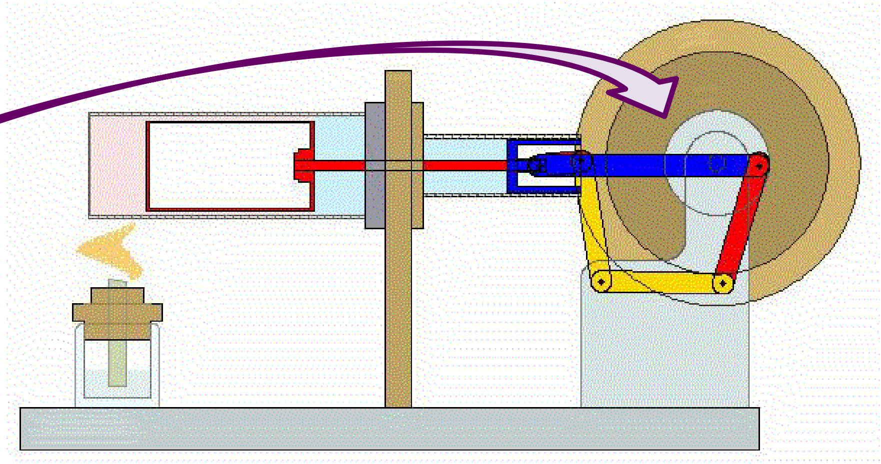
e 2: Electron Gun of the E3736.

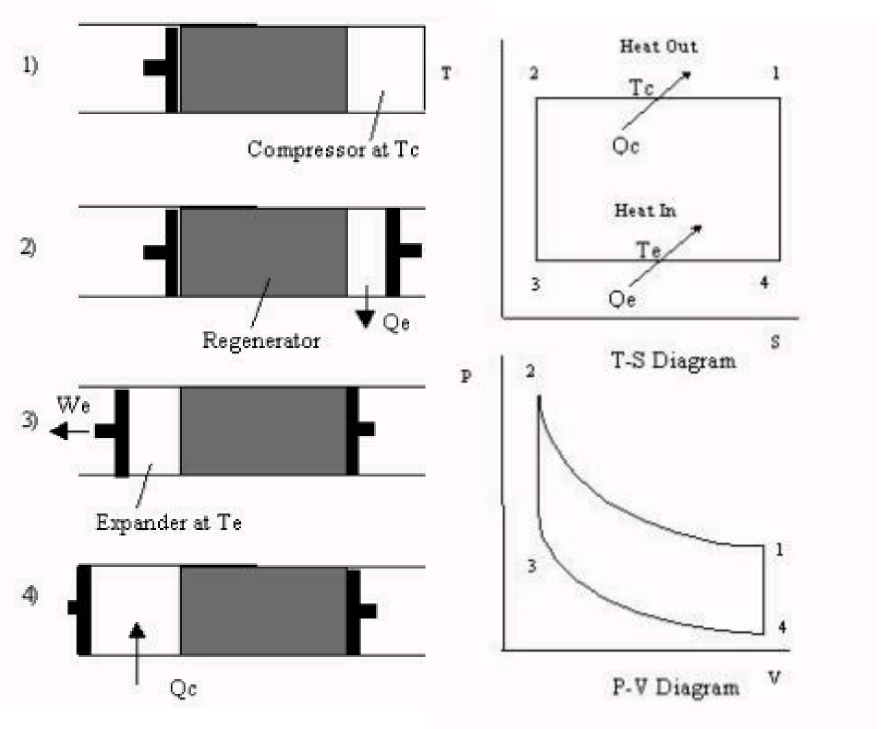
Frequency	1.3 GHz
Peak power	10 MW
Pulse width	1.6 ms
Rep. rate	5 Hz
Average power	78 kW
Efficiency	65 %
Gain	47dB
BW (- 1dB)	3 MHz
Voltage	120 kV
Current	140 A
Lifetime	40,000 h

2.2 How to Save Power in Cryogenics

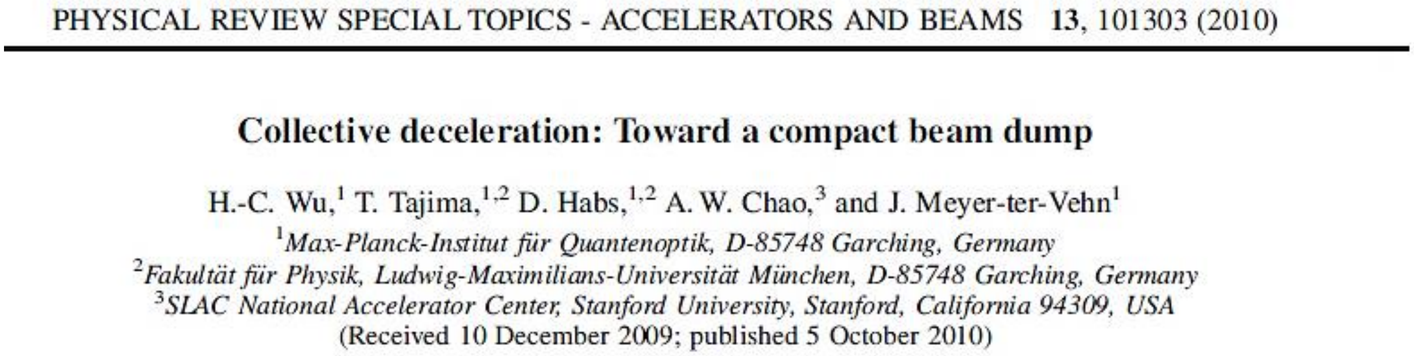
Cryogenics/Stirling Cryocooler

- High temperature operation
  - Klystron collector
  - RF Dummy load





Plasma Deceleration Dumping



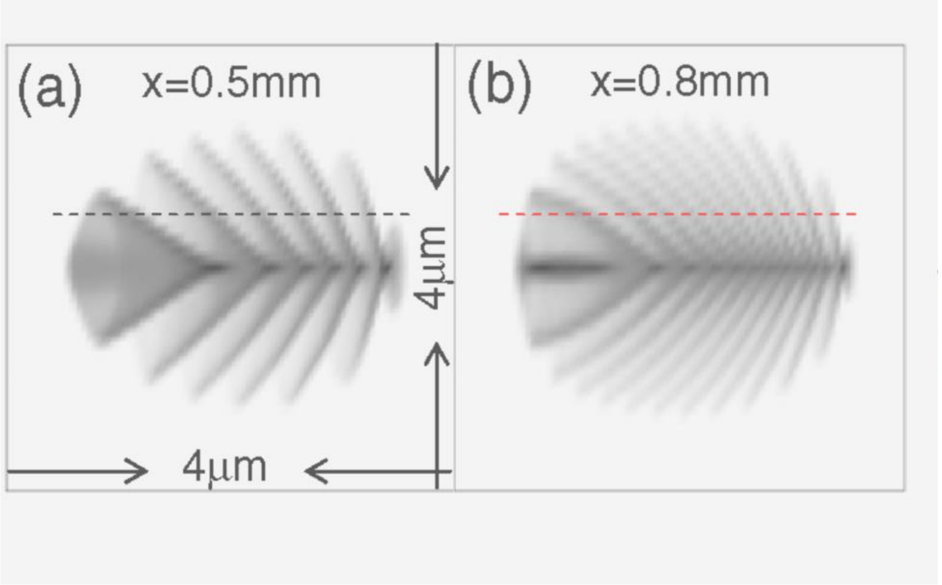
PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **13**, 101303 (2010)

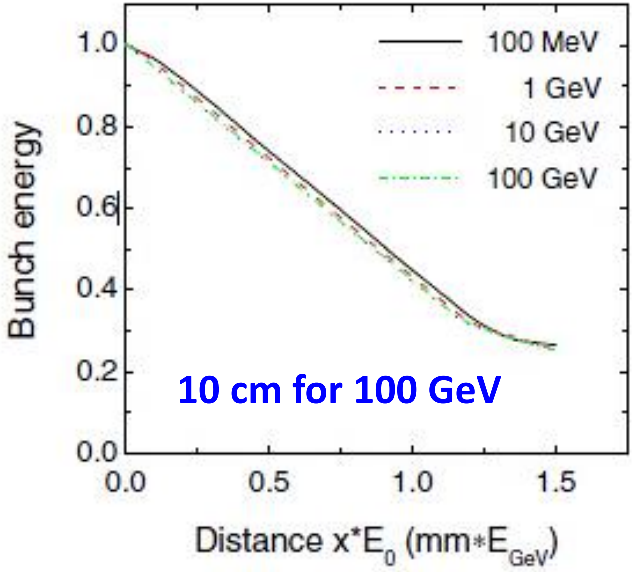
Collective deceleration: Toward a compact beam dump

H.-C. Wu,[1] T. Tajima,[1,2] D. Habs,[1,2] A. W. Chao,[3] and J. Meyer-ter-Vehn[1]
[1]*Max-Planck-Institut für Quantenoptik, D-85748 Garching, Germany*
[2]*Fakultät für Physik, Ludwig-Maximilians-Universität München, D-85748 Garching, Germany*
[3]*SLAC National Accelerator Center, Stanford University, Stanford, California 94309, USA*

(Received 10 December 2009; published 5 October 2010)

Use Collective Fields of Plasmas for Deceleration

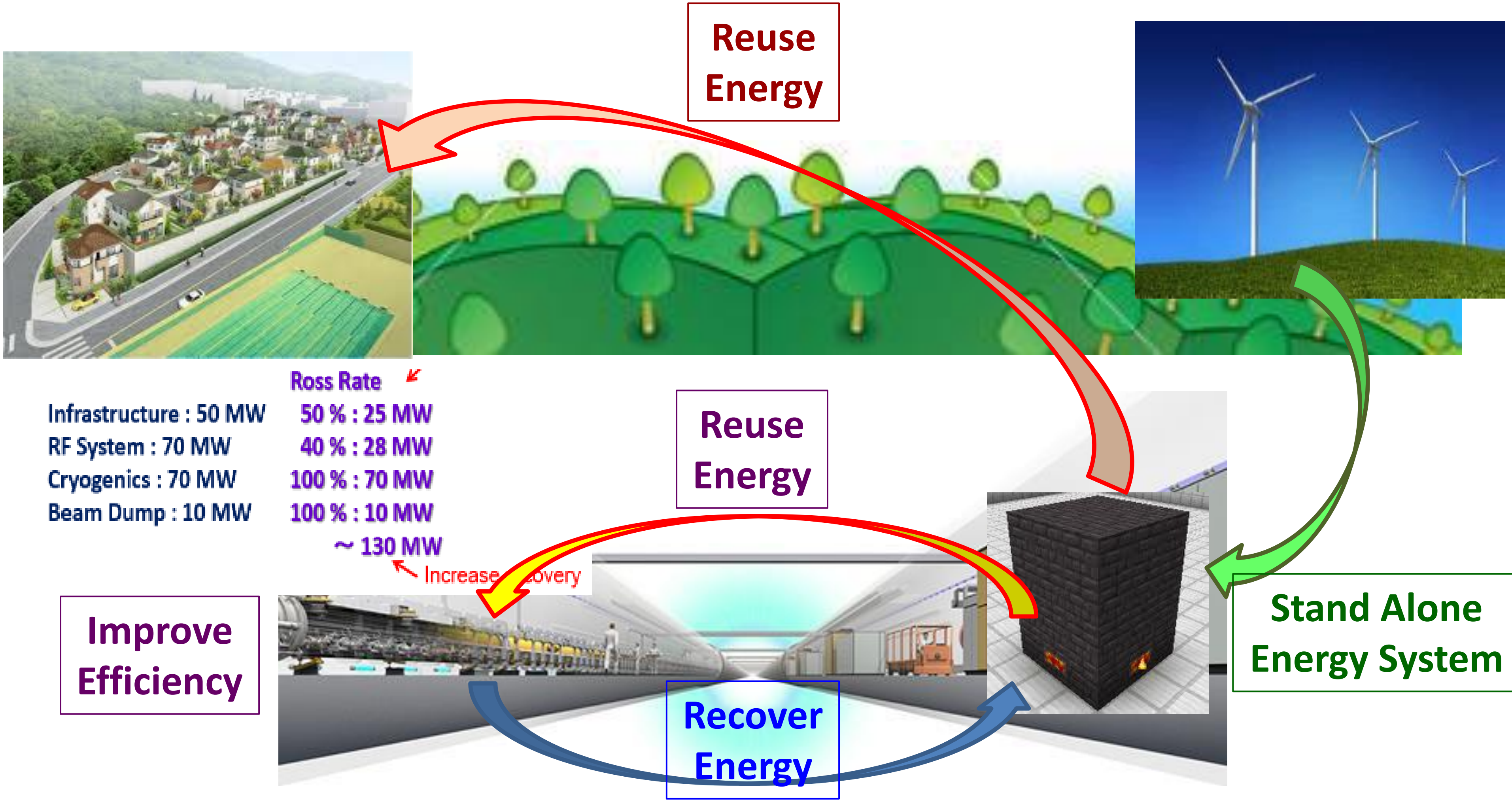




10 cm for 100 GeV

- The deceleration distance in the underdense plasma is 3 orders of magnitude smaller than the stopping in condensed matter.
- The muon fluence is highly peaked in the forward direction.

4. Summary



Reuse Energy

	Ross Rate
Infrastructure : 50 MW	50 % : 25 MW
RF System : 70 MW	40 % : 28 MW
Cryogenics : 70 MW	100 % : 70 MW
Beam Dump : 10 MW	100 % : 10 MW
	~ 130 MW

Increase covery

Reuse Energy

Improve Efficiency

Recover Energy

Stand Alone Energy System

Energy management at FERMILAB: strategy on energy management, efficiency, sustainability

Stephen Krstulovich, energy manager

2nd Workshop
Energy for Sustainable Science
at Research Infrastructures

Features of Fermilab Reconfiguration

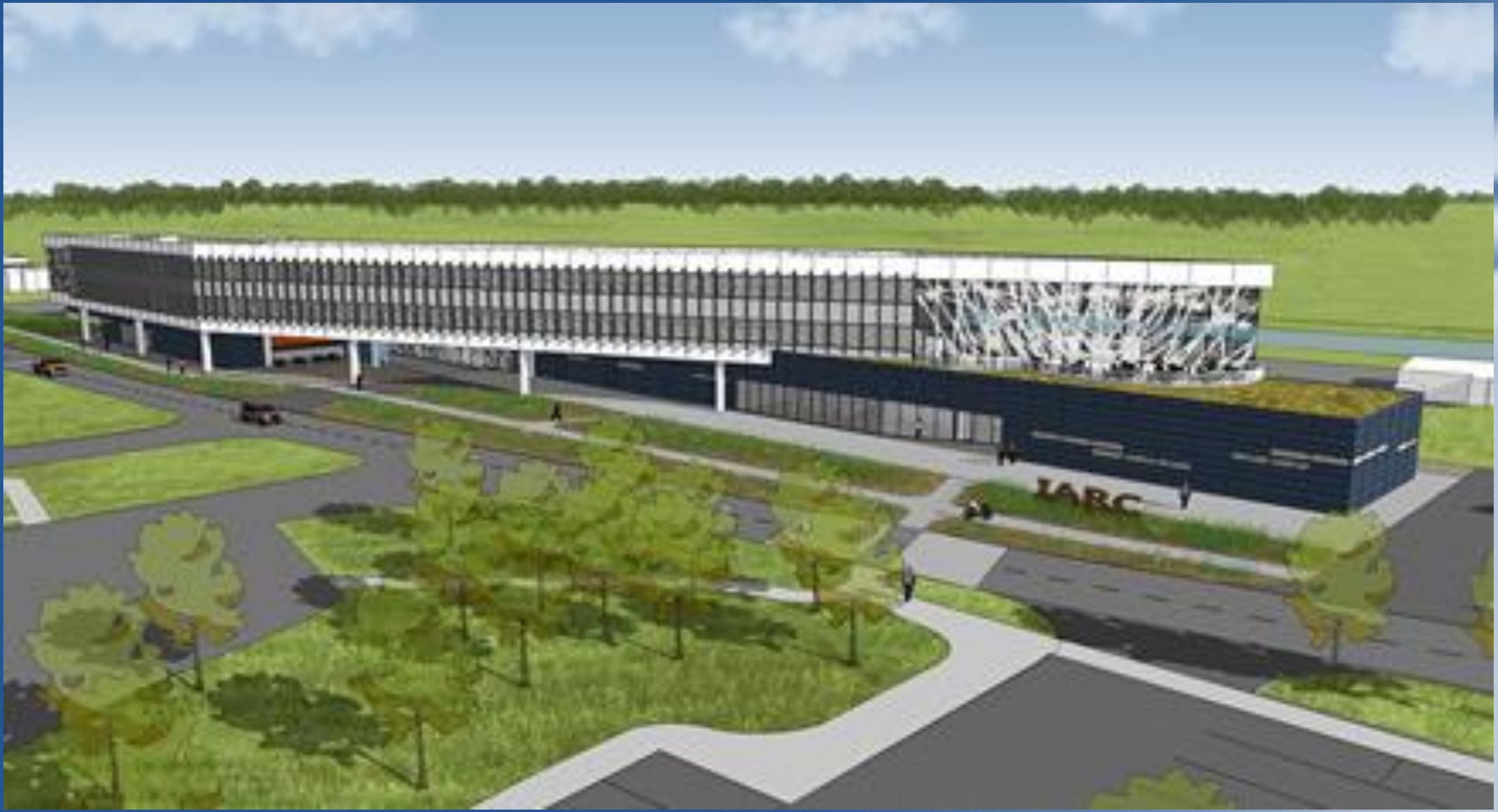
- LBNE is a primary long term initiative to study rare events of the Intensity Frontier by sending neutrinos to Homestake mine in South Dakota
- Muon experiments are mid term initiatives that may eventually help lead to the development of a Muon Collider
- Superconducting test facilities are short term initiatives that create expertise in developing more efficient accelerator technologies to be used both at Fermilab and elsewhere

SRF and Other Initiatives

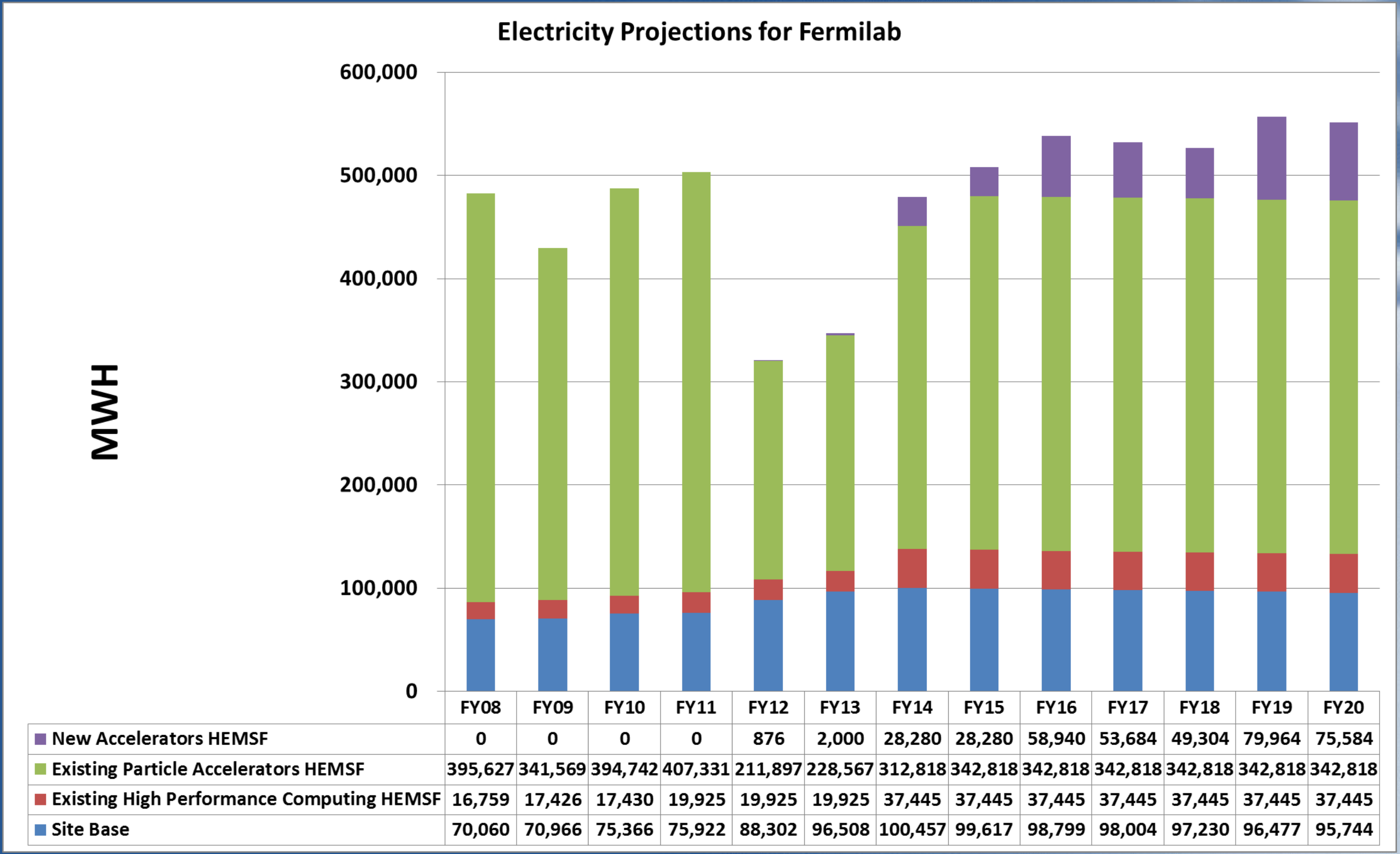
- Develop High Q Superconducting RF (SRF) cavities that reduce heat load at 2°K and minimize cryogenic system power requirements
- Develop new industrial technologies to mass produce High Q SRF cavities for new large accelerators
- Investigate Optical Stochastic Cooling to improve beam luminosity for experiments
- Investigate nonlinear integrable beam optics to improve efficiency by reducing accelerator resonance

Develop high efficiency RF sources to replace the current use of inefficient Klystrons

Illinois Accelerator Research Center



Future Mid Term Fermilab Power Needs



Electricity Projections for Fermilab

	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
🟪 New Accelerators HEMSF	0	0	0	0	876	2,000	28,280	28,280	58,940	53,684	49,304	79,964	75,584
🟩 Existing Particle Accelerators HEMSF	395,627	341,569	394,742	407,331	211,897	228,567	312,818	342,818	342,818	342,818	342,818	342,818	342,818
🟥 Existing High Performance Computing HEMSF	16,759	17,426	17,430	19,925	19,925	19,925	37,445	37,445	37,445	37,445	37,445	37,445	37,445
🟦 Site Base	70,060	70,966	75,366	75,922	88,302	96,508	100,457	99,617	98,799	98,004	97,230	96,477	95,744

Fermilab Energy Conservation Process

Goal: By FY2020 reduce site GHG emissions by 28% from FY2008 levels

- Evaluation of renewable energy opportunities on site at least every 4 years
- Audit every facility on site for energy and water conservation opportunities every 4 years
- Implement in a timely manner any cost effective energy and water conservation measures (ECMs) identified
- Provide annual M&V of ECM energy savings

Fermilab Sustainability Practices

- Used over $60M USD in alternative financing to implement energy and water conservation measures without upfront cost
- Used alternative financing vehicles such as UESC and ESPC to conduct audits and implement ECMs in a timely manner with annual M&V without upfront cost
- Used Renewable Energy Credits (RECs) to meet most of the GHG goals until cost effective renewable energy can be developed and implemented on site

Fermilab Portfolio Approach

- As a US Department of Energy (DOE) national laboratory, Fermilab's sustainability goals are tied to the entire portfolio of DOE laboratory sites under the Office of Science
- If cost effective energy solutions are not possible at any particular lab, the DOE goal may be still be achieved by combining the performance of all sites
- If combining sites does not achieve the goal, DOE can invest in the most promising sites to achieve the portfolio goal most cost effectively

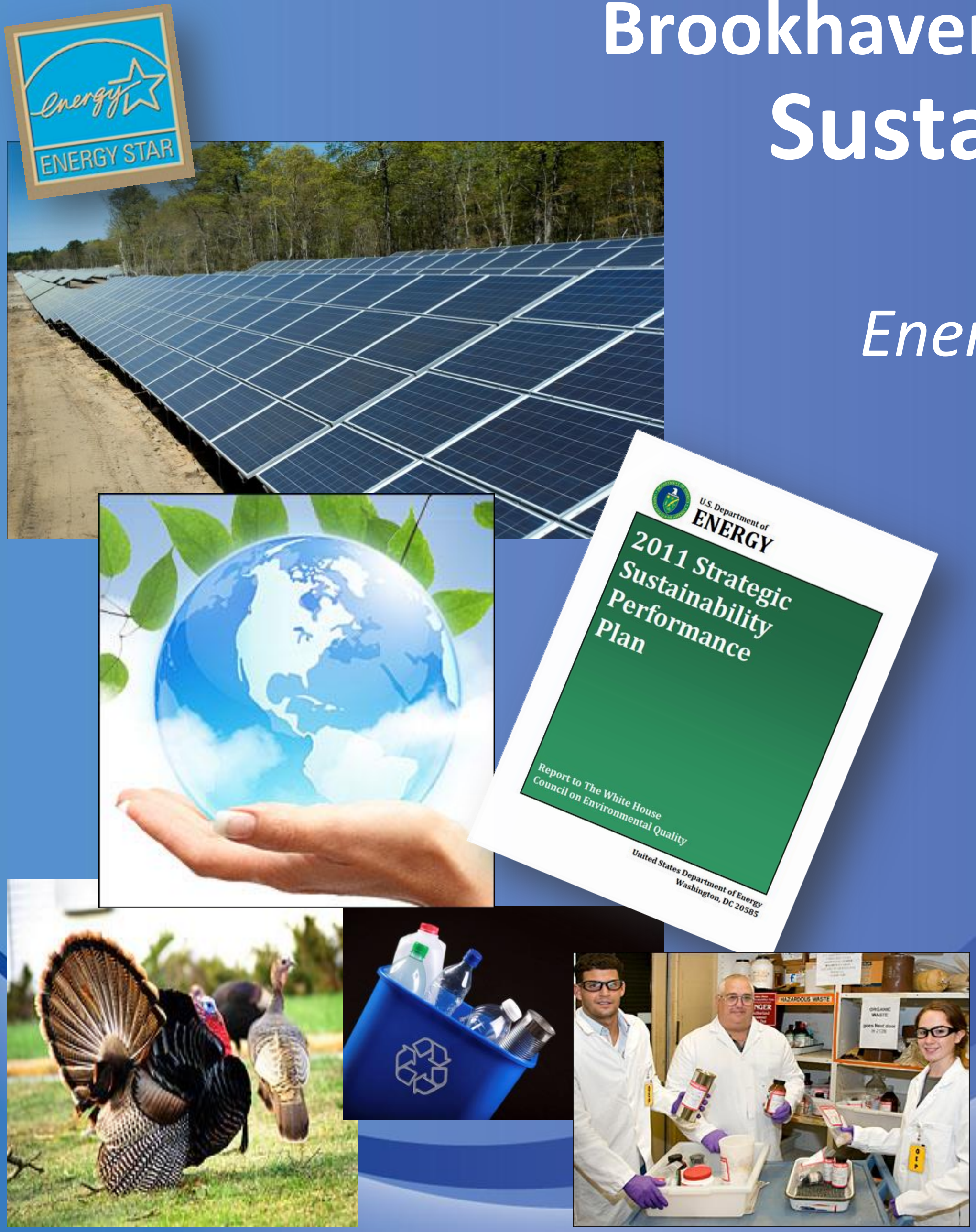
Brookhaven National Laboratory
Sustainability Program

2nd Workshop

Energy for Sustainable Science

at Research Infrastructures
CERN Geneva, Switzerland
23-25 October 2013

Ed Murphy
Chief Engineer
Manager, Energy & Utilities Division
Facilities and Operations



U.S. Department of ENERGY

2011 Strategic Sustainability Performance Plan

Report to The White House Council on Environmental Quality

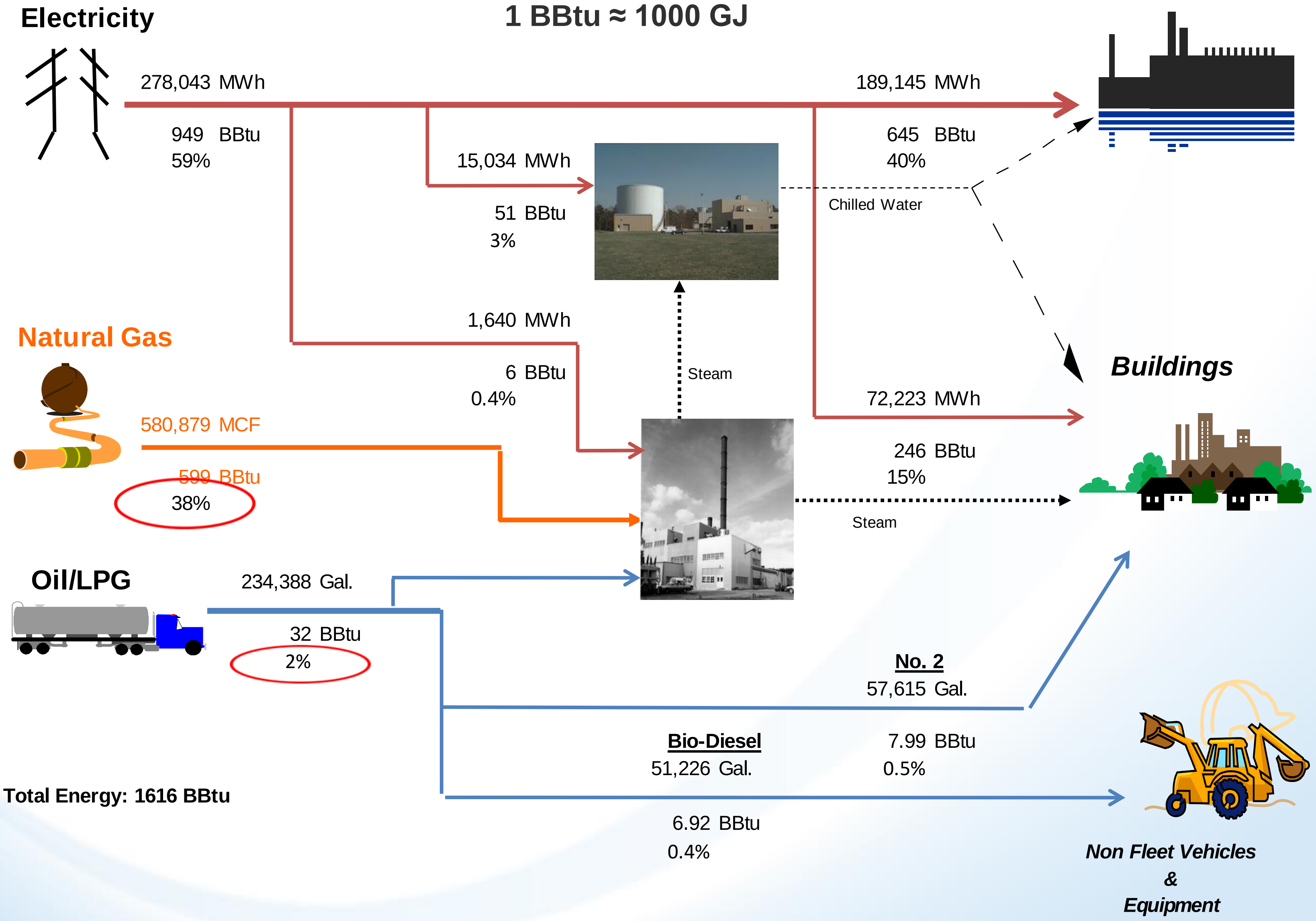
United States Department of Energy
Washington, DC 20585

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Brookhaven National Laboratory
Energy Use
FY2012

1 BBtu ≈ 1000 GJ



Electricity

278,043 MWh

949 BBtu
59%

189,145 MWh

645 BBtu
40%

Process

15,034 MWh

51 BBtu
3%

Chilled Water

1,640 MWh

6 BBtu
0.4%

Steam

72,223 MWh

246 BBtu
15%

Buildings

Steam

Natural Gas

580,879 MCF

599 BBtu
38%

Oil/LPG

234,388 Gal.

32 BBtu
2%

No. 2
57,615 Gal.

Bio-Diesel
51,226 Gal.

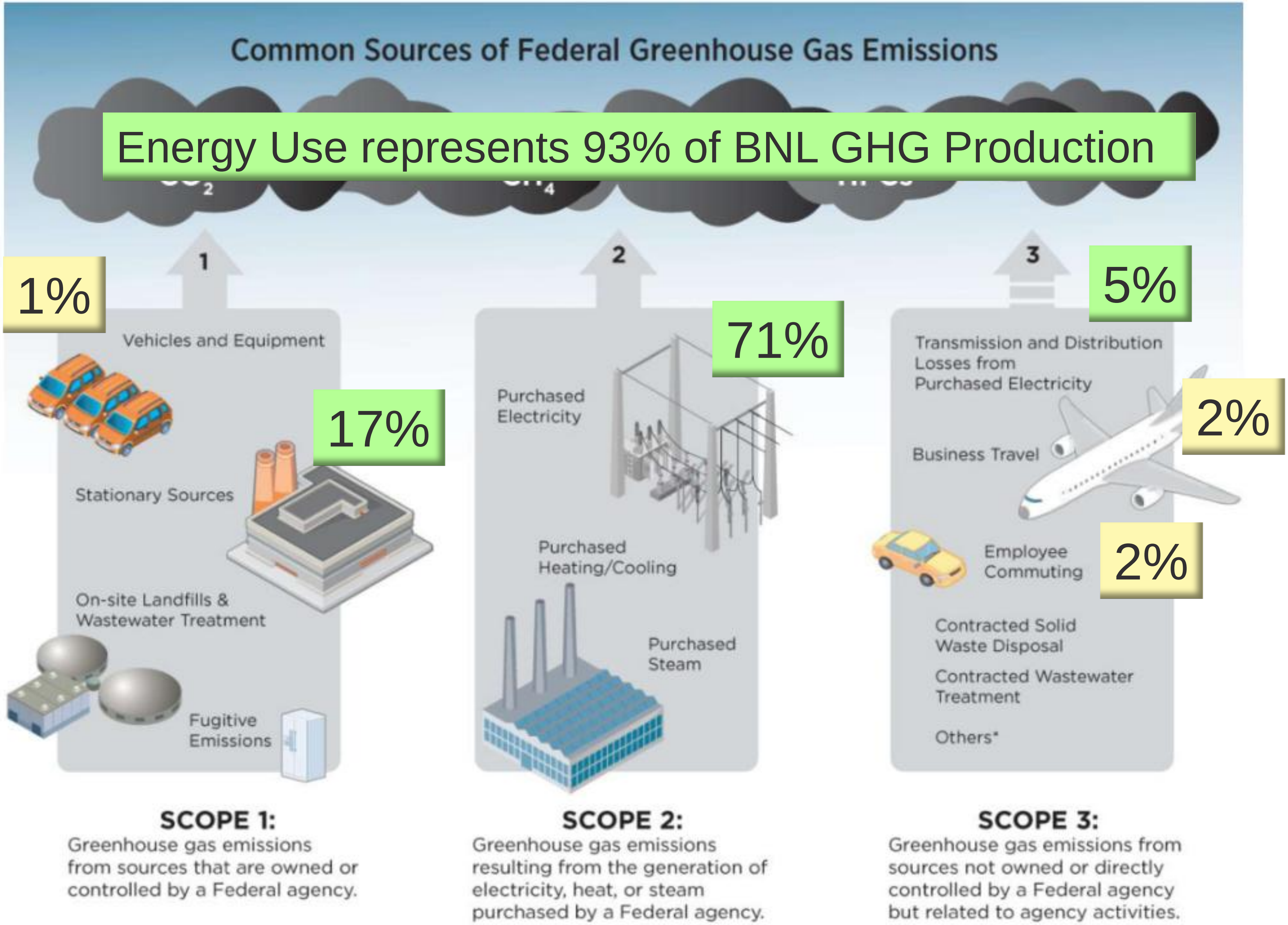
7.99 BBtu
0.5%

6.92 BBtu
0.4%

Non Fleet Vehicles
&
Equipment

Total Energy: 1616 BBtu

Energy Use represents 93% of BNL GHG Production



SCOPE 1:
Greenhouse gas emissions from sources that are owned or controlled by a Federal agency.

SCOPE 2:
Greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency.

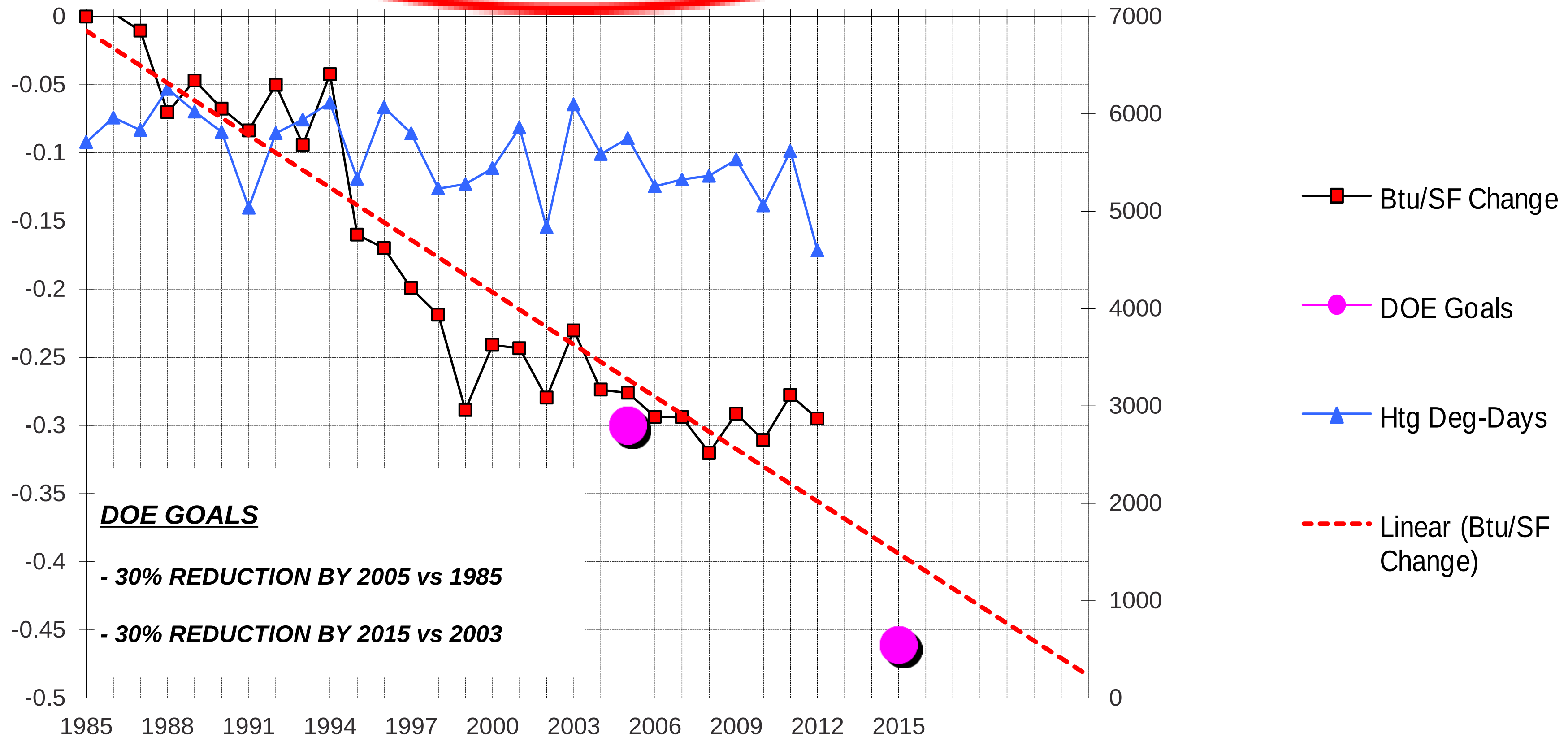
SCOPE 3:
Greenhouse gas emissions from sources not owned or directly controlled by a Federal agency but related to agency activities.

BNL’s Energy Efforts – Some History

- BNL has a long and successful history of identifying and implementing energy conservation projects
- Began an energy conservation program in 1973 to combat high energy costs (first oil crisis)
- Over $60 million has been invested in a wide range of efforts that has curbed BNL’s energy consumption dramatically
- Energy intensity (Btu/GSF) has been reduced by over 54% comparing FY2012 to FY1973
    - Saves about $15 million/year in energy costs
    - Over 110,000 $MTCO_2e$ per year avoided

BUILDING ENERGY PERFORMANCE

BTU / FT^2 Change (%) vs. Baseline Years



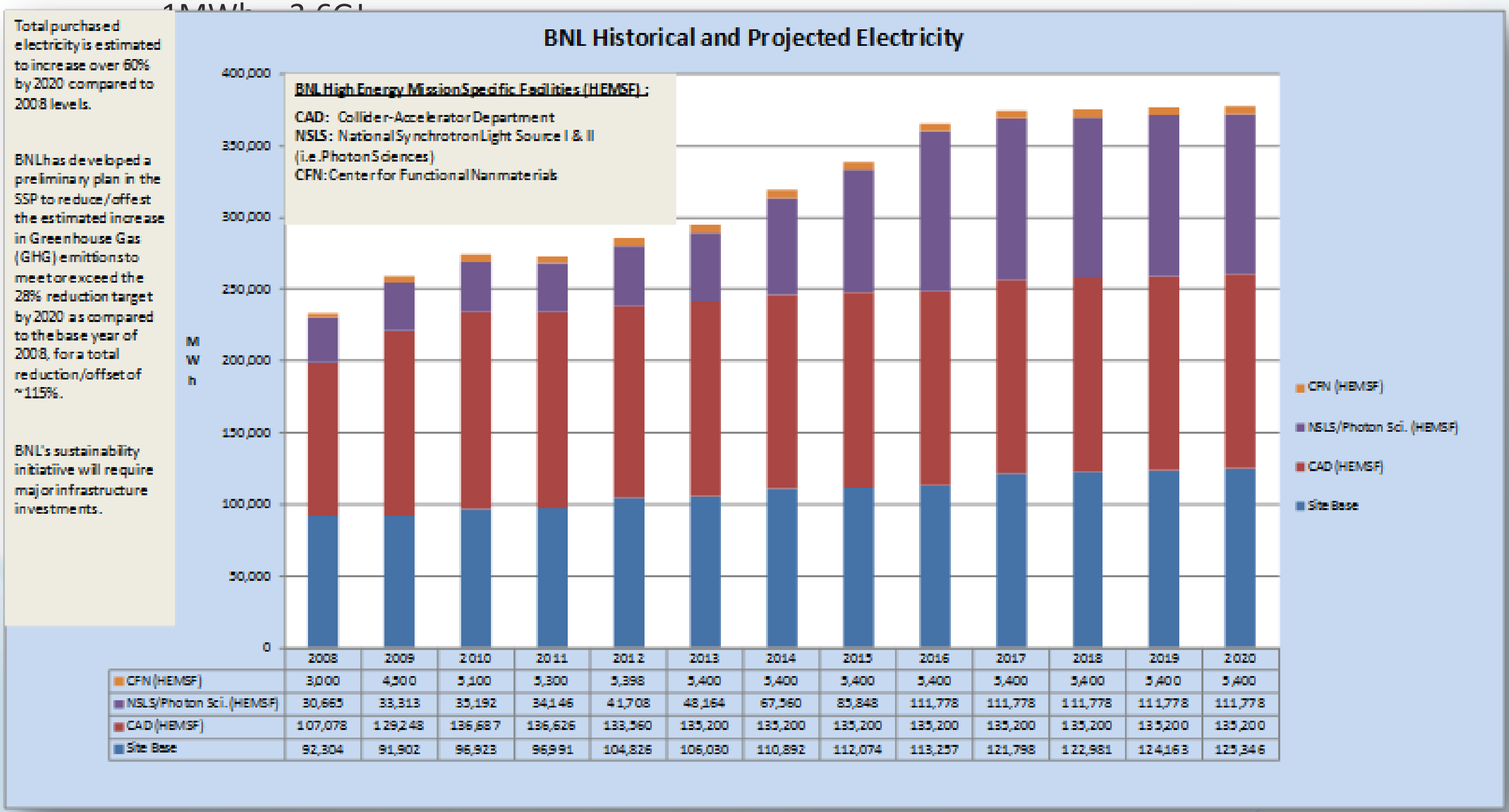
DOE GOALS

- 30% REDUCTION BY 2005 vs 1985

- 30% REDUCTION BY 2015 vs 2003

BNL Energy Usage

- BNL's electricity use is driven by research budgets and operation of our accelerators and research facilities. "Base load" follows with site activity.



Total purchased electricity is estimated to increase over 60% by 2020 compared to 2008 levels.

BNL has developed a preliminary plan in the SSP to reduce/offest the estimated increase in Greenhouse Gas (GHG) emittions to meet or exceed the 28% reduction target by 2020 as compared to the base year of 2008, for a total reduction/offset of ~115%.

BNL's sustainability initiative will require major infrastructure investments.

BNL Historical and Projected Electricity

BNL High Energy Mission Specific Facilities (HEMSF):

CAD: Collider-Accelerator Department
NSLS: National Synchrotron Light Source I & II (i.e. Photon Sciences)
CFN: Center for Functional Nanmaterials

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
🟧 CFN (HEMSF)	3,000	4,500	5,100	5,300	5,398	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
🟪 NSLS/Photon Sci. (HEMSF)	30,665	33,313	35,192	34,146	41,708	48,164	67,560	85,848	111,778	111,778	111,778	111,778	111,778
🟥 CAD (HEMSF)	107,078	129,248	136,687	136,626	133,560	135,200	135,200	135,200	135,200	135,200	135,200	135,200	135,200
🟦 Site Base	92,304	91,902	96,923	96,991	104,826	106,030	110,892	112,074	113,257	121,798	122,981	124,163	125,346

Long Island Solar Farm at BNL

- DOE and BNL made the BNL site available to host a major solar PV array
- The project executed through a Request for Proposal from the local utility (Long Island Power Authority)
- About 80 ha (200 acres) of federal land was made available through an easement
- The project began commercial operation in November 2011, produces 31.5 MW peak, and avoids ~31,000 tons of carbon per year
- Both commercial array and a 1 MW BNL array will be utilized by BNL research programs

LIPA Long Island Power Authority

bp solar

MetLife

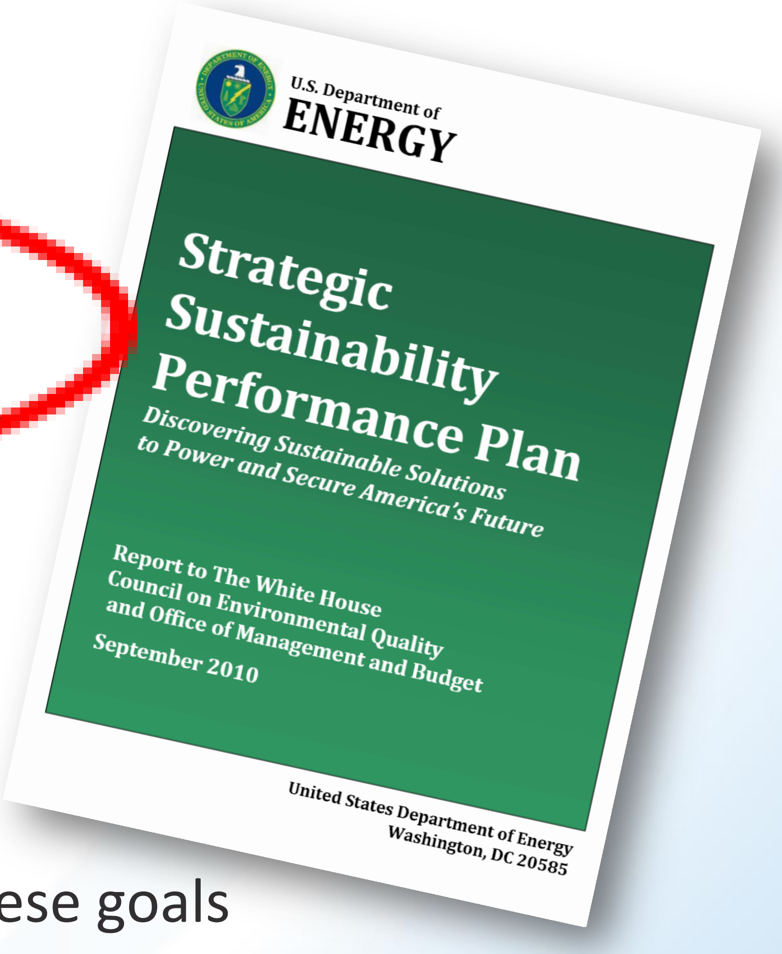
U.S. DEPARTMENT OF ENERGY

Chilled Water Thermal Storage

- BNL’s 7,200-ton (25,000 kW) Central Chilled Water Plant includes Chilled Water Thermal Storage
  - 11,400,000 liters of chilled water
  - Stratified tank (maintains thermocline)
  - 22,000 ton-hours (280 GJ) thermal storage at 10ºF (6ºC) delta-T
- Total construction cost = $3.5 million
- Benefits of thermal storage:
  - Avoids $400,000/year of electric cost through day / night demand shifting
  - Provides additional chilled water capacity for peak summer days (BNL capacity constrained)
  - Provides reliable chilled water supply to critical process (computer) loads

DOE Background

- DOE has developed a Strategic Sustainability Performance Plan in response to Executive Order 13514
- The plan establishes Department goals in a wide variety of areas of sustainability
- DOE requires each laboratory to develop and implement a Site Sustainability Plan to flow down these goals
- BNL’s first annual plan was submitted on December 31, 2010. Update for the 2014 submission is underway.



U.S. Department of
ENERGY

Strategic Sustainability Performance Plan

Discovering Sustainable Solutions to Power and Secure America’s Future

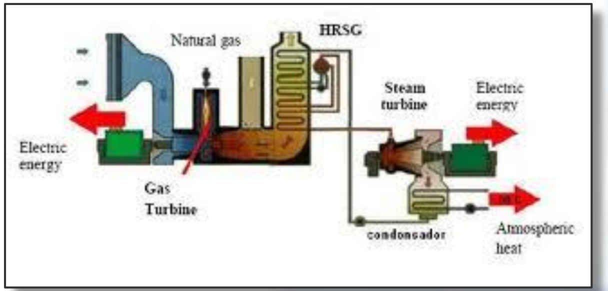
Report to The White House
Council on Environmental Quality
and Office of Management and Budget

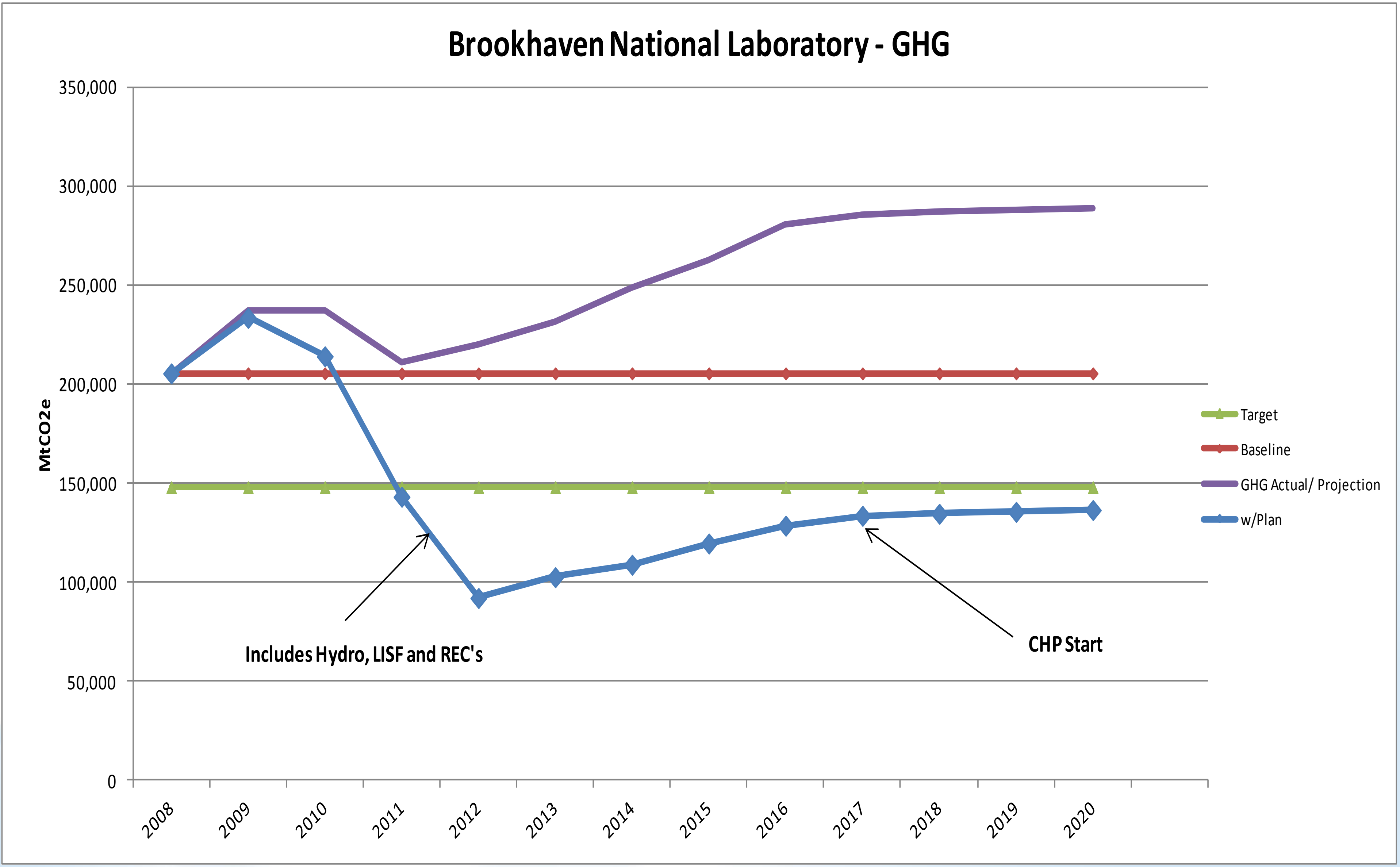
September 2010

United States Department of Energy
Washington, DC 20585

Future Sustainability Actions (Cont'd)

- Energy Conservation Projects: Phase II (UESC)
  - Lighting upgrades, enhanced controls, retro-commissioning
  - Steam system improvements
- Combined Heat and Power Plant (CHP)
  - Cogeneration of electric power and steam
- Other Initiatives
  - Modernization of the BNL site
  - Chilled water storage increase
  - Small wind and solar PV projects
  - Biomass evaluations
  - Alternatively fueled vehicles
  - Reduction of waste
  - Employee engagement and outreach





Brookhaven National Laboratory - GHG

Includes Hydro, LISF and REC's

CHP Start

Sustainability at DESY

Challenges and Opportunities

HELMHOLTZ GEMEINSCHAFT

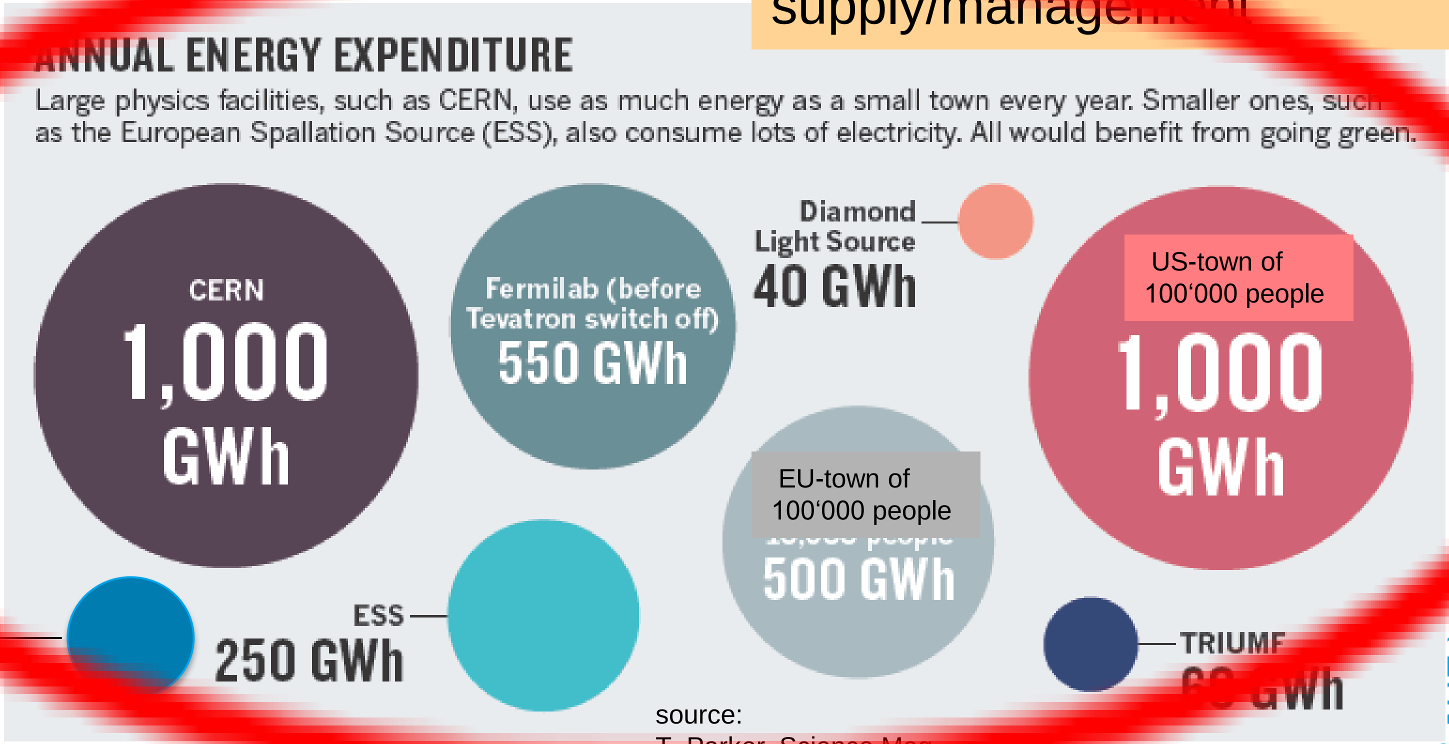
Helmut Dosch, DESY
CERN/ERF/ESS Workshop „Sustainable Science“
October 2013

DESY

Science is energy intensive

e.g. facilities at DESY have power input **23 MW**
Annual consumption of **160 GWh**
mainly provided by **fossil sources**
Releasing roughly **70 kt CO_2** per year
~ energy consumption of German city with
40 000 inhabitants

Future developments of energy prices?
How climate neutral/sustainable should research centres be?
=> Strategic question of energy supply/management



ANNUAL ENERGY EXPENDITURE

Large physics facilities, such as CERN, use as much energy as a small town every year. Smaller ones, such as the European Spallation Source (ESS), also consume lots of electricity. All would benefit from going green.

DESY
160 GWh

source:
T. Parker, Science Mag

Pillars of sustainability concept

- **Improve sustainable management** of facilities & campus
  - Focus on sustainable energy management with goal to include mid-term and long-term sustainability aspects as integral elements into all business processes
  - Reduce consumption, increase efficiencies, recover waste heat, smarter energy management
  - Campus buildings and mobility also play a major role
  - develop “sustainability culture for research”
- **Strategic Research** in Advanced Materials for Renewable Energies
  - Interdisciplinary research effort in Helmholtz association: Materials Science
  - Joint effort between research fields “Matter”, “Energy” and “Key Technologies”
  - DESY: in-situ high precision analysis of materials performance on a molecular level
- New **Strategic Partnership** between European RIs and MENA region
  - Building Bridges between Europe and MENA
  - Science & Energy Cooperation

I. Building/Campus

- more than 50 buildings on campus, some of them 50 years old
- started energetic renovation of building structure (through stimulus funds) over last years – four buildings completed
  - ~50% savings in energy, expect 200k€/a savings in energy cost– reduction of 600t/a CO_2
- Orientation to sustainable energy standards for new buildings – use evaluation instruments BNB

  Bewertungssystem “Nachhaltiges Bauen”

  (Evaluation scheme sustainable construction)

  http://www.nachhaltigesbauen.de

Improve waste heat re-usal at DESY

Concrete Project: Cryogenic waste heat utilization for DESY and EU.XFEL

Study shows good potential for using waste heat of a cryogenic plant for heat utilization

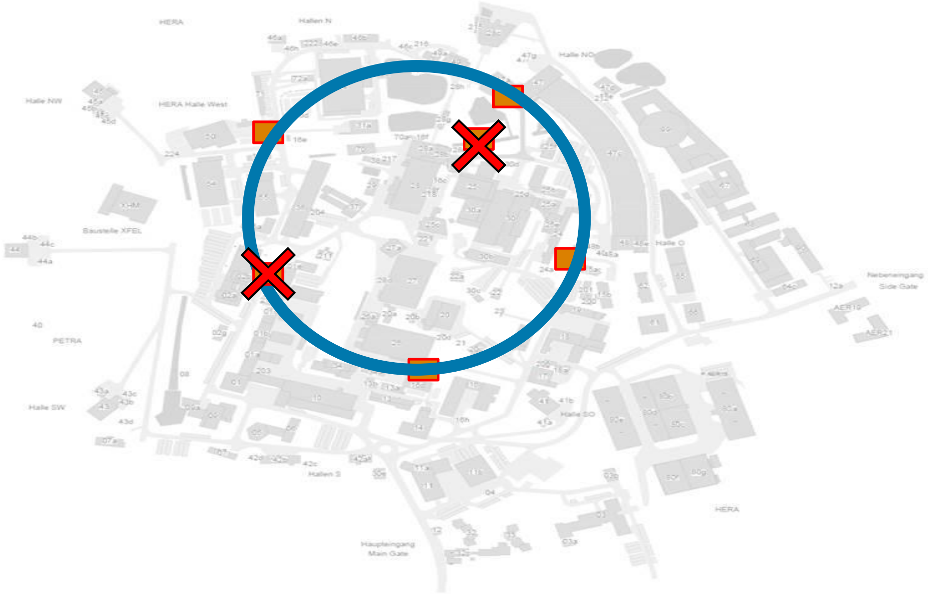
	1 cryo street	2 cryo streets
heat extraction (30-35 deg)	4,6 GWh/a	7,0 GWh/a
cost savings[1)]	228.450 €/a	350.600 €/a
payback period [2)]	2,6 a	1,7 a
cash value after 10 years [3)]	807.740 €	1.558.298 €
Reduction of CO_2-Emission [4)]	1.087 t-CO_2/a	1.669 t-CO_2/a

1) price for district heating: 0,05 €/kWh
2) investment costs: 592.000 €
3) adequate target rate: 10 %
4) district heating: 238 g-CO_2/kWh

See talk by J.-P. Jensen
Thu, 24 October
Parallel B2

Cold water ring

- Concrete project: improve cold water ring (T=8C) at DESY ("Fernkältering")
  - ~4 MW refrigeration power for cooling building, IT, power supplies, …
  - Ring connect nearly all refrigerator plants on campus, improve efficiencies, eliminate decentralized, isolated solutions
- Reduce installed power from 13.6MW to 9.6MW, increase average efficiencies from 50% to 60%



Energy Management at CERN

Motivation and mandate
Present energy usage at CERN
Projects
Policy recommendations

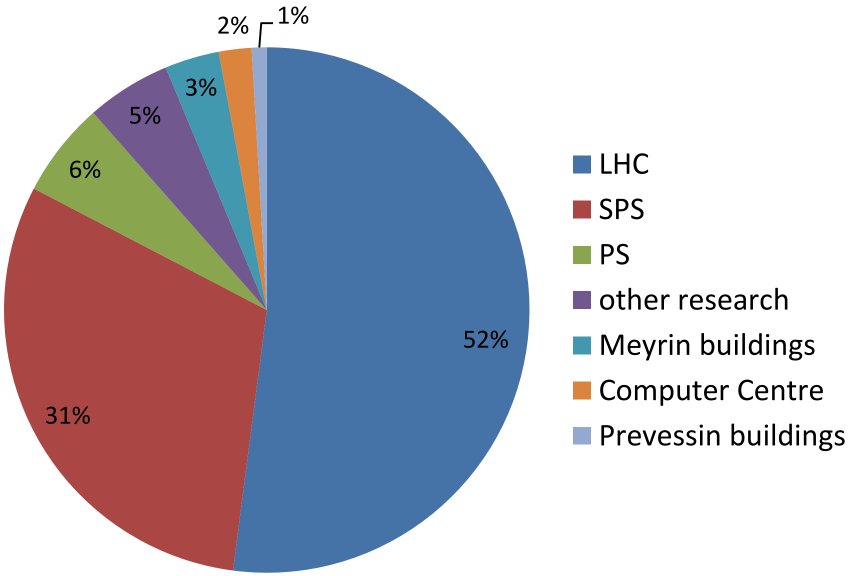
Helfried J. Burckhart
CERN Energy Coordinator

Electricity consumption

Power demand:

- Full operation : 220 MW
- Shutdown: 50 MW

Annual consumption: 1.2 TWh

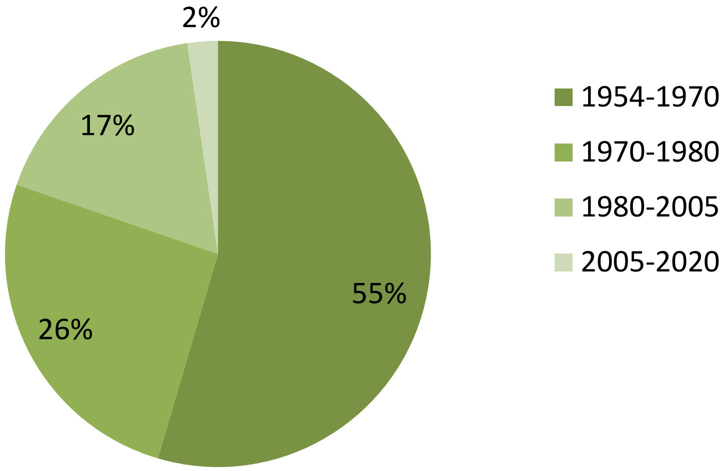


CERN Campus

CERN buildings 600.000 m^2 total

- 360.000 m^2 Meyrin site
- 130.000 m^2 Prevessin site
- Surface buildings of accelerators

Construction date Meyrin site

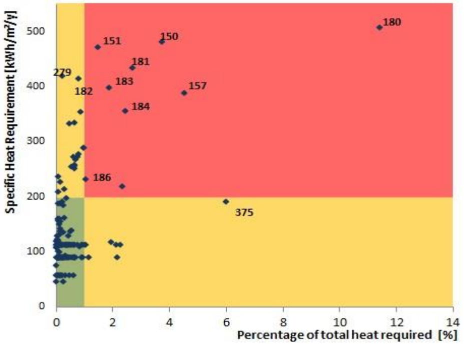


80 % of buildings are older than 30 years

- High energy consumption
- General refurbishment needed

Projects Campus

- **Study heating energy needed by buildings of Meyrin site,** see L.Scibile in session B3
  - – Simulate need of heating energy for each building
    - Type, age, size
    - Constrain by total energy measured
  - ➔ **Prioritization of renovation**



- **Refurbishment and extension of computer centre,** see W.Salter, A3
  - – Improve air flow management
  - – Use free cooling
  - – Increase temperature
  - ➔ **substantial savings**

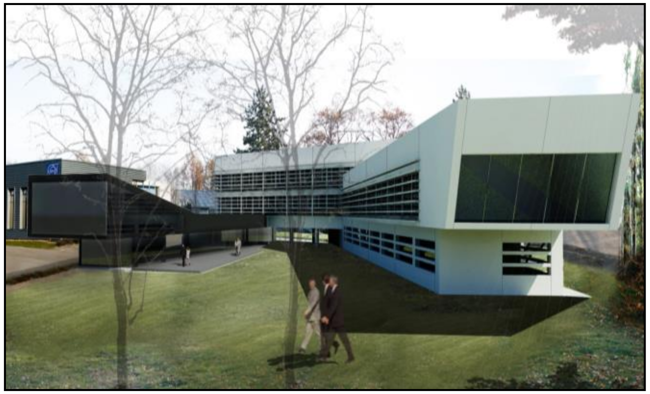
- **Hot water preparation for restaurant 2**
  - – 50 m² thermal solar panels
  - ➔ **save 50% of energy**

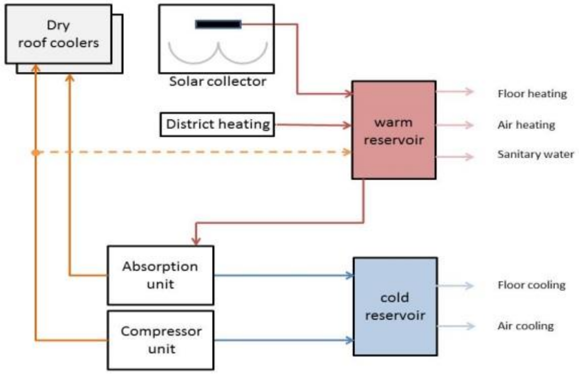
Projects Campus *contd.*

- **New building at Prevessin site**
  - Integrated design of heating and cooling system
    - Re-use of “waste” heat
  - 90 kW absorption machine for cooling and “rafraichissement
  - 250 m² solar field (collectors are CERN spin-off) for cooling and heating

L.Scibile, B3

C.Benvenuti, B4





- **New building for surface treatment**
  - Heat pump air-water

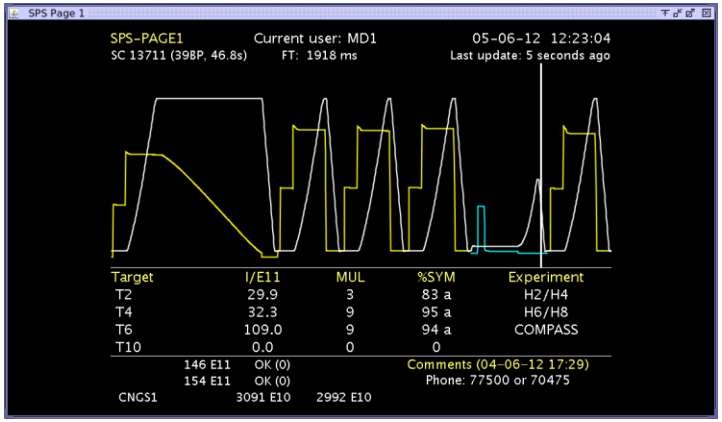
- **New building at LHC point 5**
  - Heat pump air-water
  - Option water-water to use “waste” heat
  - Solar collectors for hot water

Projects accelerators

- **Further optimisation of cycles (drop, shorten, down-size)**
  - HW upgrade: e.g. precise B-field measuring and control
  - SW upgrade: e.g. additional control procedures
  - Trigger: either operator-driven or automatic

➔ Some savings

➔ Increased flexibility



SPS-PAGE1 Current user: MD1 05-06-12 12:23:04

SC 13711 (39BP, 46.8s) FT: 1918 ms Last update: 5 seconds ago

Target	I/E11	MUL	%SYM	Experiment
T2	29.9	3	83 a	H2/H4
T4	32.3	9	95 a	H6/H8
T6	109.0	9	94 a	COMPASS
T10	0.0	0	0	

146 E11 OK (0)

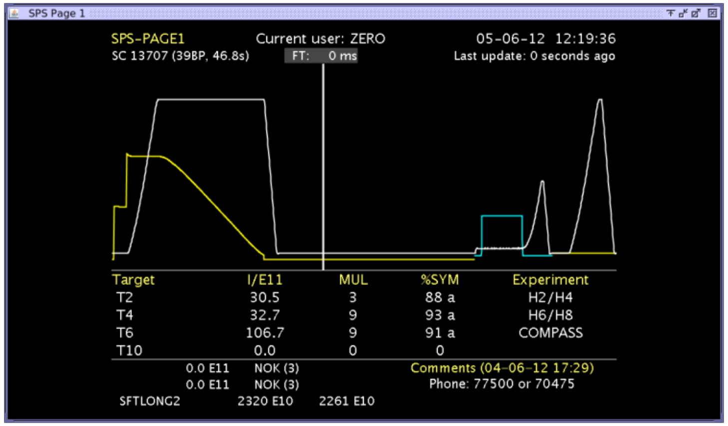
154 E11 OK (0)

CNGS1 3091 E10 2992 E10

Comments (04-06-12 17:29)

Phone: 77500 or 70475

→



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Target	I/E11	MUL	%SYM	Experiment
T2	30.5	3	88 a	H2/H4
T4	32.7	9	93 a	H6/H8
T6	106.7	9	91 a	COMPASS
T10	0.0	0	0	

0.0 E11 NOK (3)

0.0 E11 NOK (3)

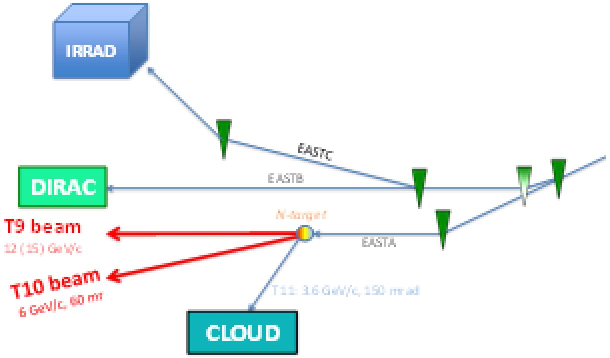
SFTLONG2 2320 E10 2261 E10

Comments (04-06-12 17:29)

Phone: 77500 or 70475

Projects accelerators *contd.*

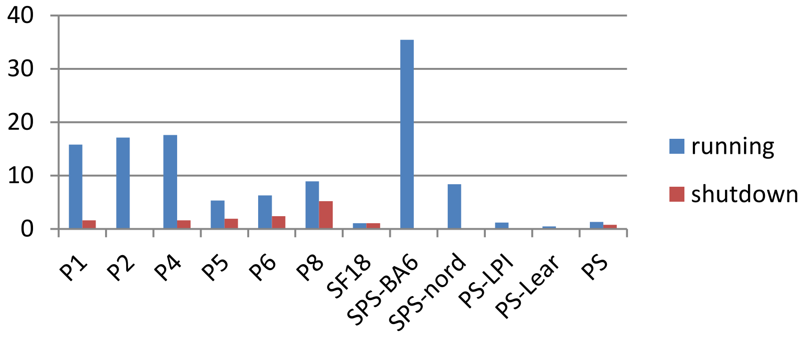
- **Pulsing magnets for fixed target area East hall,** see K.Papastergiou, B2
  - Investment: replace magnet yokes and power converters
  - Enormous energy saving (90%)



- **Studies for upgrades and future accelerators**
  - High temperature SC cables, see A.Ballarino, B4
  - Recuperate (waste) RF energy
    - Thermal
    - Electrical

Projects “waste” heat

80% of electricity used in accelerators is dissipated in cooling towers



Energy dissipation on cooling towers [MW]

CERN’s waste energy

- Intermittent (shutdown)
- Limited life time (LHC)
- out of phase with need (LHC runs in summer)
- low temperature (generally < 30°C)

… complete operational independence needed ➔ back-up solution on provider and consumer side

Projects studied

- Heat apartment blocks in Meyrin (shortage of investment)
- Heat new halls of airport (airport time scale 2016+)
- Heat new buildings of St.Genis (distance problems)
- Heat new CERN buildings (ongoing)

Energy policy recommendations

- **Buildings**
  - New: integrated energy concept (combine hot/cold streams, use waste heat, solar energy)
  - Existing: “complete” renovation (energetic, structural, functional, aesthetic)
  - Consider long-term evolution/usage (Masterplan)
- **Projects**
  - Life time assessment of energy usage
  - Optimize investment-operation
- **Accelerator/experiments**
  - Optimize operations (machine cycles, coherent operation of all elements of the accelerator chain)
  - Pulse transfer and fixed target beam line
  - Stop equipment when not needed (needs often HW or SW investment)
- **Managerial**
  - Incentive for energy savings (account for energy, let saver benefit)
  - Each project (infrastructure, accelerator, experiment) should include energy planning
  - Make it an work objective (individuals, groups, departments)
  - Re-adapt operations schedule to (new) energy tariff
  - Make good use of Energy Coordinator

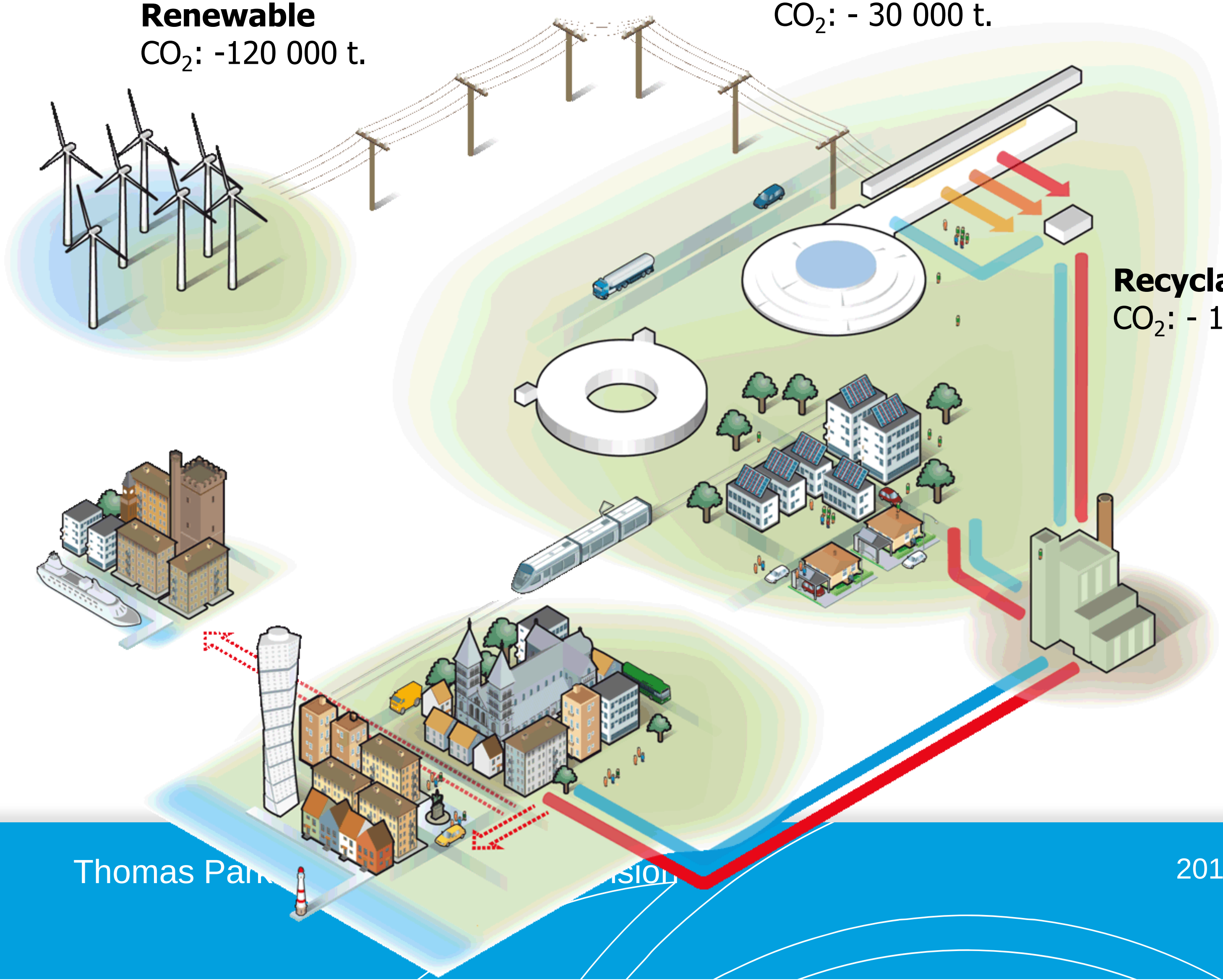
EUROPEAN
SPALLATION
SOURCE

Responsible
Renewable
Recyclable

Thomas Parker

October 2013

Responsible – Renewable – Recyclable

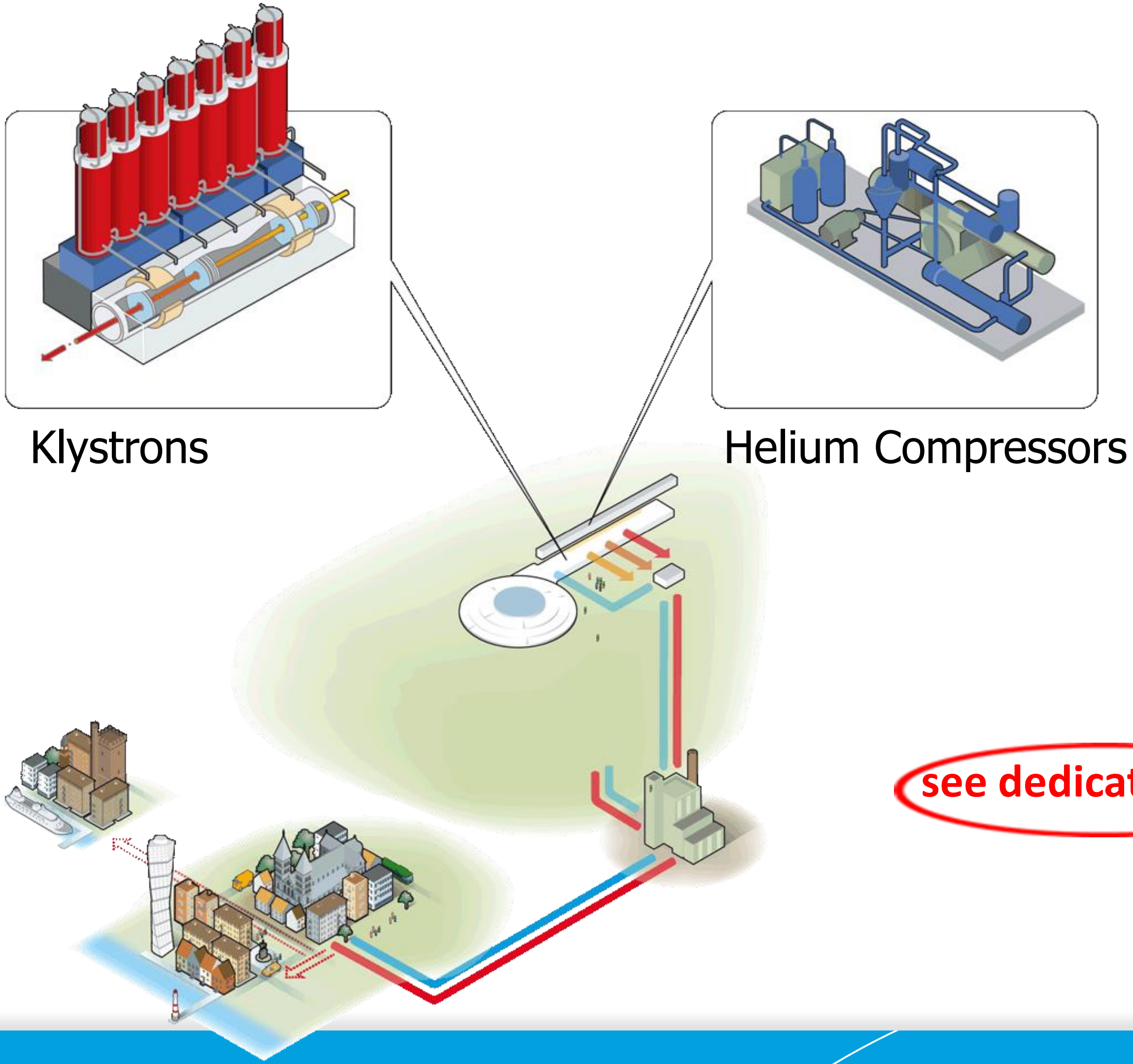


Renewable
CO_2: -120 000 t.

Responsible
CO_2: - 30 000 t.

Recyclable
CO_2: - 15 000 t.

High-temperature cooling



see dedicated talk

Conclusions

- The energy strategy Responsible Renewable Recyclable was instrumental in winning ESS
- "Responsible, Renewable, Responsible" is neither perfect nor universal, but is being implemented and will be a benchmark for future development.
- Attention to temperature in design of machine and buildings
- Collaboration is a key success factor.
- Innovation is a requirement.

Wir schaffen Wissen – heute für morgen

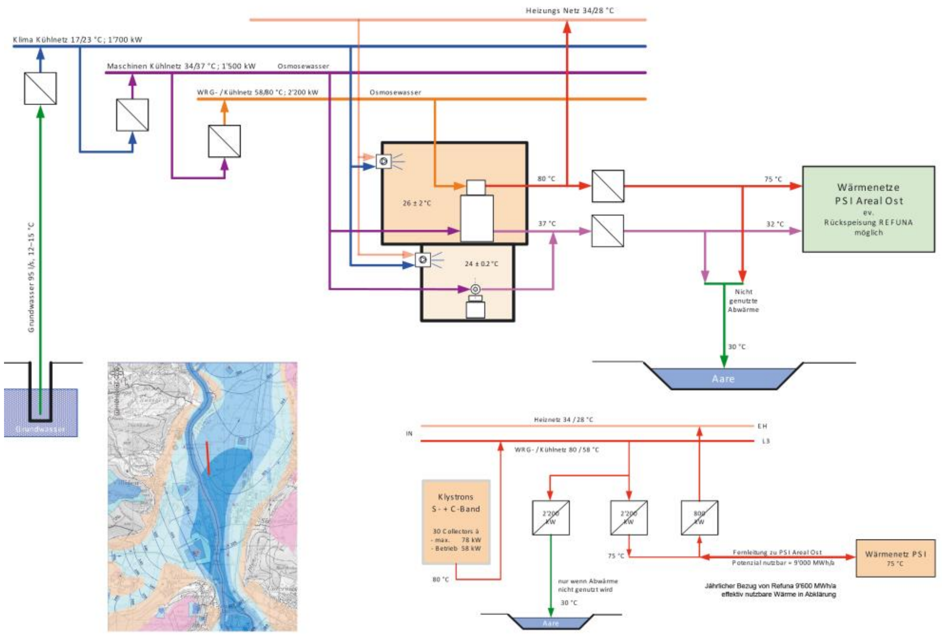
Paul Scherrer Institut

Reinhard David

Heat Recycling at PSI, a Project to Cover up to 75% of the Campus`s Heat Consumption

Saving Potential of New Machines (Swiss FEL)?

- Infrastructure
  - Cooling Design (ground water, minimized through cascading temperature levels)
  - HVAC concept and design (ventilation efficiency, very limited compression chillers)
  - Class A components (Motors, Pumps, Ventilators, Filters, etc.)
  - Heat Recycling (focus of this presentation)



Grundwasserkarte

Wärmerückgewinnung

Heating Infrastructure of PSI Campus

- District heating system Refuna
- Heat source nuclear power plant Beznau I+II
- Future heat source unknown, today`s low CO2-emission source not further guaranteed!
- System designed for high temperature of 115° C

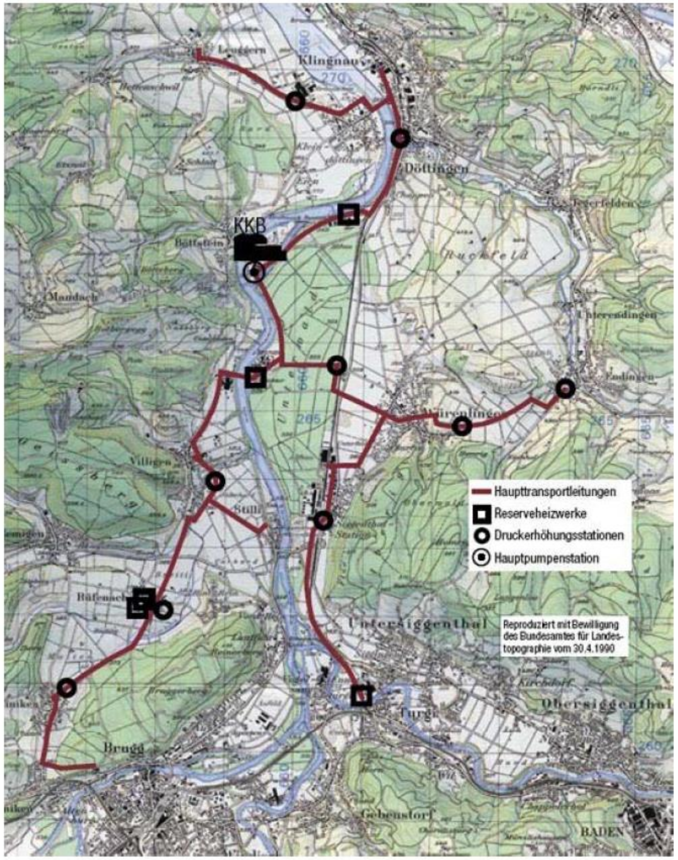
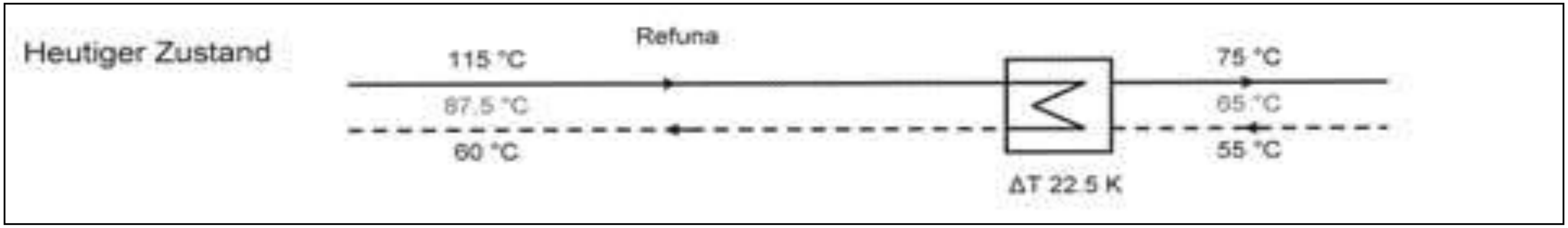
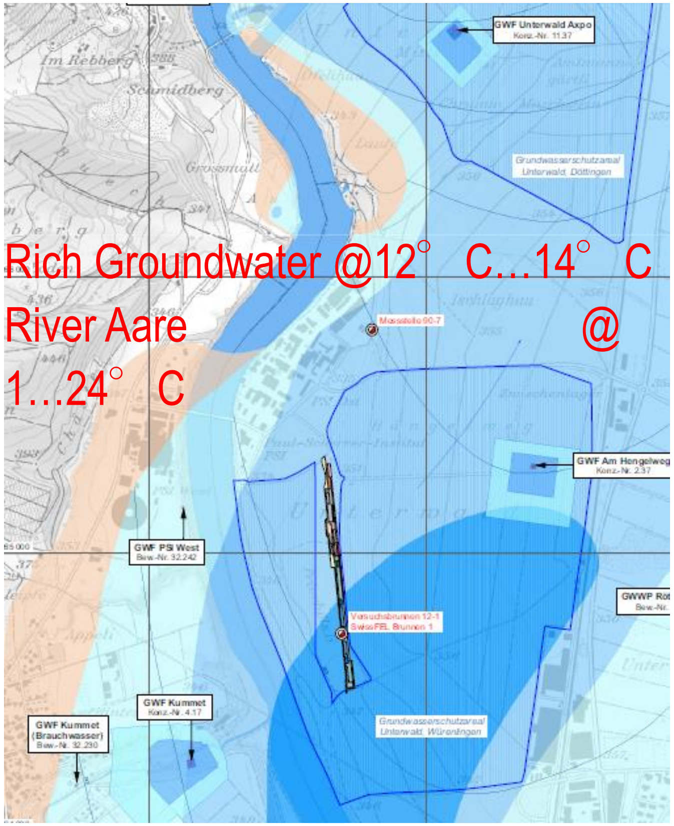


Abbildung 1 Situation Fernwärmenetz der REFUNA (Total ca. 70 MW



Heat Sinks PSI

River “Aare”	15MW	(cavities, magnets, …)
Ground water	5MW (+6MW from 2017 for SwissFEL)	(various, 3 cascading circuits)
Air	2.5MW +5MW	(direct+indirect mainly for HVAC`s only)
Total	27.5 MW (33.5 MW incl. SwissFEL)	



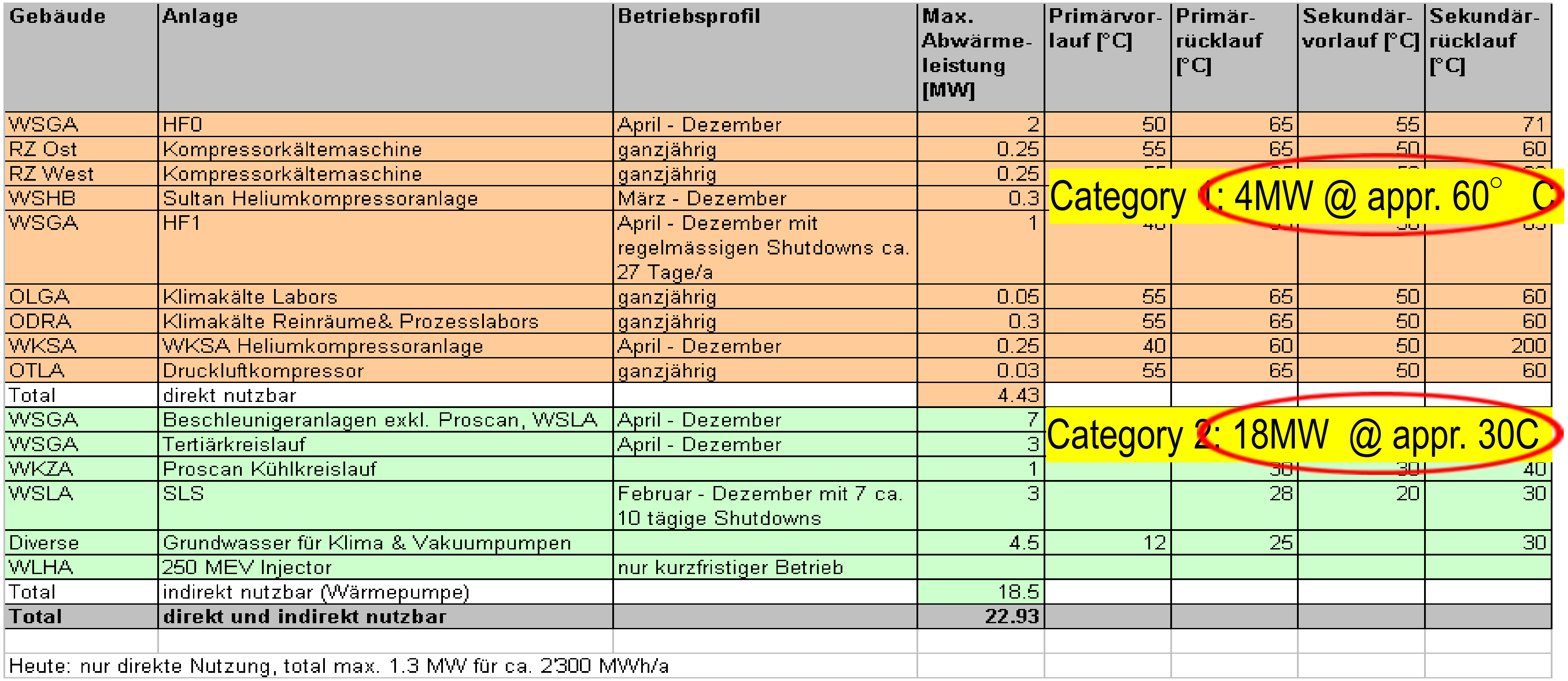
Rich Groundwater @12° C…14° C

River Aare @

1…24° C

→Most efficient cooling systems with very little compressing cooling machines in terms of energy! (capacity is 5MW for peak and/or summer loads or redundancy)

Potential Heat Sources and Demand

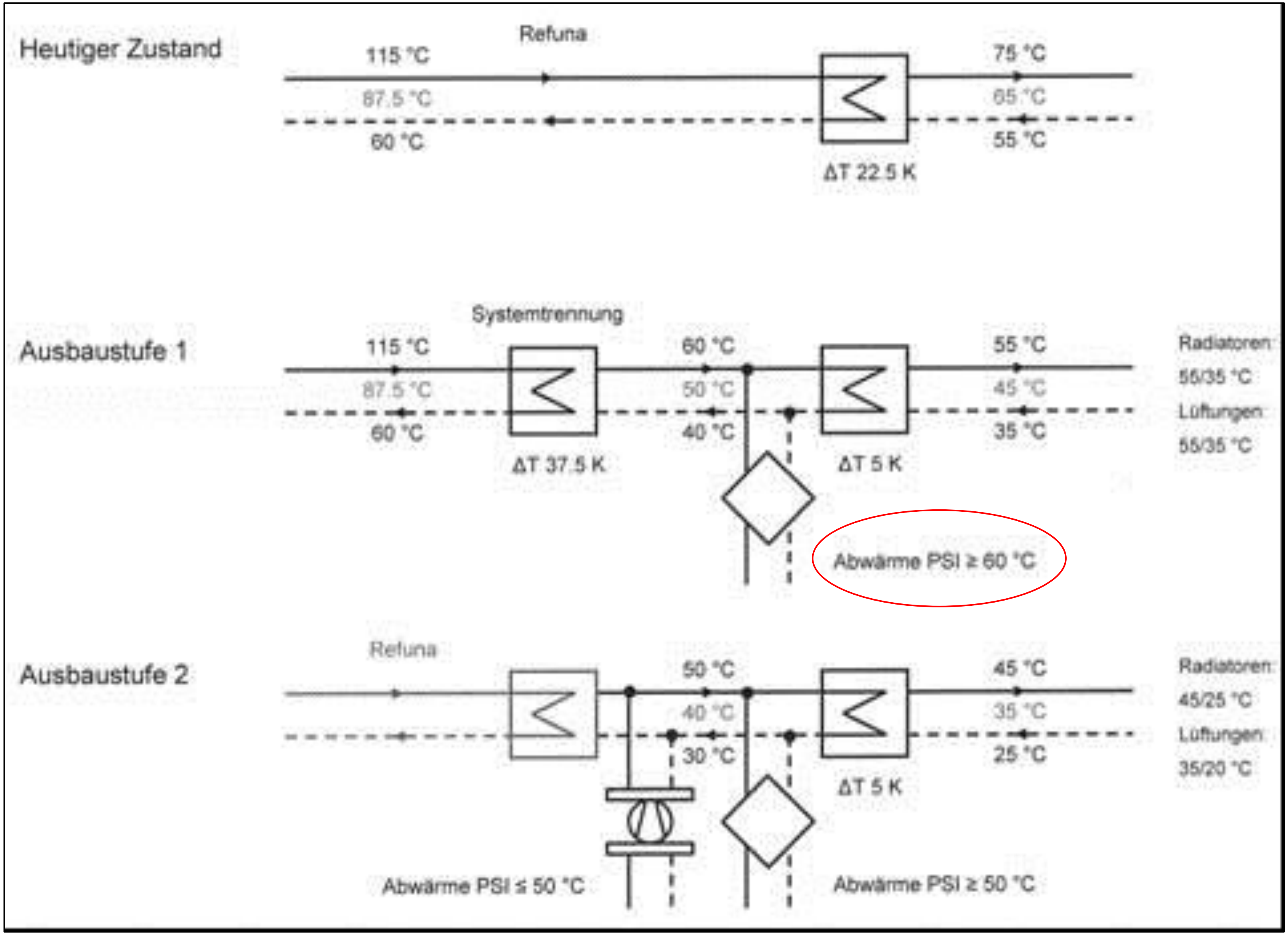


Gebäude	Anlage	Betriebsprofil	Max. Abwärme-leistung [MW]	Primärvor-lauf [°C]	Primär-rücklauf [°C]	Sekundär-vorlauf [°C]	Sekundär-rücklauf [°C]
WSGA	HF0	April - Dezember	2	50	65	55	71
RZ Ost	Kompressorkältemaschine	ganzjährig	0.25	55	65	50	60
RZ West	Kompressorkältemaschine	ganzjährig	0.25	[illegible]	[illegible]	[illegible]	[illegible]
WSHB	Sultan Heliumkompressoranlage	März - Dezember	0.3	[illegible]	[illegible]	[illegible]	[illegible]
WSGA	HF1	April - Dezember mit regelmässigen Shutdowns ca. 27 Tage/a	1	[illegible]	[illegible]	[illegible]	[illegible]
OLGA	Klimakälte Labors	ganzjährig	0.05	55	65	50	60
ODRA	Klimakälte Reinräume& Prozesslabors	ganzjährig	0.3	55	65	50	60
WKSA	WKSA Heliumkompressoranlage	April - Dezember	0.25	40	60	50	200
OTLA	Druckluftkompressor	ganzjährig	0.03	55	65	50	60
Total	direkt nutzbar		4.43				
WSGA	Beschleunigeranlagen exkl. Proscan, WSLA	April - Dezember	7	[illegible]	[illegible]	[illegible]	[illegible]
WSGA	Tertiärkreislauf	April - Dezember	3	[illegible]	[illegible]	[illegible]	[illegible]
WKZA	Proscan Kühlkreislauf		1		30	30	40
WSLA	SLS	Februar - Dezember mit 7 ca. 10 tägige Shutdowns	3		28	20	30
Diverse	Grundwasser für Klima & Vakuumpumpen		4.5	12	25		30
WLHA	250 MEV Injector	nur kurzfristiger Betrieb					
Total	indirekt nutzbar (Wärmepumpe)		18.5				
Total	**direkt und indirekt nutzbar**		**22.93**				
Heute: nur direkte Nutzung, total max. 1.3 MW für ca. 2'300 MWh/a							

Category 1: 4MW @ appr. 60° C

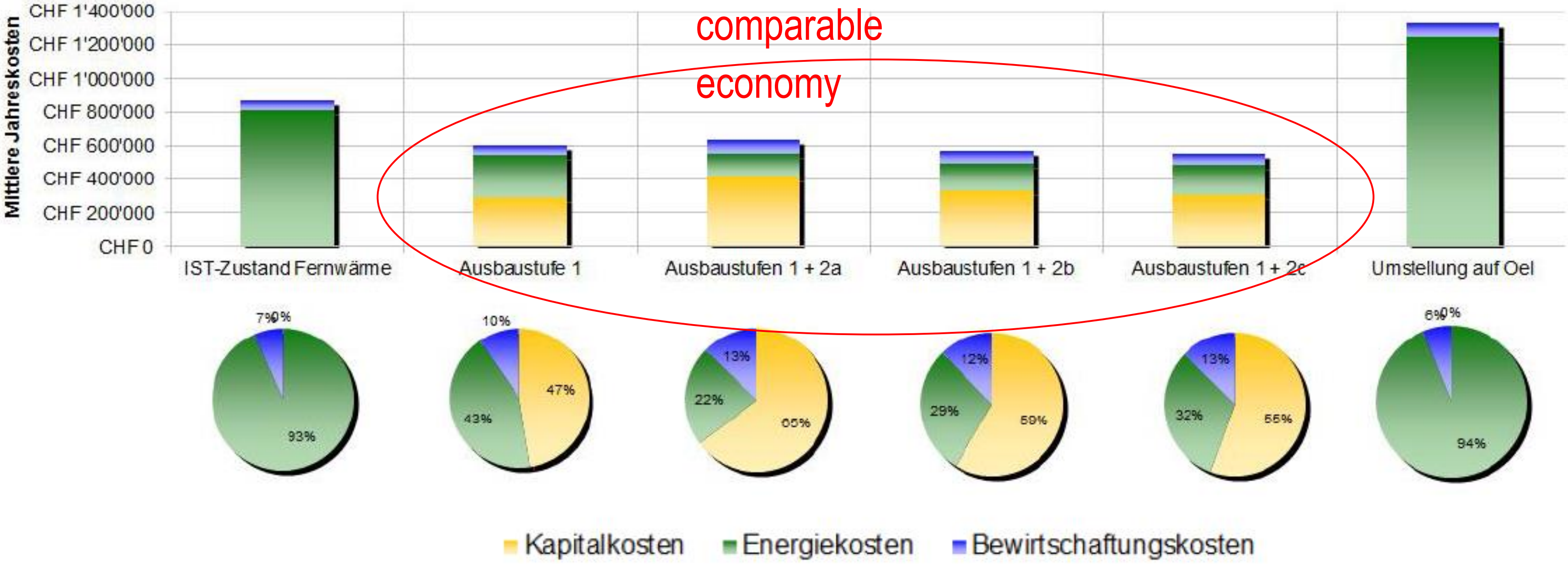
Category 2: 18MW @ appr. 30C

Temperature Decrease to Comply with Heat Sources



Economy Heatrecovery Step 2

Variantenbezeichnung	**IST-Zustand Fernwärme**	**Ausbaustufe 1**	**Ausbaustufen 1 + 2a**	**Ausbaustufen 1 + 2b**	**Ausbaustufen 1 + 2c**	**Umstellung auf Oel**
Kapitalkosten	CHF 0	CHF 284'422	CHF 412'851	CHF 331'549	CHF 308'045	CHF 0
Energiekosten	CHF 809'213	CHF 256'495	CHF 143'359	CHF 165'041	CHF 176'992	CHF 1'244'943
Bewirtschaftungskosten	CHF 58'099	CHF 58'099	CHF 81'338	CHF 69'719	CHF 69'719	CHF 81'338
Total pro Jahr	CHF 867'312	CHF 599'016	CHF 637'549	CHF 566'309	CHF 554'757	CHF 1'326'281



comparable economy

Abb. 8 Zusammensetzung der jährlichen Kostenanteile in CHF und % mit Kapitalzins

→ We have an alternative to todays efficient district heating system

Conclusions

- For the PSI it is effective and economic to recycle waste heat
- A considerable investment of 4Mio approximately was permitted
- Heat recycling is more effective and much more cost efficient than reducing the heat consumption by passive insulation only.
- Optimised campus wide energy concepts with a long-term stategy are highly recommended since according our experience more effective than fulfilling typical energy standards for buildings only!

The Project supports

- Reduction of Primary Energy
- Reduction of Cost for Energy

Conclusions: Energy Management at RIs

Existing RIs:

- Not easy to modernize
- Improve energy networks
  - District heating
  - Cold network with storage
- Integrated energy approach
  - Buildings: heat – cold
  - Energy supply: co-generation (or even tri-)
  - Don’t forget the sun (heating, absorption cooling)
- Use of “Alternative Funding” ≡ “PPP”
- National labs get national “economy stimulation” funds
- GHG consciousness (US)

Conclusions: Energy Management at RIs

New RIs

- Energy issues are part of the design
  - Optimize investment – operation costs
  - Energy: efficiency – recovery
    - May even sacrifice efficiency if recovered “waste” is valuable
  - Integration of RI in local environment is essential
    - Profit from local possibilities
    - Give something to local region
- Good progress underway
  - RF efficiency
  - Extent usage of SC
  - Cooling at different temperature levels

➔ **No new, large RI w/o acceptance by society**