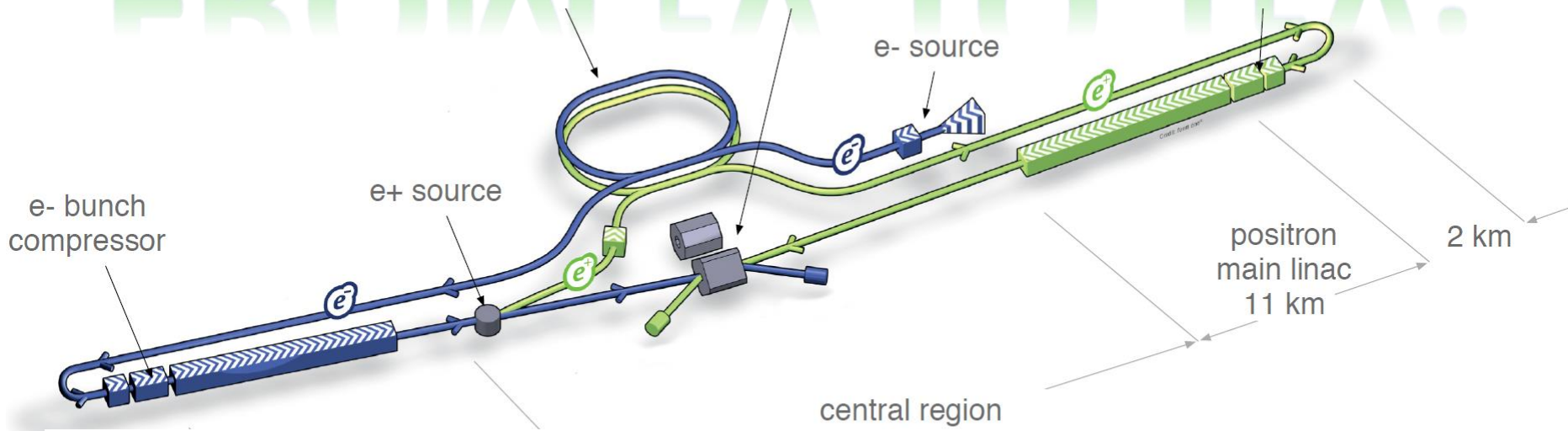


ILC: an amazing energy transformer

FROM eV TO TeV:



THE GREEN ILC

Overview

- ILC and the society
- ILC Energy Budget requirement
- Green Energies for ILC
- Global organization for a Green ILC
- Conclusions

ILC and the society

- ILC: the **first Global Fundamental Science project**, as such it will:
 - Attract worldwide attention: a unique showroom for physics and basic research
 - Host a large number of experts from various fields in an open science framework
- ILC: a **large power consumer**
 - 1.2 TWh (500 GeV) 20% of a nuclear reactor, ~ a large city
 - “Only” for fundamental science
 - In an energy/global warming/financial crisis in the world and in Japan

Energy for colliders

CERN at peak **180** MW, total one year **1.2** TWh ~ **140** MW average (24/7)

"**82%** accelerators, **12%** experiments,
3% computer center, **3%** campus infrastructure.
About **1** TWh gets dissipated in cooling towers"

(H.J.Burckhart et al. IPAC2013)

Compared to Geneva canton (500,000 residents):

Total energy 11.4 TWh/year, 25% goes to electricity (2009)

- CERN is 10% of Geneva total energy
- 40% of Geneva electrical power, equivalent to consumption of 200,000 p
- Electricity bill: 40-50€/MWh ... still 3 times cheaper than mine ... ☹

For 1.2 TWh -> 50-60 M€/year

Energy for ILC (rough estimates)

- e+e- Linac RF, Magnets, Cryo plants: **164MW** @500GeV-**300MW**@1TeV (TDR)
- Experiment ~ 5 MW (one of the LHC experiments)
- Computing ~ 4 MW (estimated from CERN)
- Buildings ~ 4 MW (estimated from CERN)

Very similar to CERN consumption let's take 180 MW (peak) and 1.2 TWh/year

"A primary voltage of **275 kV** was assumed for the site."

"The power capacity is designed to be **300MW** and space is reserved for an additional **200MW** for the future 1TeV upgrade." ILC TDR Vol. 3-1 → **500 MW**

180	-	320 MW	1.2-2.2% of Tohoku region (15 GW) ~ Morioka (300,000)
500 GeV BL		1 TeV	18-32% of Iwate prefecture (ILC location)

- 135€/MWh 2011 in Japan for industry (OECD 2013 report)

Yearly electricity running cost ~ **160 M€** (500 GeV BL)
Even if 50% rebate for very large users → 80 M€/year

ILC baseline energy budget

Table 11.6

Estimated DKS power loads (MW) at 500 GeV centre-of-mass operation. 'Conventional' refers to power used for the utilities themselves. This includes water pumps and heating, ventilation and air conditioning, (HVAC). 'Emergency' power feeds utilities that must remain operational when main power is lost.

Accelerator section	RF Power	Racks	NC magnets	Cryo	Conventional		Total
					Normal	Emergency	
e ⁻ sources	1.28	0.09	0.73	0.80	1.47	0.50	4.87
e ⁺ sources	1.39	0.09	4.94	0.59	1.83	0.48	9.32
DR	8.67		2.97	1.45	1.93	0.70	15.72
RTML	4.76	0.32	1.26		1.19	0.87	8.40
Main Linac	52.13	4.66	0.91	32.00	12.10	4.30	106.10
BDS			10.43	0.41	1.34	0.20	12.38
Dumps					0.00	1.21	1.21
IR			1.16	2.65	0.90	0.96	5.67
TOTALS	68.2	5.2	22.4	37.9	20.8	9.2	164

MW

Rank: 1 6 3 2 4 5
 % : 42 3 15 23 13 5

Green ILC

- Energy saving and improving efficiency (J. Fujimoto)
 - Better component efficiency: klystron, cryocooler (see M. Yoshioka*)
 - Beam energy and beam dump heat recovery (See A. Suzuki*)
 - Heat recovery from cooling system (Sterling engines and heat pumps, thermoelectricity, osmosis, ...)
- Production: Developing Sustainable energies for ILC
 - How to adapt the ILC component power requirements to the various energy sources distinctive features (DC (PV) supply for cryo and RF, variability, ...)
 - How to build energy storage to cope with ILC running conditions (batteries, liquid helium, hydrogen, hydro, compressed air, ...)
 - What is the best mix to cover ILC specific needs ? 24/7, long shutdowns
- Distribution: Smart (Local) GRID: Full scale multi-sourced GRID management and control
 - Smooth and rapid switching between energy sources, including conventional supply
 - Energy Management and forecast: production, storage and backup

*Energy for sustainable science workshop (CERN 2013)

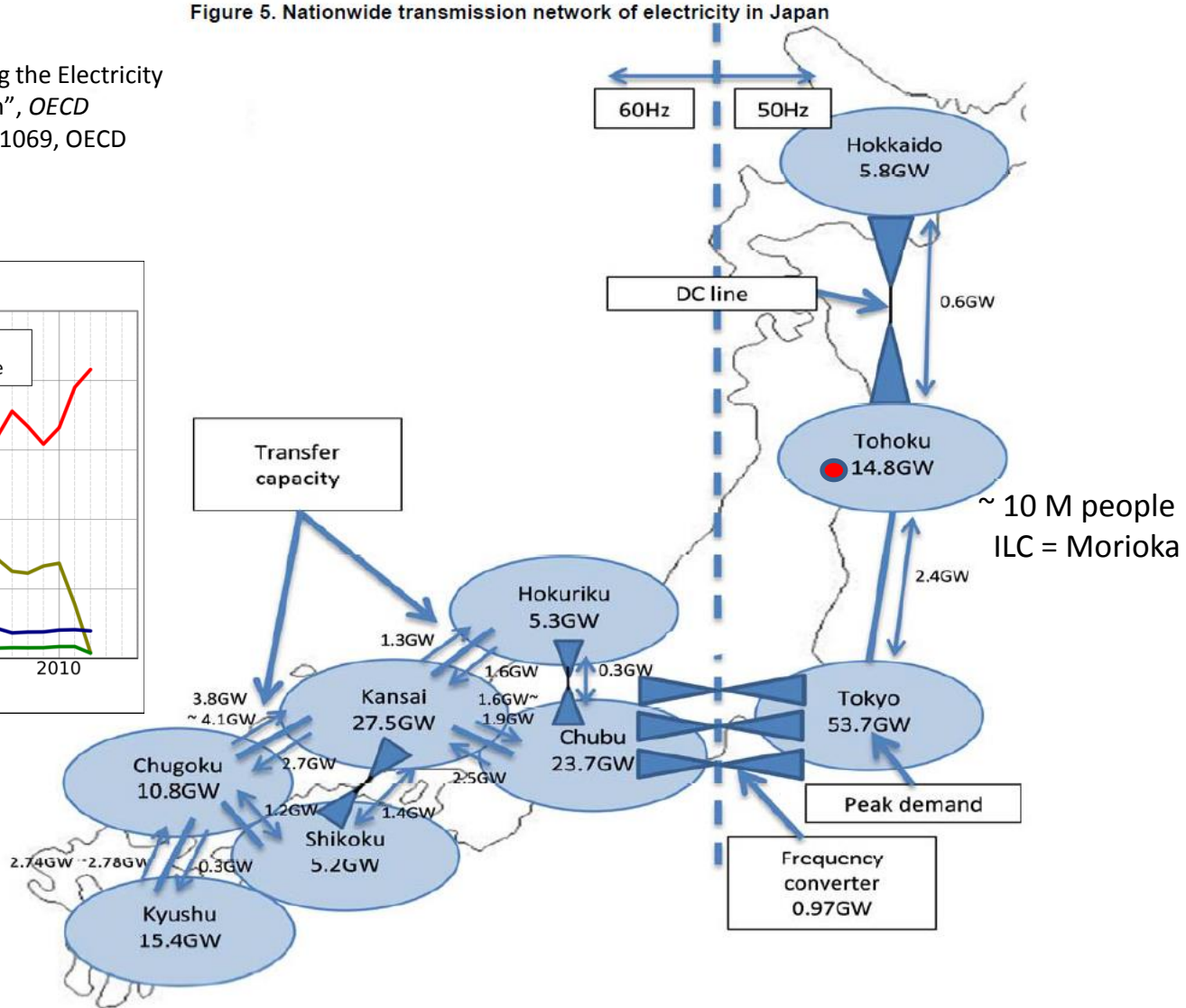
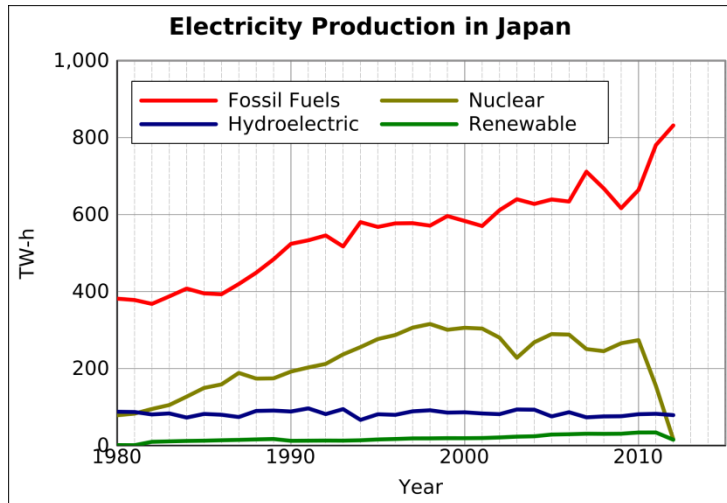


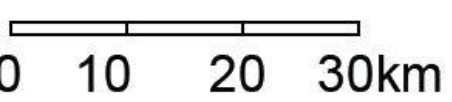
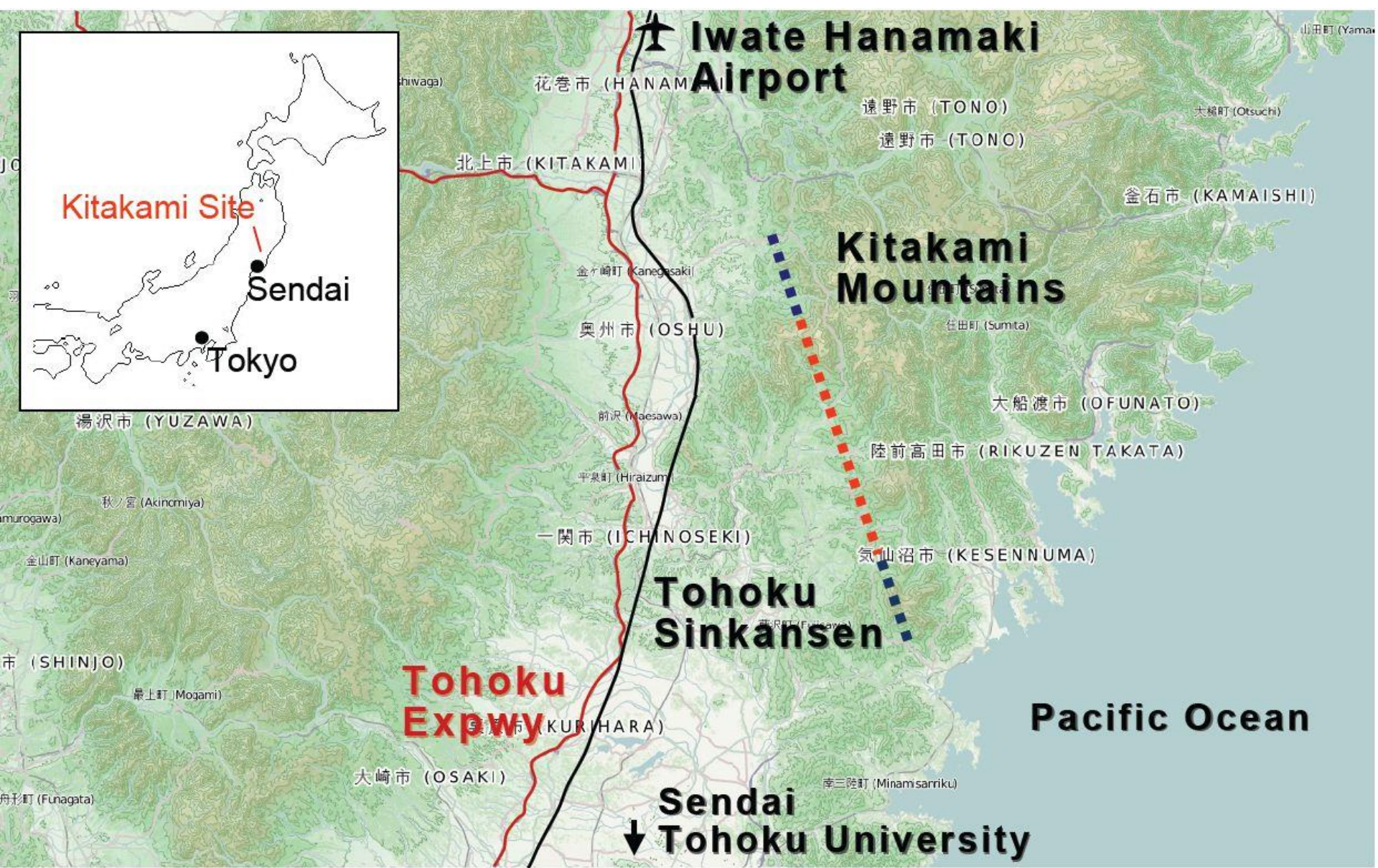
ILC site

The Japanese GRID

Figure 5. Nationwide transmission network of electricity in Japan

Jones, R. S. and M. Kim (2013), "Restructuring the Electricity Sector and Promoting Green Growth in Japan", *OECD Economics Department Working Papers*, No. 1069, OECD Publishing.
<http://dx.doi.org/10.1787/5k43nrxrhjtd-en>





LEGEND :

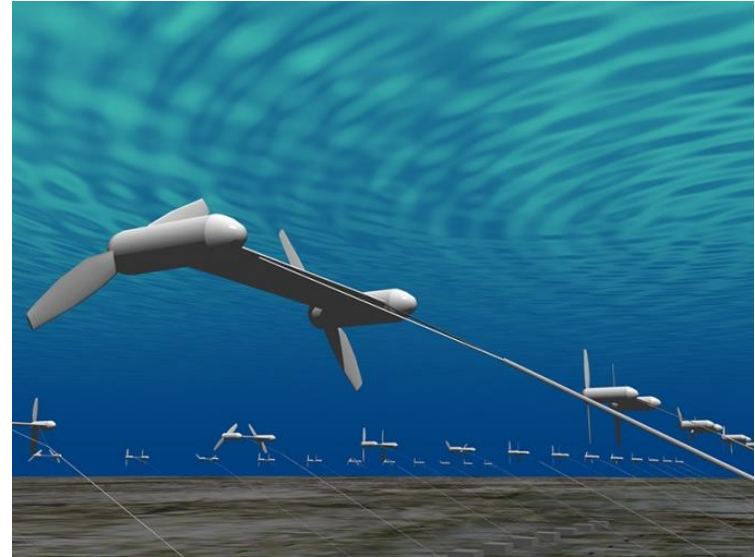
ILC 500GeV

ILC 1TeV

Wind/Marine Energy



2 MW Goto island prototype

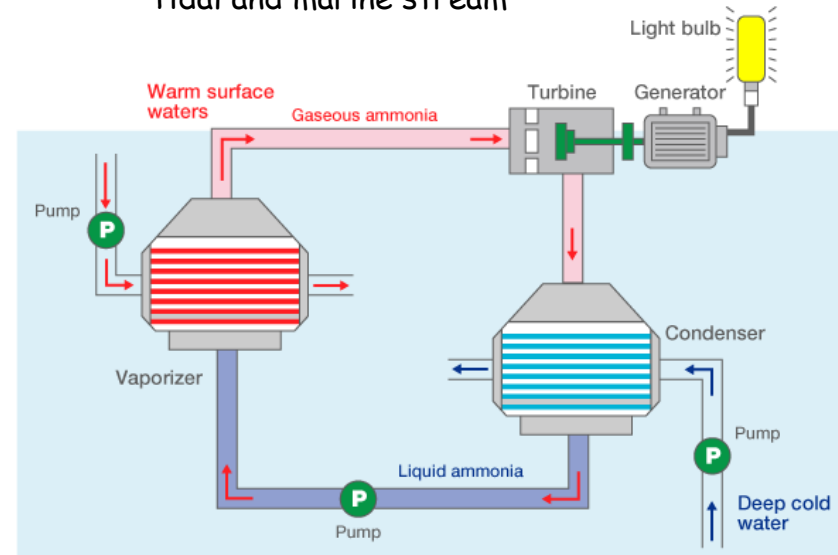


Tidal and marine stream

2.3 GW installed, none failed after 3/11

Wind Projects

6 floating 2MW wind turbines off Fukushima
up to 80 in 2020



Sea temperature gradient

Biomass/biofuels Energy



Idemitsu Kosan Co. 5 MW

Installed 2.3 GW (2011)
very little progress since 2011

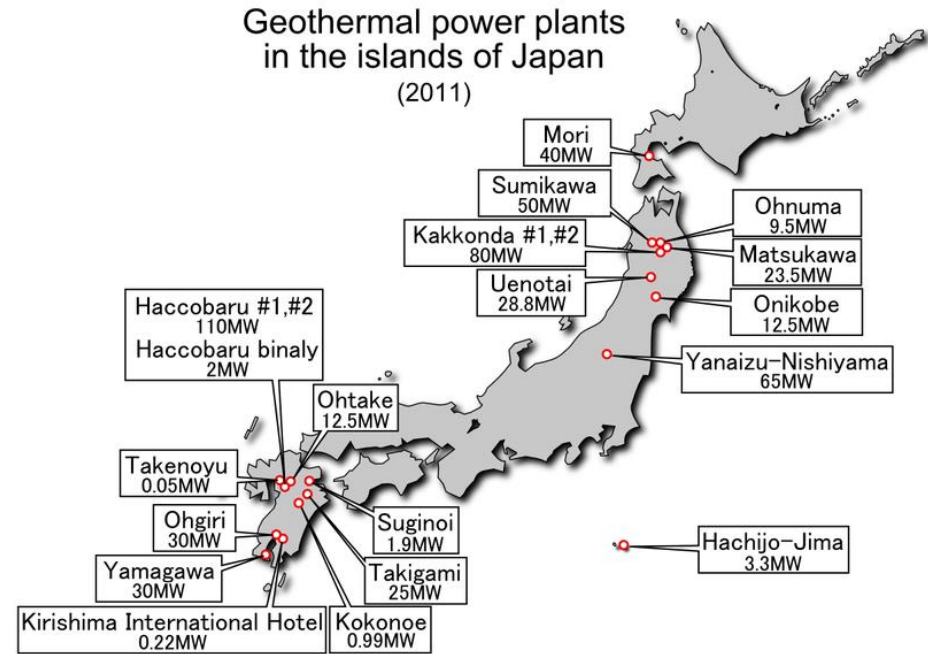


Miyasaki, Nishinippon Env. Energy co. 11.7 MW

Many sources including:
Rice, fishery and agricultural wastes
Algae
Other cattle and human wastes

Co-generations heat and electricity

Geothermal Energy



Installed 2011 : **0.5 GW**.

Geothermal potential sources : ~ **20 GW**

No substantial progress since 2011

But:

- Avoid National Parks
- Get agreement with the onsen industry
- No Fracking

Photovoltaic and Thermal Solar energy



10 MW Komekurayama 30 km Fuji-san (TEPCO)

Installed: 8.5 GW

Projects:

341 MW in Hokaido

100 MW Minami Soma

2009 Target Japanese gov.

28 GW of solar PV capacity by 2020

53 GW of solar PV capacity by 2030

10% of total domestic primary energy demand met with solar PV by 2050

LCWS, Tokyo Univ. Nov. 2013

Denis Perret-Gallix
LAPP/IN2P3.CNRS (Fr)



70 MW in Kagoshima started Nov. 7 2013

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Major contract signed for supply of solar panels derived from CERN technology

09 Mar 2012



SRB Solar field in Valencia (Image: CERN)

Solar thermal Energy

C. Benvenuti
CERN Physicist

Note in passing

ILC: an amazing energy transformer

Assuming an ILC powered by photovoltaic energy:

Energy at the particle level:

from 1 eV to 1 TeV:

12 orders of magnitude, a Tera scaling

Energy concentration:

Ratio of the PV surface to collect 82 MW(one beam) to the beam size:

20 orders of magnitude, almost Zetta scaling

But energy transformation efficiency:

Beam power/AC power: 6-7%

Global organization for Green ILC

ILC Energy Center

ILC High-Energy Research Center

Fundamental Research

HEP Applications

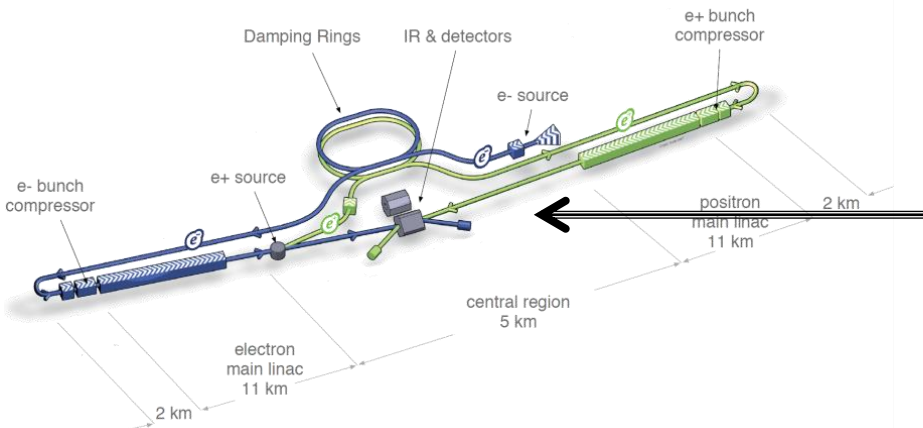
ILC Sustainable Energy Research Center

Basic Research

Application R&D

Pilot Power plant for ILC

Electrons, photons,
neutrons factories
HPC/GRID Computing



ILC Sustainable Energy Research Center

- Two main objectives:
 - R&D on Sustainable Energies, attracting the best experts.
 - Powering ILC
- Industry participation
 - Energy issues relate to most of the industry (much more than HEP)
 - Twofold interest: be part of a global research endeavor and reach ILC market
 - ILC achievements: a showcase for the companies
- Institutes and organizations over the world can be involved:
 - In Japan JCRE Japan council on renewable energies, JREF, ..
 - In the world: IEA, NREL (US), CREST, Narec(UK), CENER(SP), ..

However:

- Must run parallel to ILC, minimum impact on ILC timeline
- Must have its own specific budget from:
 - public programs, governmental and regional (EU) plans (US-EU energy council, ...)
 - Industry participation and contribution

Main missions

- Contribute to the most advanced and promising researches:
 - **Basic research ... is the most needed and less funded**
 - Nanotech for energy production and storage, for lighting, ...: graphene, nanotubes, quantum dots, ...
 - Biomimetic research (artificial photosynthesis) and quantum effects in solid states
 - New materials for: catalysts, fuel cell membranes, high-Tc SC, solar cells high efficiency
 - Low energy harvesting devices, STEG (thermo-electricity), ...
 - Characterization tools and computer modeling
 - **Technology and engineering (devices and systems)**
 - Hybrid systems, best mix, energy transformation, **matching energy source and accelerator components**
 - Specific equipment like: Solar Powered Cryocooler (DC compressor, Thermoacoustic Stirling Heat Engine Pulse Tube), solar energy to RF, fuel cells for computing systems
 - R&D on biomass, geothermal, wind/stream turbines
 - Smart GRID
- Power the ILC:
 - Identify power plant **locations** with low environmental impacts.
 - Design and build **pilot power plants** (a few 10 MW each) from various complementary energy sources for real scale studies and substantial ILC power supply.
 - Build the **ILC Smart Grid** with connection to: conventional grid, pilot plans, storage

Can the ILC project reach **energy self-sufficiency**? How and when ?

Benefits for Energy Research

Research in a cross-disciplinary and global center.

"Scientific work is still too fragmented and specialized, with a focus on incremental change rather than on transformation." OECD Sustainable Energy Forum 2013

Focus on basic research, rarely done in other frameworks: Innovation and Industry target short term returns

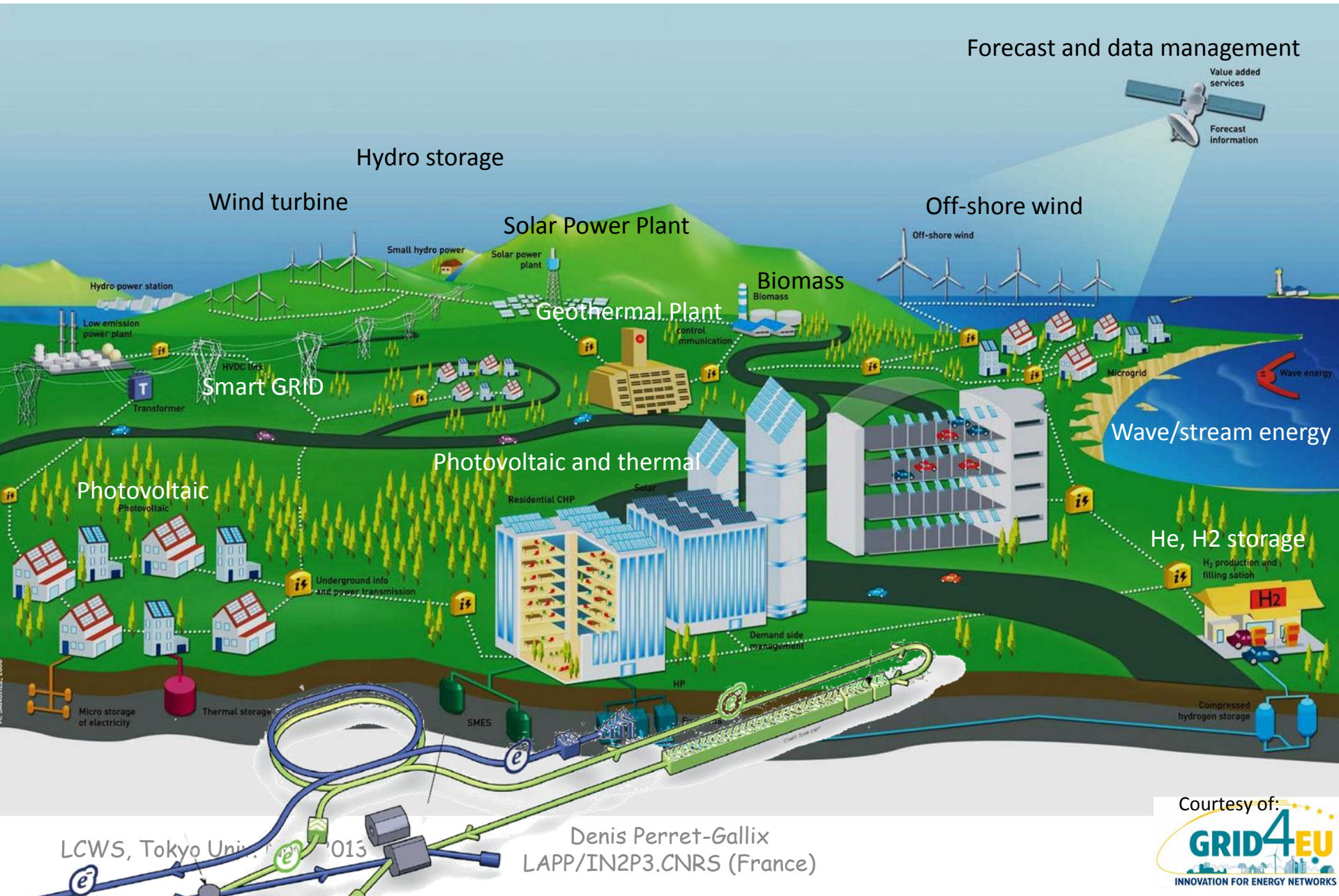
"Science can be perceived as working too much for vested corporate interests and not enough for the public interest" OECD Sustainable Energy Forum 2013

Comprehensive framework: From basic research to pilot plants

Synergies with HEP/accelerator:

- Material analysis (photon factories (XFEL), neutron sources, ...)
- Large computing centers (GRID), Geant4 simulations, turbulences,
- Expertise in advanced electronics, large electronics and computing system management,
- Expertise in very high vacuum, surface treatment and cleaning, ...
- Expertise in large scale manufacturing industrialization (cavities and magnets): from design to commissioning (quality control, ...)

ILC center futuristic view

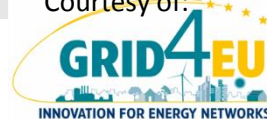


LCWS, Tokyo Univ.

013

Denis Perret-Gallix
LAPP/IN2P3.CNRS (France)

Courtesy of:



Gradual Multi-Staged Implementation

1. As a backup of the conventional power supply (~ 7 MW current diesel engines)
2. To cover buildings energy (electricity and heating) (~ 10 MW) (zero energy)
3. To power some parts of the ILC components: some of the cryo plants, computers, (10-20 MW)
4. To power more of the previous components (30-40 MW)
5. To power some of the klystrons (100 MW)
6. All 500 GeV ILC electrical supply (170 MW)
 - Conventional power supply is now in backup mode
7. Get ready for the 1 TeV (additional 150 MW)

ILC Sustainable Energy Research Center Location

- Most genuinely close to ILC, in Kitakami vicinity
- But not necessarily, through special agreements between electrical power utility companies
 - could be anywhere in Japan or even with plants disseminated at the most favorable locations
 - Anywhere in the world, could be part of the country running costs contributions, but should be sustainable energy... reinventing the Data GRID model

Next step

ILC Energy Working Group

- Members: Energy, ILC and Industry experts
- Missions:
 - Identify all possible energy saving and recovery technologies related to the ILC project
 - Setup a baseline project as well as an advanced research line on more innovative technologies
 - Evaluate the impacts on the ILC project it-self in term of:
 - ILC Design modification and implementation
 - Budget spending and saving
 - Design a global sustainable energy project for the ILC
 - Identify short term renewable energy pilot plants with build-in upgradability
 - Identify basic energy researches in line with the ILC project
 - Propose an "ILC Energy Center" global organization
- Report: *Green ILC Feasibility* report by 2014-2015

The Green ESS

European Spallation Source -- 4R

Renewable:

All energy from new, dedicated renewable production at a stable and competitive cost

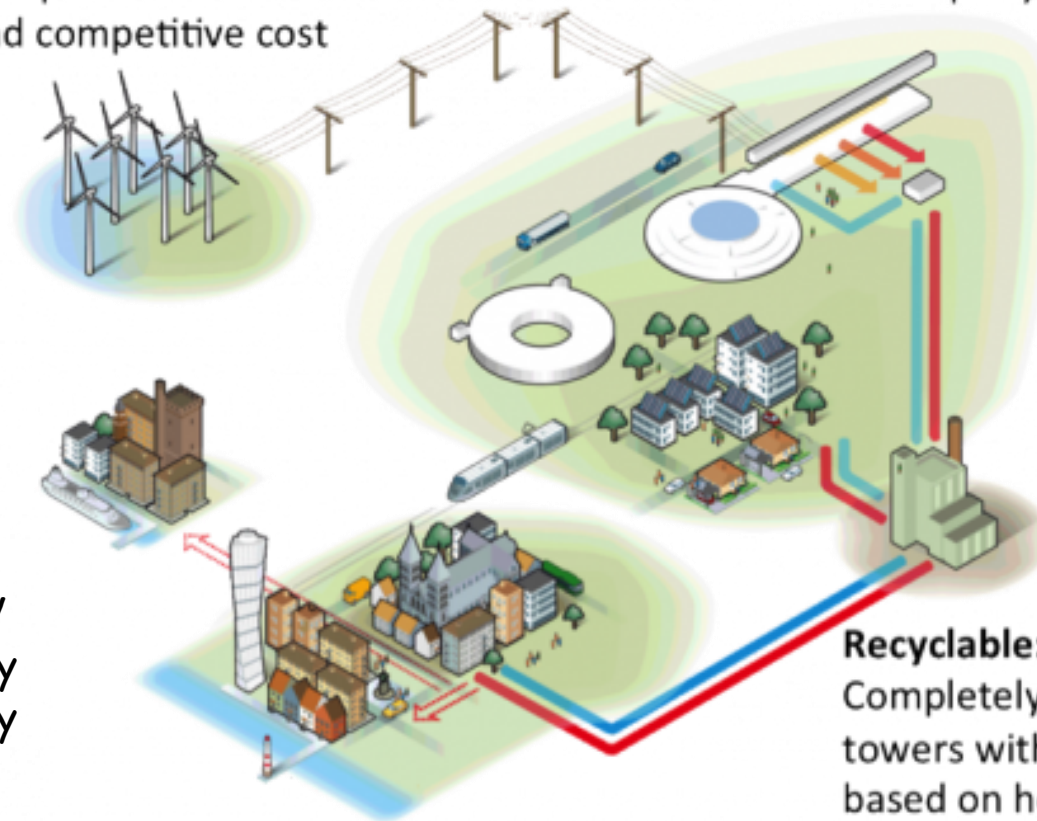
Responsible:

Reduce energy use to under 270 GWh per year

Reliable

stable electricity and cooling supplies

Wind Power: 100 MW
Machine: 278 GWh/y
Cooling: 265 GWh/y



Recyclable:

Completely replace cooling towers with a cooling system based on heat recycling.

Conclusions

- **ILC** being the size of a city, is a **real scale workbench** to develop, maintain and manage a mix of sustainable energy sources.
- HEP: a driver for innovation: a unique opportunity **to link HEP and Energy R&D** in an ambitious but rewarding endeavor:
 - **Societal impacts:**
 - Tackle one of the most important world-wide issue: **Energy**, boost basic energy research which is most needed today
 - Raise ILC and fundamental research public visibility and appreciation
 - Better local appraisal: ILC provides rather than consumes energy resources
 - **Great saving** in running cost particularly if R&D/infrastructures are supported by a separate additional budget. ILC is a (very) **long term effort**, investing in green energies makes sense.
 - **Better flexibility** in ILC operations (less GRID dependence)
- Additional motivations for the decision makers: ILC goes beyond basic science
 - **In Japan:**
 - Revitalization of the economics (Abenomics), Re-industrialization after Tsunami in Tohoku, Global cities (Japan Policy Council), industry (AAA) and internationalization
 - **Elsewhere:** fewer incentives. But **energy** is a big and motivating issue for everyone

Additional slides

Renewable energy Japan (METI)

Energy Source	Total capacity before FY2011	Total capacity starting operation in FY2012	Total capacity starting operation in FY2013 (as of May 31, 2013)
Photovoltaic power (for households)	4.4 GW	1.269 GW	0.279 GW
Photovoltaic power (non-household)	0.9 GW	0.706 GW	0.961 GW
Wind power	2.6 GW	0.063 GW	0.002 GW
Small and medium hydropower (1,000 kW or more)	9.4 GW	0.001 GW	0 GW
Small and medium hydropower (less than 1,000 kW)	0.2 GW	0.003 GW	0 GW
Biomass power	2.3 GW	0.036 GW*	0.038 GW
Geothermal power	0.5 GW	0.001 GW	0 GW
Total	20.3 GW	2.079 GW	1.280 GW