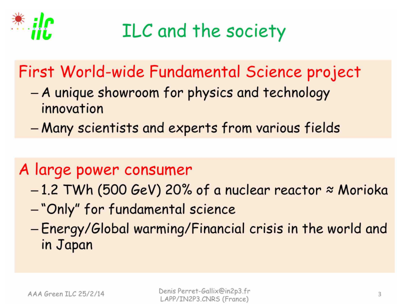
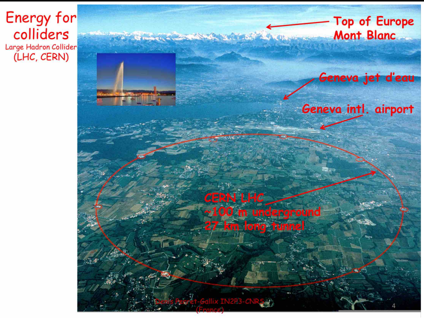
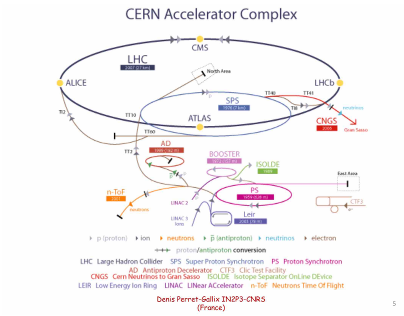
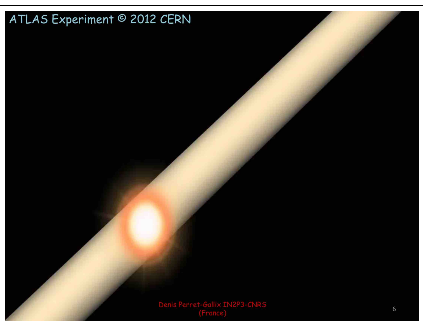
3 Green Technology Trends and Application to Accelerator in the World

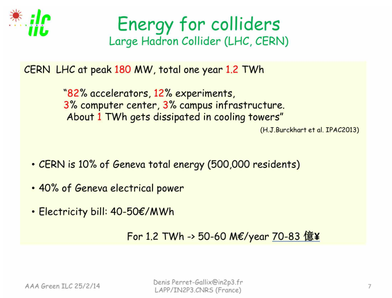
The Green-ILC
(Denis Perret-Gallix, LAPP/IN2P3/CNRS)

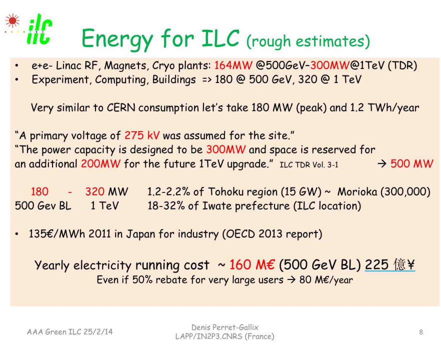


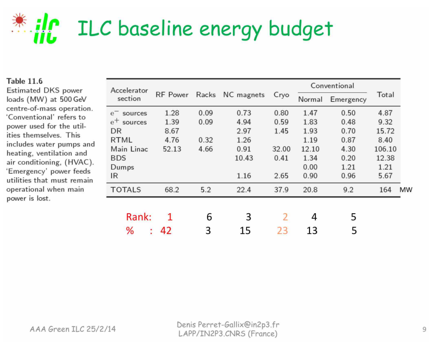












Accelerator section	RF Power	Racks	NC magnets	Cryo	Conventional Normal	Conventional Emergency	Total	
e^- sources	1.28	0.09	0.73	0.80	1.47	0.50	4.87	
e^+ sources	1.39	0.09	4.94	0.59	1.83	0.48	9.32	
DR	8.67		2.97	1.45	1.93	0.70	15.72	
RTML	4.76	0.32	1.26		1.19	0.87	8.40	
Main Linac	52.13	4.66	0.91	32.00	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		

Some other Green Projects

- Synchrotron light (Tohoku) 3.7 MW
- European Spallation Source (ESS) 100 MW
- Studies of the Future Circular Colliders 500 MW
- Hyperloop high speed train 21 MW
- Car factories and Mori Tower 38 MW
- Workshop " Energy for sustainable science"
- ……

AAA Green ILC 25/2/14 Denis Perret-Gallix@in2p3.fr LAPP/IN2P3.CNRS (France) 10

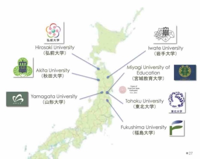
東北放射光計画

Synchrotron Light in Tohoku, Japan (SLiT-J)

– 光源加速器システムの概要 –
Outlook of Light Source Accelerator Complex

version 2013.5

濱 広幸、早稲田嘉夫 ＋ ビーム物理研究部門
東北大学電子光理学研究センター
東北大学大学院理学研究科物理学専攻
＋
SLiT-Jデザインチーム
SPring-8/高輝度光科学研究センター/理研



建屋・消費電力

消費電力見込み	
光源リング	2.02
線形入射器	0.25
制御系	0.10
ビームライン・実験系（24本）	0.24
施設・ユーティリティ	1.10
計	3.71 MW

約15400平米の加速器施設棟の屋上に0.22kw/m²の発電能力を持つソーラーパネルを設置すれば約3.4MWの発電量を得ることができ、ほぼ運転消費電力をまかなうことができる。

AAA Green ILC 25/2/14 Denis Perret-Gallix@in2p3.fr LAPP/IN2P3.CNRS (France)

The Green ESS

European Spallation Source -- 4R

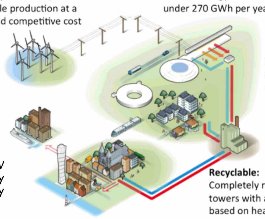
neutron source

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

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



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

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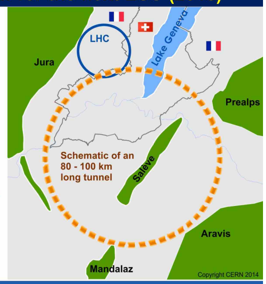
Future Circular Collider Study - SCOPE
CDR and cost review for the next ESU (2018)

Forming an international collaboration to study:

- *pp*-collider (*FCC-hh*)
  → defining infrastructure requirements

~16 T ⇒ 100 TeV *pp* in 100 km
~20 T ⇒ 100 TeV *pp* in 80 km

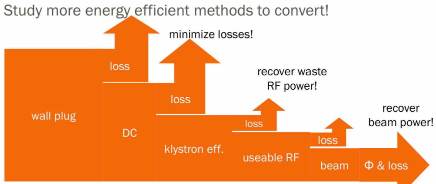
- e^+e^- collider (*FCC-ee*) as potential intermediate step
- *p-e* (*FCC-he*) option
- 80-100 km infrastructure in Geneva area



Future Circular Collider Study
Michael Benedikt
FCC Kick-Off 2014 13

Energy Efficiency

- For FCC-ee of major importance – 100 MW CW RF requires at least 200 MW from the grid to produce (in addition to cryogenic power mentioned above)
- Study more energy efficient methods to convert!

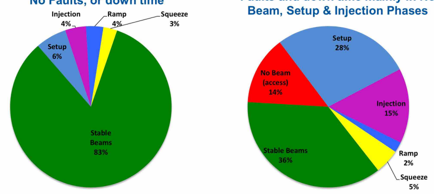


Future Circular Collider Study Kick-Off Meeting, Geneva 2014
Erk Jensen
100 MW RF System 14

LHC Operational Efficiency

LHC Design
Minimum Time for each operation
10 hour Physics Coasts
No Faults, or down time

LHC 2012
Average Time in each phase
6 hour Average Physics Coasts
Faults and down time mainly in No Beam, Setup & Injection Phases



In spite of how it looks LHC operation in 2012 was very good !!

20 February 2014 Paul Collier FCC Kick-Off Meeting 15

FCC-ee Power Consumption Estimates

Based on the 80km Machine Study – Should not be too different to a 100km version. Pre-injectors not included.

It includes the infrastructure scaled to the need for TLEP and not that which would be installed to allow a future installation of a pp machine.

TLEP (175)	MW
RF System	218
Cryogenics	24
Cooling & Ventilation	60
Magnet Systems	6
General Services	15
Experiments	25
Total	353

The Key Driver here is the RF system: Cavity characteristics and efficiency of the RF power sources (assumed 55%)

Paul Collier FCC Kick-Off Meeting 16

FCC-hh Power Consumption

System	LHC	FCC-hh
Power Converters	20	80
Machine Cryogenics	35	140
Cooling	20	80
Ventilation	14	56
RF	18	72
Other Machine	2.5	10
Experiments	22	30?
Total / MW	131.5	468

To first approximation:

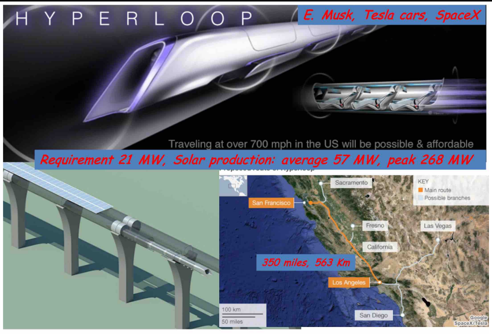
Most will scale to FCC-hh very approximately according to length (ie x4)

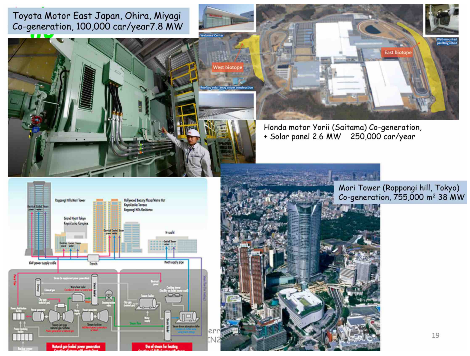
The Experiments are likely to be more than LHC but not by a large factor

Beware: This is a ball-park figure to set a rough scale!!

Clearly the Cryogenics is a key driver
But the infrastructure itself (cooling/ventilation) will also be a large consumer
The RF system itself (if >60MV is needed) is significant
➢ same R&D for ee and hh machines !!

Paul Collier FCC Kick-Off Meeting 17





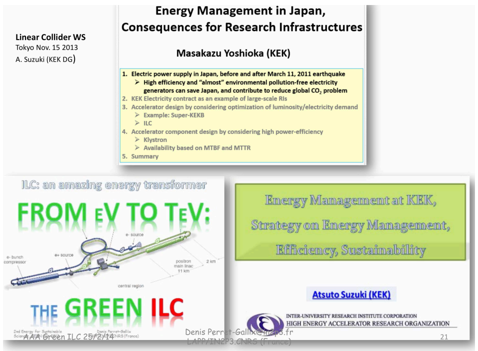
Energy for Sustainable Science

23-25 October 2013
CERN

2nd Workshop Energy for Sustainable Science at Research Infrastructures

- Campus and building management
- Co-generation
- Computing energy management
- Energy efficiency of the facilities
- Energy management, quality, storage
- Energy management technologies developed in Research Facilities
- Waste heat recovery

CERN — EUROPEAN SPALLATION SOURCE — ERF European Association of National Research Facilities



Green ILC strategy

1. Energy Saving: improving efficiency
2. Energy Recovery: recycling energy
3. Energy Production: Renewable energies
4. Energy Storage
5. Distribution and Management: Smart Grid

➡ DESIGN

Green ILC
Energy Saving

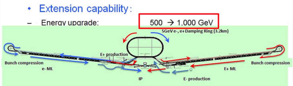
On components:
- klystrons R&D for higher efficiency
- cryocooler and cryogenic system optimization
  - New ideas: Thermoacoustic Stirling Heat Engine Pulse Tube
- ILC Lattice optimization

On operation
- Power reduction during idle periods:
  - system on standby and energy saving mode
  - More effective if made on design
  - Long running period (fewer, but longer shutdown due to cryo)
- Increase reliability (to avoid down time)

Power Balance of Consumption and Loss in ILC

Linear Collider WS
Tokyo Nov. 15 2013
A. Suzuki (KEK DG)

Requirements from Physics Exp.
- Basic requirements:
  - Luminosity : $\int Ldt$ = 500 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

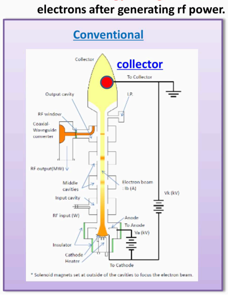
How to Improve RF Efficiency

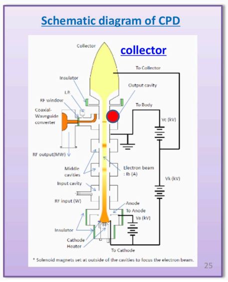
Linear Collider WS
Tokyo Nov. 15 2013
A. Suzuki (KEK DG)

R&D of CPD (Collector Potential Depression) Klystron

CPD is an energy-saving scheme that recovers the kinetic energy of the spent electrons after generating rf power.

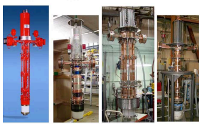
Conventional | Schematic diagram of CPD

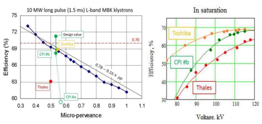




Multi-beam klystrons: State of the art

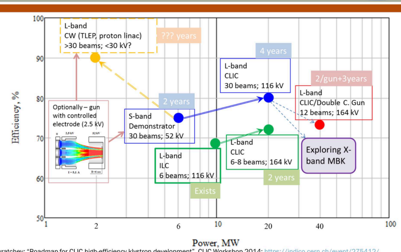
- Space charge is limiting efficiency → many small beams to reduce space charge effects.
- State of the art: Developed for ILC/X-FEL, 1.3 GHz, 10 MW peak (1.5 ms · 10 Hz), $\eta = 65\%$.





Igor Syratchev, CLIC Workshop 2014

90% efficiency on the horizon?



I. Syratchev: "Roadmap for CLIC high-efficiency klystron development", CLIC Workshop 2014: https://indico.cern.ch/event/275412/

IOTs

Inductive Output Tube: density modulation with a grid (like a tetrode) output to a cavity (like in a klystron). IOT shorter, less gain than klystron. IOT in 70 kW class used for DVB transmitters.

- Klystrons reach maximum efficiency only in saturation.
  - Is it necessary to back-off in operation? (we did during LEP2!)
- IOTs (Inductive Output Tubes) may be better in this respect:

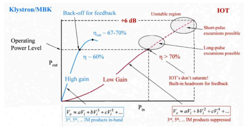
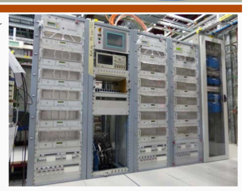


Illustration from CPI

Solid state?

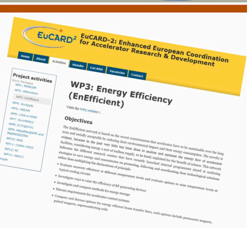
- Picture shows a 100 kW installation for Linac4 (352 MHz)
- 100 MW may not be possible today (or at least much more expensive), but investment into R&D may pay off!
- Interesting feature (concerning availability, to be studied) – one may consider a module replacement while the systems continues to run at nominal performance with small built-in fault tolerance margin…



The goal of the Linac4 project is to build a 160 MeV H− linear accelerator replacing Linac2 as injector to the PS Booster (PSB). The new linac is expected to increase the beam brightness out of the PSB by a factor of 2, making possible an upgrade of the LHC injectors for higher intensity and eventually an increase of the LHC luminosity

Energy Efficiency

- High efficiency, high power RF generation is needed for many future accelerator projects (proton drivers for several applications, linear colliders, material test facilities) and certainly has impact beyond the accelerator community.
- A network called "**Energy Efficiency**" has started to pick up momentum inside the European Project EuCARD2, see http://eucard2.web.cern.ch/activities/wp3-energy-efficiency-enefficient
- You are invited to become part of this network!



Green ILC
Energy Recovery

- Heat recovery from cooling systems:
  - More than 80% of the consumed electrical power is lost as heat: highest temperature preferable
  - Sterling engines and heat pumps, thermoelectricity, heat recovery steam generators, …
  - Heat/cool close by cities, green houses, fish farms, …
  - Recycling efficiency ? Cooling efficiency ? Saving/investment ratio ?
  - Many Industrial applications

- Beam energy and beam dump energy recovery
  - Linear collider (single pass) vs circular collider (recycling beam), but
  - 10-25 MW/beam … a lot of heat and high-radiation
  - Energy Storage
  - New idea … Plasma deceleration dumping

Plasma Deceleration Dumping

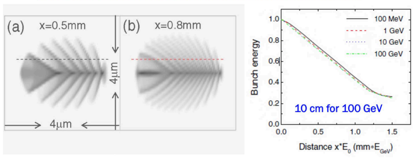
PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 13, 101303 (2010)

Linear Collider WS
Tokyo Nov. 15 2013
A. Suzuki (KEK DG)

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



- 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.

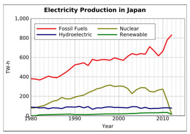
Green ILC

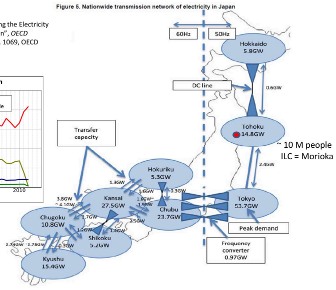
- Energy Production: Sustainable energies for ILC
  - Study the (dis)-advantages of the various sources: solar, wind, geothermal, sea, …)
    - A case study: Availability, Price, Flexibility, Potential to improvement, Environmental impact
  - Find the best mix to cover ILC specific needs ? 24/7, long shutdowns
  - Accommodate the ILC component power requirements to the various energy sources distinctive features:
    - RF power converter: PhotoVoltaic (DC) , wind/sea (variable AC, DC), geothermal,
    - Cryocooler or asynchronous liquefactors, Solar (DC motors), wind/sea Variable AC, or mechanical compressor (no electricity)
    - New cooling technology (
- Energy Storage
  - liquid helium, SMES(Sc Magnetic Energy Storage), Flywheel energy storage, Hydrogen, Hydro (Dam), Compressed air, Batteries,
- Distribution: Smart (Local) GRID:
  Full scale multi-sourced, AC/DC, GRID management and control
  - Smooth and rapid switching between energy sources, including conventional supply
  - Energy Monitoring, Management and forecast: production, storage and backup

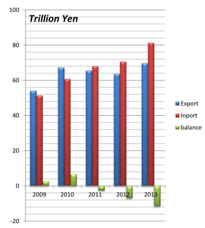
ILC site

The Japanese GRID

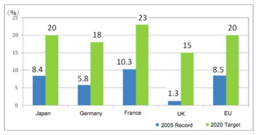
Jones, R. S. and M. Kim (2013), "Restructuring the Electricity Sector and Promoting Green Growth in Japan", *OECD Economics Department Working Papers*, No. 1069, OECD Publishing.
http://dx.doi.org/10.1787/5k43nxrhfjtd-en

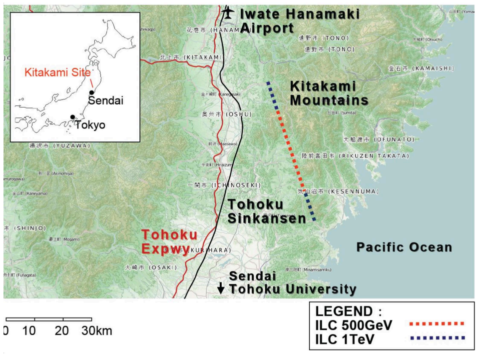






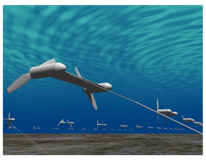
Yen depreciation and energy





Wind/Marine Energy

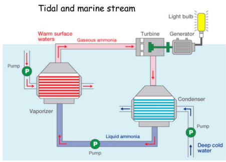
2 MW Goto island prototype



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

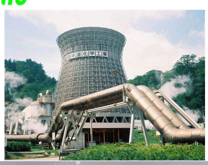
Miyasaki, Nishinippon Env. Energy co. 11.7 MW

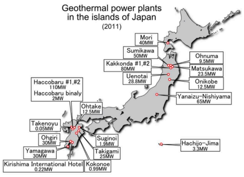
Installed 2.3 GW (2011)
very little progress since 2011

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

Funny note
ILC: an amazing energy transformer

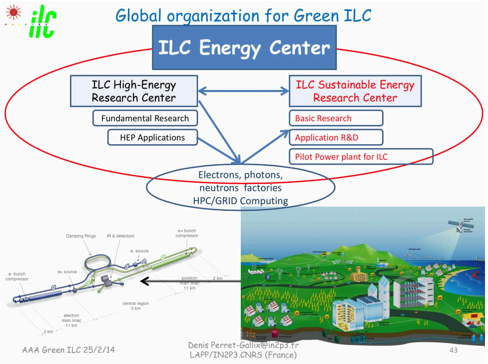
Assuming an ILC powered by photovoltaic energy:

Energy at the particle level:
from 1 eV to 1 TeV:
12 orders of magnitude, a Tera scaling, x 10^{12}

Energy concentration:
Ratio of the PV surface to collect 82 MW(one beam) to the beam size:
20 orders of magnitude, almost Zetta scaling, x 10^{20}

But energy transformation efficiency:
Beam power/AC power: 6-7%

Global organization for Green ILC



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 (Japan Renewable Energy Foundation), ..
  - 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

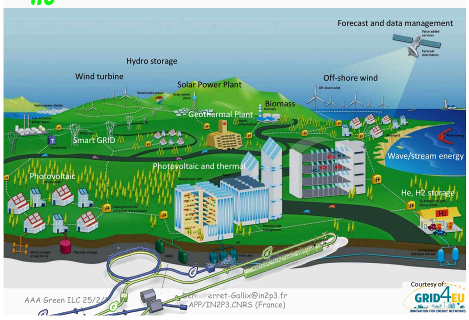
"*Science can be perceived as working too much for vested corporate interests and not enough for the public interest*" OECD Sustainable Energy Forum 2013

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



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

Green ILC tasks (some)
Design and R&D

- Estimation of the energy saving and recovery potentials for all major ILC components
- Setup a baseline project and an advanced research line on more innovative technologies.
- Evaluate the impacts on the ILC project in term of:
  - ILC Design modification, implementation and timeline
  - Budget: additional spending and saving
- Design a global sustainable energy project for the ILC
  - Propose an "ILC Energy Center" global organization
  - Identify short term renewable energy pilot plants with build-in upgradability
  - Identify basic energy researches in line with the ILC project

Green ILC tasks

Governance and Communication

A global open-research framework between Research, Academy, Industry and (Local) Government (Citizens)

- First time in the world
- A pluri-disciplinary R&D dedicated to Energy
- Open to foreign research organizations and companies
- Intellectual Property issues, cross-funding, …

Green ILC Communication

- Towards the ILC community: LCWS workshops and other CERN LHC, CERN FFC, ESS, …..
- More general Conference on "Power Innovation" for large research/industrial infrastructures
- Within the industries involved
- Toward the public and the local citizens
  Prototype: http://tinyurl.com/mj8t3o3

Green ILC Feasibility report by 2014-2015

AAA Green ILC 25/2/14 Denis Perret-Gallix@in2p3.fr LAPP/IN2P3.CNRS (France) 50

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:
    - One of the most important 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

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Additional slides

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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**

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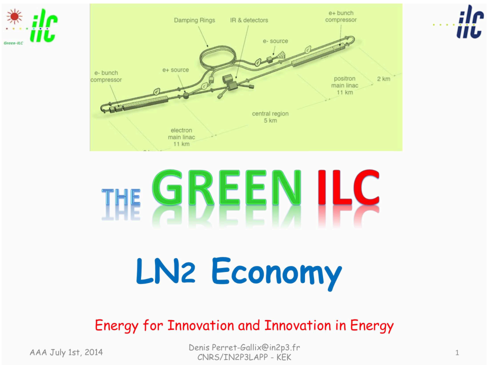
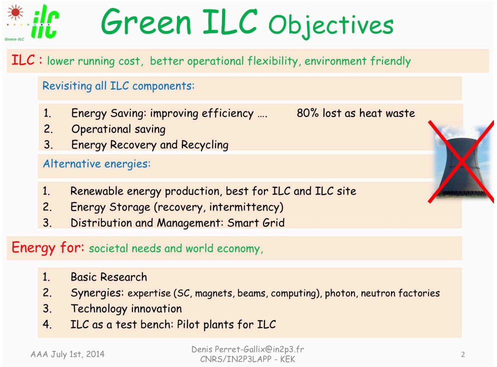
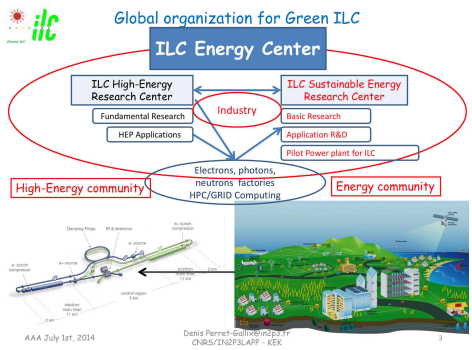
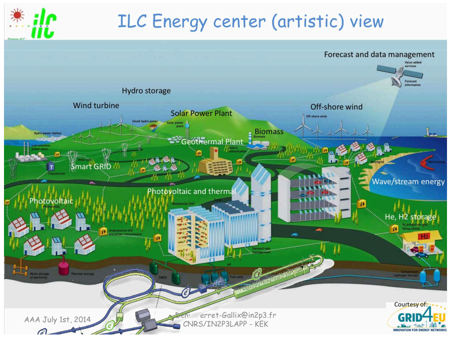
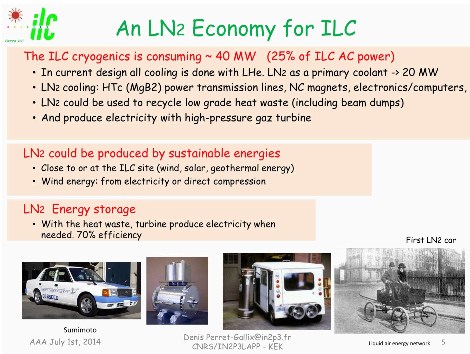
LN_2 Economy
(Denis Perret-Gallix, LAPP/IN2P3/CNRS)

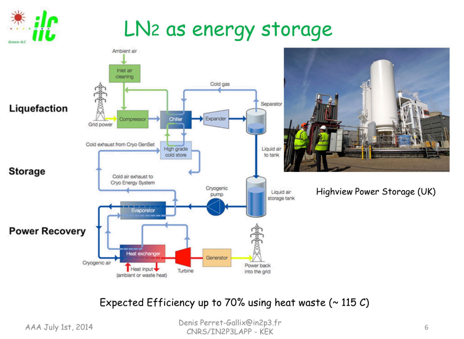


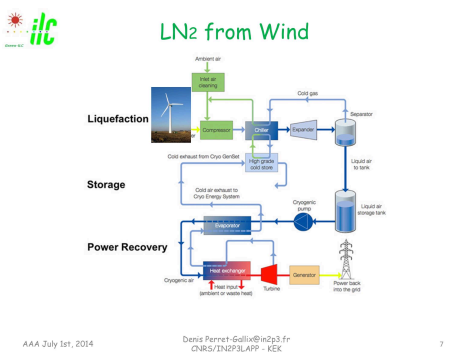


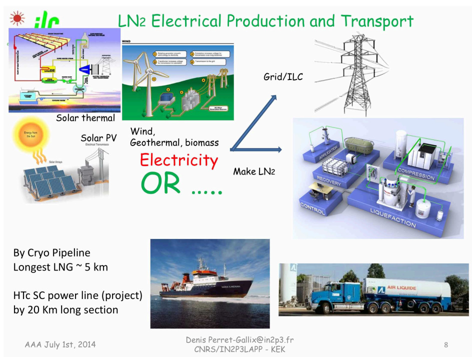




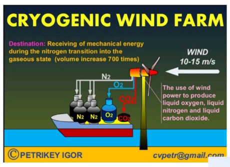






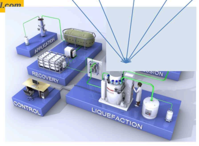


LN2 direct from wind, no electricity … ???



Only compressor in the nacelle

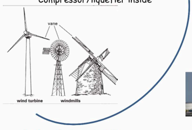
Or …



LN2 process cycle

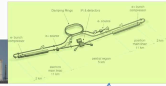
- Cryocooler may save 50% electrical power
- Cooling NC magnets
- HTc power Transmission lines
- Cooling electronics and computers

Compressor/liquefier inside



LN2

Energy storage



LO_2, LAr, SCO_2 Dry ice

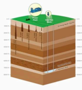
To Industry For Cooling or Sequestration

LN2 heat waste

Turbine → electrical generator

N2 gas applications Electricity Back to ILC/GRID

i.e. Drying and preservation industry



Air cleaning !!!

LN2 for ILC, just as an example Needs R&D

Many positive aspects:
- Negative (less than zero) carbon emission technology, air cleaner
- Important cryogen for ILC:
  - Cooling: cryocooler, HTc transmission lines, ..
  - Heat waste recovery
  - Storage: 1 gazometer (like for NLG): ILC runs ~ 4 days
    - Fast startup (minutes)
    - Long life-time

Applications to industry
- Energy Storage
- Heat waste recovery
- Drying

Safety issues, specially in ILC tunnel:
- N2 gas suffocation
- Cryogenic fluid hazard
- LN2 may liquefy ambient oxygen

Other discussions …. Hydrogen economy

Soon at: Research-up.kek.jp/group/Green-ILC

Green ILC

Energy for Innovation, Innovation in Energy

Home | Blog | Archives | Energy Saving | Energy Recycling | Sustainable Energies | Contacts

MAR 30TH, 2014

The Green ILC Project

ILC, the International Linear Collider, is the next fundamental science project in high energy physics and the first ever true global basic science center.

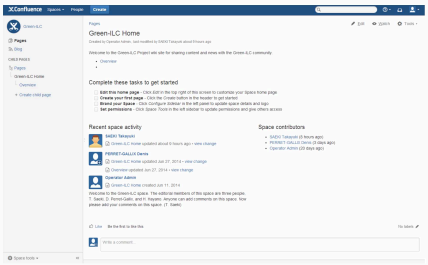
What CERN did for the European HEP community, ILC will do for the world. But the e+e- ILC project may go even beyond mere fundamental science and contribute to one of the world most pregnant issue: Energy, not merely high-energy but, more generally: energy for the society.

Artistic view of the ILC center in Kitakami (Japan)

The ILC scientific goal is simple: high precision study of the Higgs particle recently discovered at LHC (CERN) and other signals LHC could possibly single out. New effects will also be searched for, effects which could have been missed by the LHC due to the heavy background. Higher precision here concerns, more particularly, the various Higgs couplings, limited at LHC, in part, by the

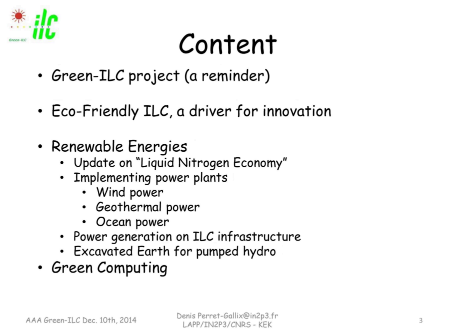
Recent Posts

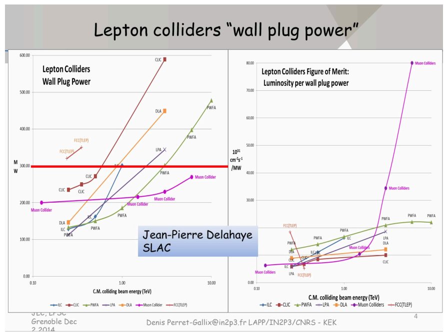
Wiki site for Green-ILC internal discussion:
http://wiki.kek.jp/ Space-> Green-ILC

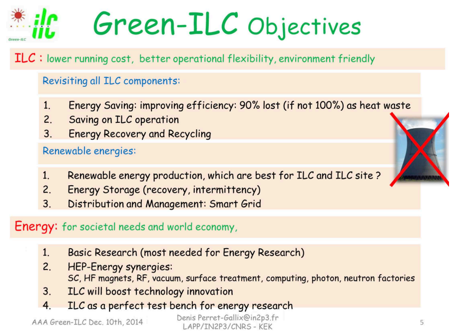


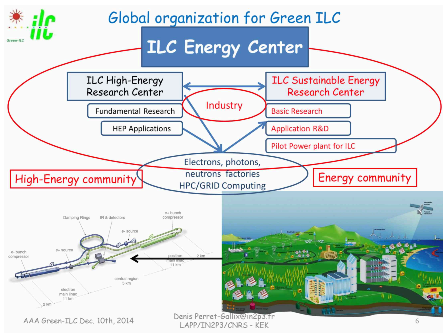
Thank you

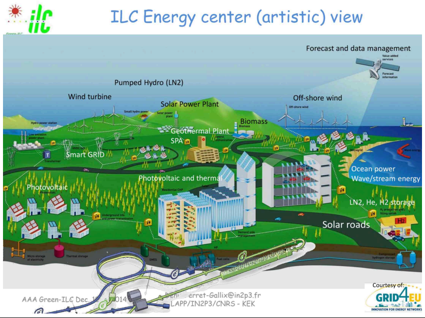
Renewable Energies and Environment
(Denis Perret-Gallix, LAPP/IN2P3/CNRS)

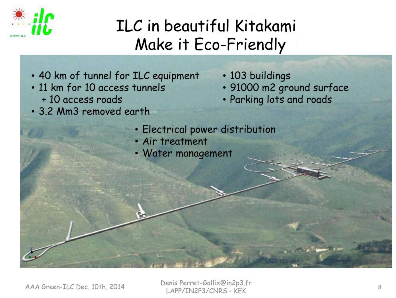












ILC: an Eco-Friendly Model

We know how to build ILC, let's make it beautiful.

- Conserve resources: land, water, air, energy
- Minimize pollution
- Keep it aesthetic

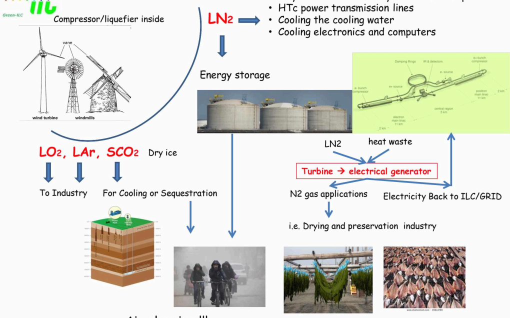
- For the quality of life at ILC site and for the local people
- For Japan and the world: ILC should be a model… should be inspiring
- A green field project: new concepts, new methods, new technologies: Rewarding to the society

- Be ready for environmental impact evaluation (by the local Gov. and people)
- Should be planned from the start, for quality and efficiency
- Driver for innovation: Business opportunities and growth potential
  - Mitigation of construction impact, landscape (re)design, energy plant integration, gardening,
  - Transportation and security: personnel and equipment over ~ 30-40 km long lab. Drones, balloon, …
  - Water and air management,

LN2 Economy Update

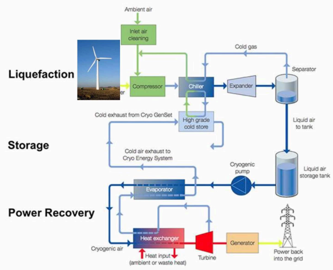
LN2 process cycle

- May save 30-50% on cryocooler consumption
- HTc power transmission lines
- Cooling the cooling water
- Cooling electronics and computers



Air cleaning !!!

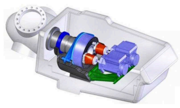
LN2 from Wind



Hydraulic Wind engine

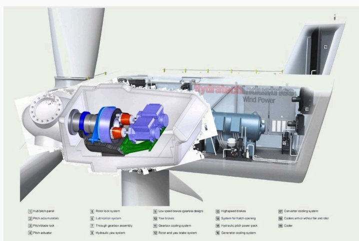
"Liquid nitrogen economy" update:

- The Fukushima Offshore Wind Consortium project update:
- November 2014: 7MW first large scale hydraulic wind engine (MHI, Artemis)

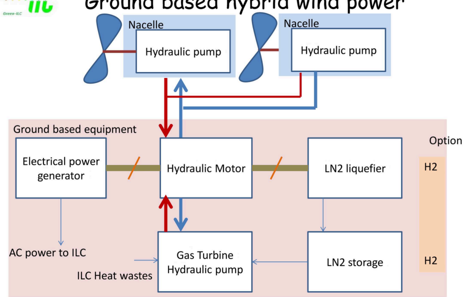


Many technical advantages:
- Smaller, lighter nacelle
- Less mechanical parts and vibration
- Hydraulic accumulator
  - Larger wind speed range
  - No electrical frequency converter
- Easier maintenance at ground level

Good for the LN2
- "Base" based LN2 liquefier
- Many mills to one liquefier
- Hybrid: LN2 and electricity



Ground based hybrid wind power



Implementing Sustainable Power plants for ILC

Access tunnels: Power plants

- 10 access points on ILC main Linac
- Proposal: Each house a renewable energy plant
- ~ 10-20 MW at each of the 10 tunnel/pit access
  - 3 - Geothermal/biomass: close to cities, ILC lab site
  - 3 - Wind power: electricity and LN2:ILC lab site, costal side
  - 3 - Solar (best orientation)
  - 3 - 1 - Ocean Power: ocean side

~ Total 100-200 MW

ILC Candidate site in Kitakami, Tohoku

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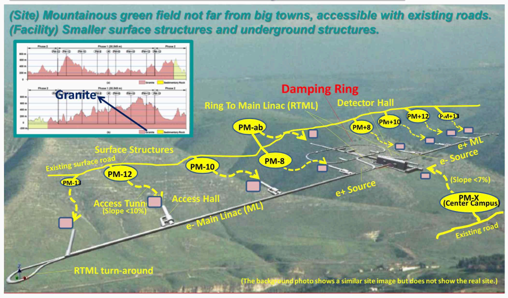
Global Design Effort - CFS

Asian Site Conventional Facility – Introduction

(Site) Mountainous green field not far from big towns, accessible with existing roads.
(Facility) Smaller surface structures and underground structures.



6 February 2013 — International Linear Collider TDR Cost Review (Asian Region) — 18

Geothermal power

- Japan has a huge potential
- No fracking, medium depth…
- Let's work with the onsen/spa industry for hybrid projects
- Output warm water: Many applications:
  - Onsen/spa for the local community
  - Heating close-by cities/villages
  - Greenhouses for vegetable and flowers growing
  - Fish farming needs to adjust water temperature

Similar for Biomass power

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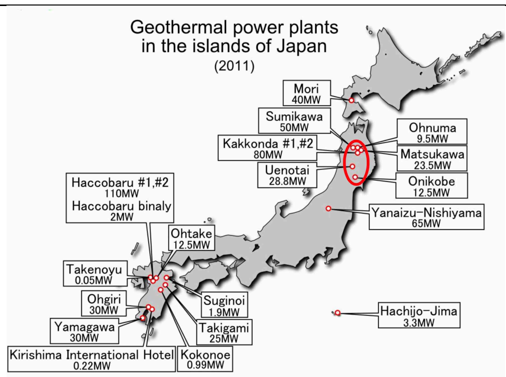
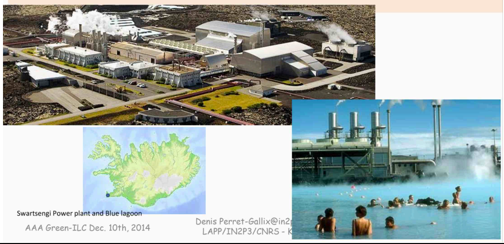


Geothermal Energy and SPA center

Iceland Svartsengi
- Geothermal plant: electricity 75 MW, thermal 150 MW
- 37 years of operation
- 600 m drill 240 C + 1000m and 2000m steam wells
- Hot drinking water to the city



Swartsengi Power plant and Blue lagoon

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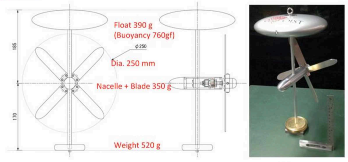
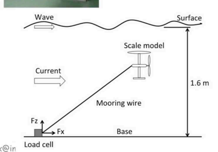
Ocean Power (by Tsumoru Shintake, OIST)





- Many big projects:
  - Little impact on landscape
  - little intermittency, but variable power
  - Could be close to the shore
- Prof. T. Shintake future presentation

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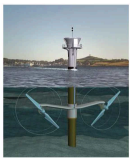

0.5 MW France

Tide power (Canada)

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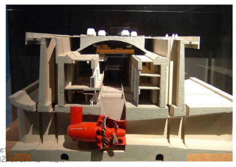
Tidal power

Rance Tidal Power station (1966), France

Type of dam	Barrage
Length	700 m (2,300 ft)
Reservoir	
Tidal range	8 m (26 ft)
Power station	
Type	Tidal barrage
Turbines	24
Power generation	
Nameplate capacity	240 MW
Capacity factor	40%
Annual generation	600 GWh



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Solar power on Infrastructure

Infrastructures, not very eco-friendly, but necessary,
Better to use them to produce energy ?

Assuming: solar panels (thermal or PV) ~200 W/m2

- ILC Buildings: ~ 103 buildings ~ 91,000 m2 (80%) -> ~15 MW
- Roads: 10 tunnel access → 10 semi-private roads (1-2 Km each)
  - ~ 10-20 km
    - Side road: * 3m = 30-60.000 m2
    - Top road: * 10 m = 100-200,000 m2
- Parking lots: covered by solar panels

- PB.: cleaning, snow, support structures, storage, … price …

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"Renault" car company to install 450,000m2 of solar panels: 60 MW
140W/m2

Shandong Huayi Sunlight Solar Energy
115W/m2

SRB and CERN: Thermal panels, Geneva airport roof

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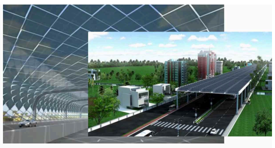
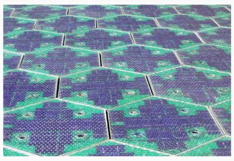


http://www.greenpepperenergy.com/index.php/roof-over-roads-to-tap-solar-power/



Solar roadways

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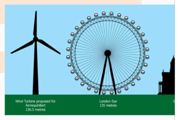
Visually disruptive equipements

Industrial complex, reuse of polluted zone,

Fos sur mer (France)

Off-shore

Amusement parks (Ferris Wheel ~165 m high)



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Excavated earth for pumped hydro dam

~ 3.2 Mm^3 will be removed from tunnels digging
Can be used to build earth dams see for comparison:

Kutataragi Pumped Storage Power Station (奥多々良木発電所) 1.9 GW
Kansai Electric Power Company (Hyōgo Prefecture

Kurokawa Reservoir (3.6 Mm^3 earth)
98 m tall, 325 m long

Tataragi Reservoir (1.4 Mm^3 earth)
64.5 m tall, 278 m long

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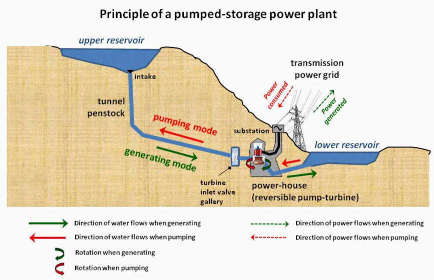

Energy Saving in Computing

Suiren, KEK computer ranking 2nd in the GREEN500 Nov. 2014 listing

- ~ 5 GFLOP/S/W for ~ 0.185 PFLOP/S submersion liquid coolant fluorinet
  http://www.kek.jp/ja/NewsRoom/Release/20141121140000/ Tadashi Ishikawa (KEK)

Green500 Rank	MFLOPS/W	Site*	Computer*	Total Power (kW)
1	5,271.81	GSI Helmholtz Center	L-CSC - ASUS ESC4000 FDR/G2S, Intel Xeon E5-2690v2 10C 3GHz, Infiniband FDR, AMD FirePro S9150 Level 1 measurement data available	57.15
2	4,945.63	High Energy Accelerator Research Organization /KEK	Suiren - ExaScaler 32U256SC Cluster, Intel Xeon E5-2660v2 10C 2.2GHz, Infiniband FDR, PEZY-SC	37.83
3	4,447.58	GSIC Center, Tokyo Institute of Technology	TSUBAME-KFC - LX 1U-4GPU/104Re-1G Cluster, Intel Xeon E5-2620v2 6C 2.100GHz, Infiniband FDR, NVIDIA K20x	35.39

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And more …

- Ground water power generation
- Natural Tunnel ventilation and heating/cooling
- SmartGRID

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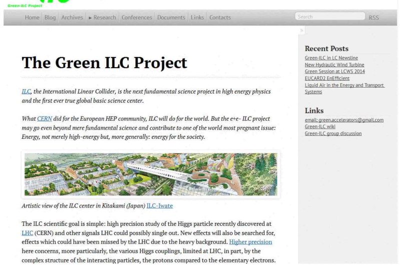
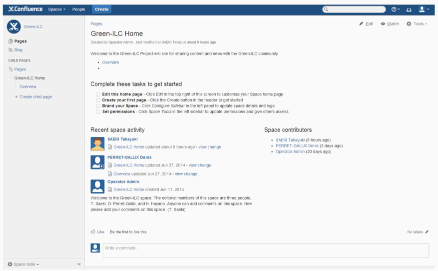
Needed: ILC site region data

- Temperature
  - Daily Day-night T° for these last 20 years or more
  - Degree-days: nb of days above or below a given T° and |T- T°|
- Solar
  - Map of solar irradiance (max. 1 kW/m2) Morioka ~ 180 W/m2
  - Map of the average sunshine days or hours per week (Morioka 176D, 1684H)
- Wind
  - Map of wind conditions: costal, off-shore, in land. Weekly average
- Ocean
  - Map of the ocean streams and tides
- Geothermal and Biomass
  - Map of geothermal data (water T°, depth, water quality, …)
  - Map of biomass availability
- Geography
  - Possible locations for pumped-hydro storage
  - Underground water
  - Reusable lands

http://green-ILC.in2p3.fr
Now on http://interactions.org "blog watch"



Wiki site for Green-ILC internal discussion:
http://wiki.kek.jp/ Space-> Green-ILC



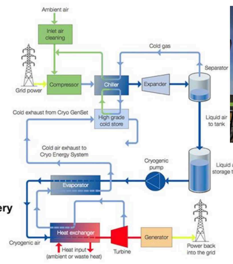
Thank you

LN_2 as energy storage

Liquefaction

Storage

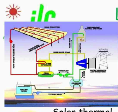
Power Recovery



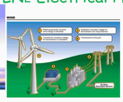
Highview Power Storage (UK)

Expected Efficiency up to 70% using heat waste (~ 115 C)

LN_2 Electrical Production and Transport



Solar thermal



Grid/ILC

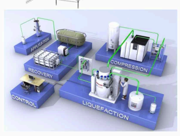
Solar PV

Wind,
Geothermal, biomass

Electricity

OR …..

Make LN_2



By Cryo Pipeline
Longest LNG ~ 5 km

HTc SC power line (project)
by 20 Km long section

LN2 for ILC, just as an example
Needs R&D

Many positive aspects:
- Negative (less than zero) carbon emission technology, air cleaner
- Important cryogen for ILC:
  - Cooling: cryocooler, HTc transmission lines, ..
  - Heat waste recovery
  - Storage: 1 gazometer (like for NLG): ILC runs ~ 4 days
    - Fast startup (minutes)
    - Long life-time

Applications to industry
- Energy Storage
- Heat waste recovery
- Drying

Safety issues, specially in ILC tunnel:
- N2 gas suffocation
- Cryogenic fluid hazard
- LN2 may liquefy ambient oxygen

Other discussions …. Hydrogen economy

Underground water power ?

- Currently expect: 1m3/km/minute ~0.5 m3/s
- High pressure underground water experienced at LEP/LHC at one point 100m deep:
  0.6m3/s pressure 20 atm ~ 200 m of water ~ 1MW
- 1 MW enough to tunnel light and ventilation