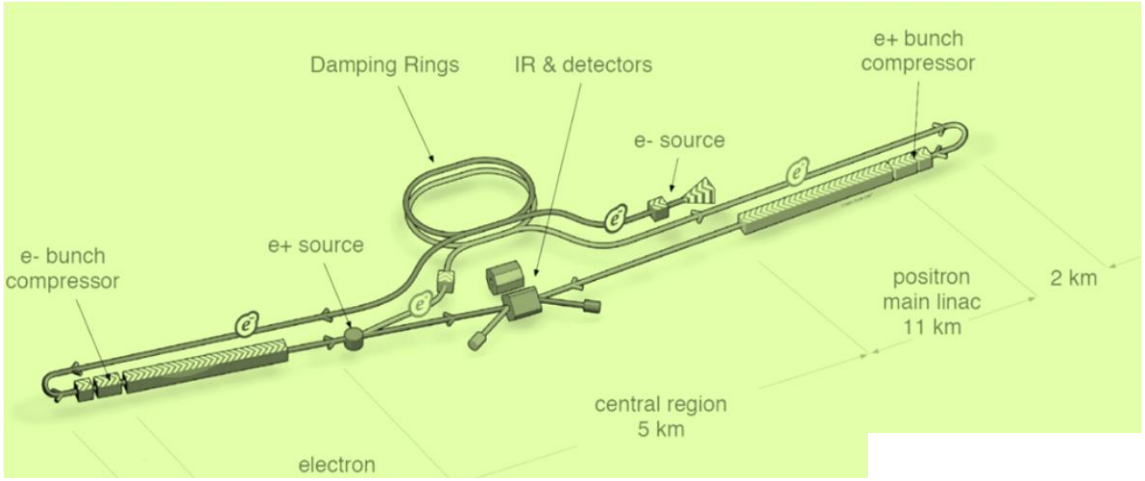

THE GREEN ILC

Renewable Energies and Environment

Energy for Innovation, Innovation in Energy

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International Linear Collider

I L C

Innovation = Leadership x Creativity

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Content

- Green-ILC project (a reminder)
- Eco-Friendly ILC, a driver for innovation
- Renewable Energies
  - Update on "Liquid Nitrogen Economy"
  - Implementing power plants
    - Wind power
    - Geothermal power
    - Ocean power
  - Power generation on ILC infrastructure
  - Excavated Earth for pumped hydro
- Green Computing

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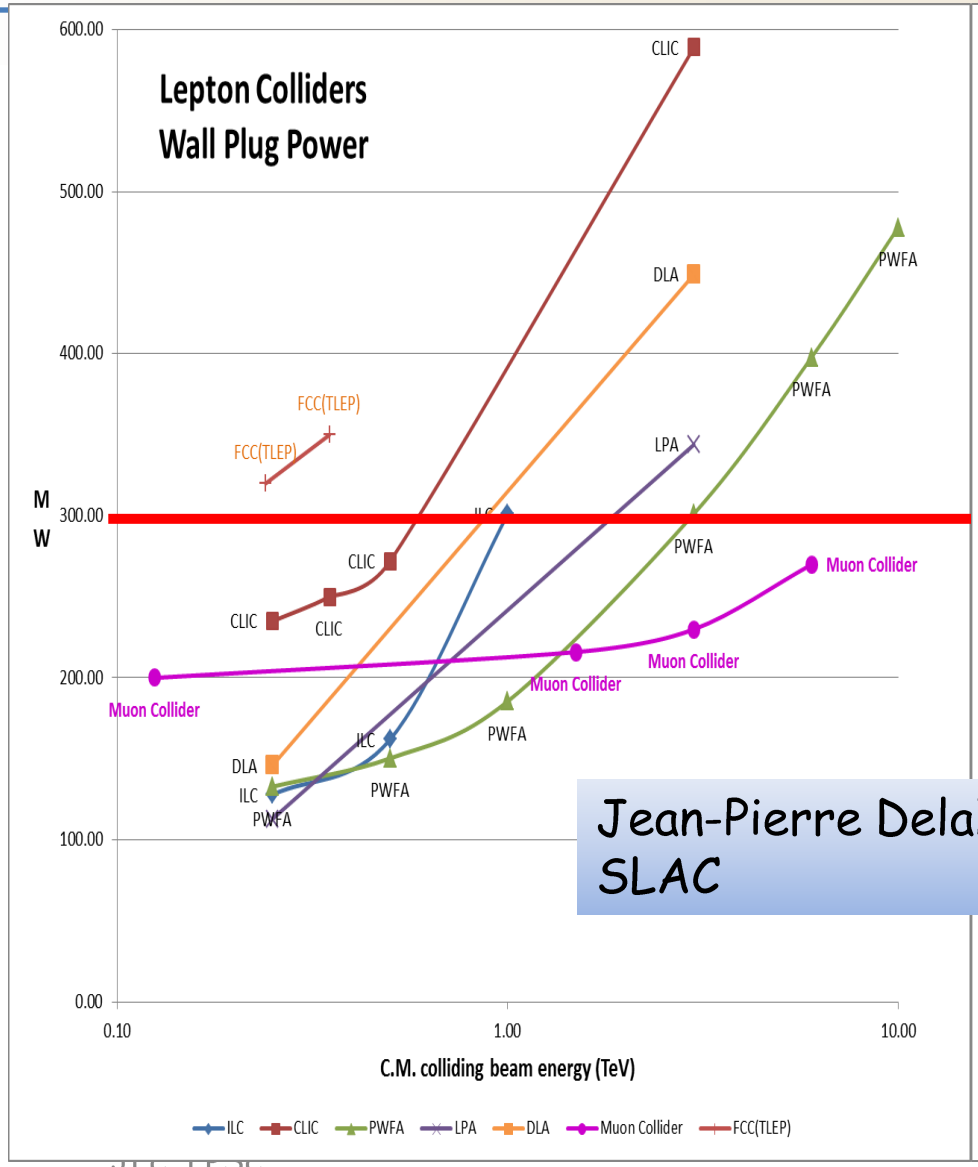
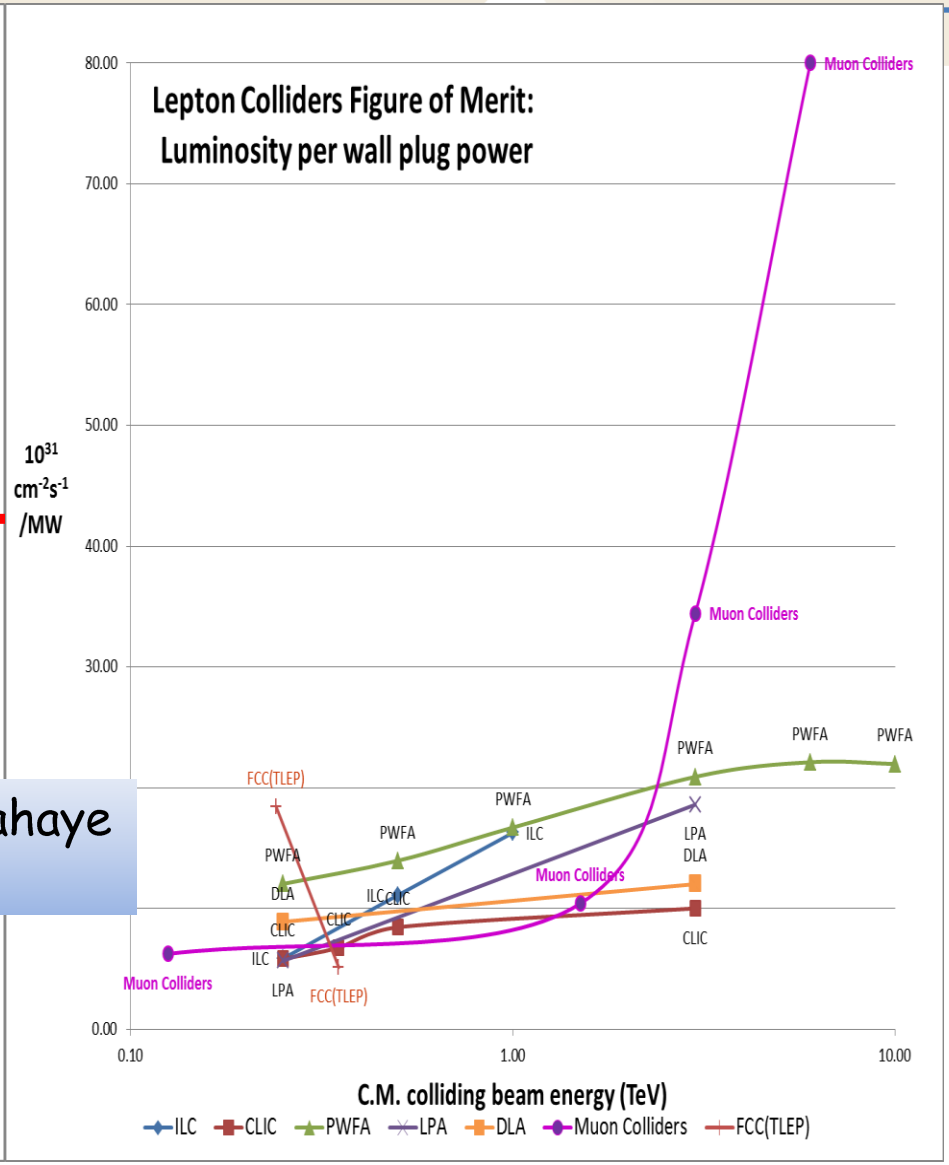
Lepton colliders "wall plug power"





Jean-Pierre Delahaye
SLAC

Green-ILC Objectives

ILC : lower running cost, better operational flexibility, environment friendly

Revisiting all ILC components:

1. Energy Saving: improving efficiency: 90% lost (if not 100%) as heat waste
2. Saving on ILC operation
3. Energy Recovery and Recycling

Renewable energies:

1. Renewable energy production, which are best for ILC and ILC site ?
2. Energy Storage (recovery, intermittency)
3. Distribution and Management: Smart Grid

Energy: for societal needs and world economy,

1. Basic Research (most needed for Energy Research)
2. HEP-Energy synergies:
   SC, HF magnets, RF, vacuum, surface treatment, computing, photon, neutron factories
3. ILC will boost technology innovation
4. ILC as a perfect test bench for energy research

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Global organization for Green ILC

ILC Energy Center

ILC High-Energy Research Center

- Fundamental Research
- HEP Applications

ILC Sustainable Energy Research Center

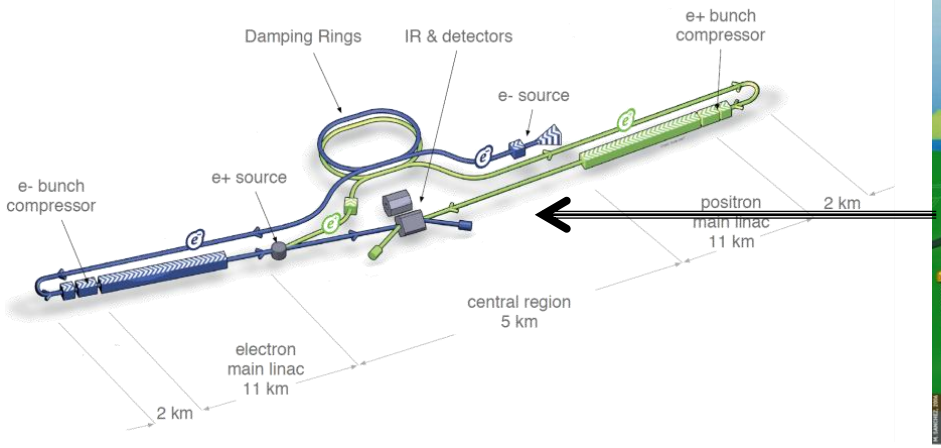
- Basic Research
- Application R&D
- Pilot Power plant for ILC

Industry

Electrons, photons, neutrons factories HPC/GRID Computing

High-Energy community

Energy community



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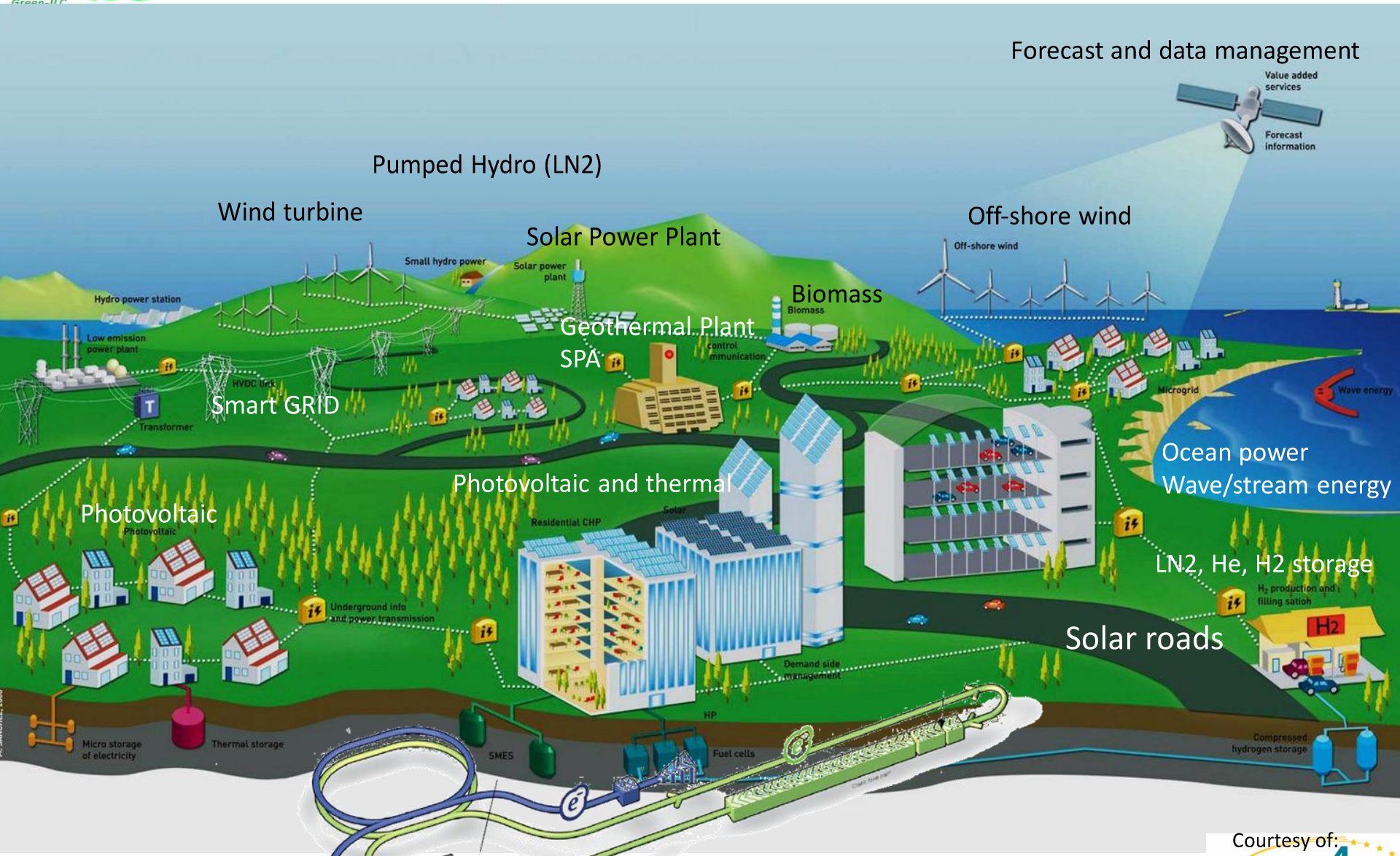
ILC Energy center (artistic) view



[illegible]erret-Gallix@in2p3.fr
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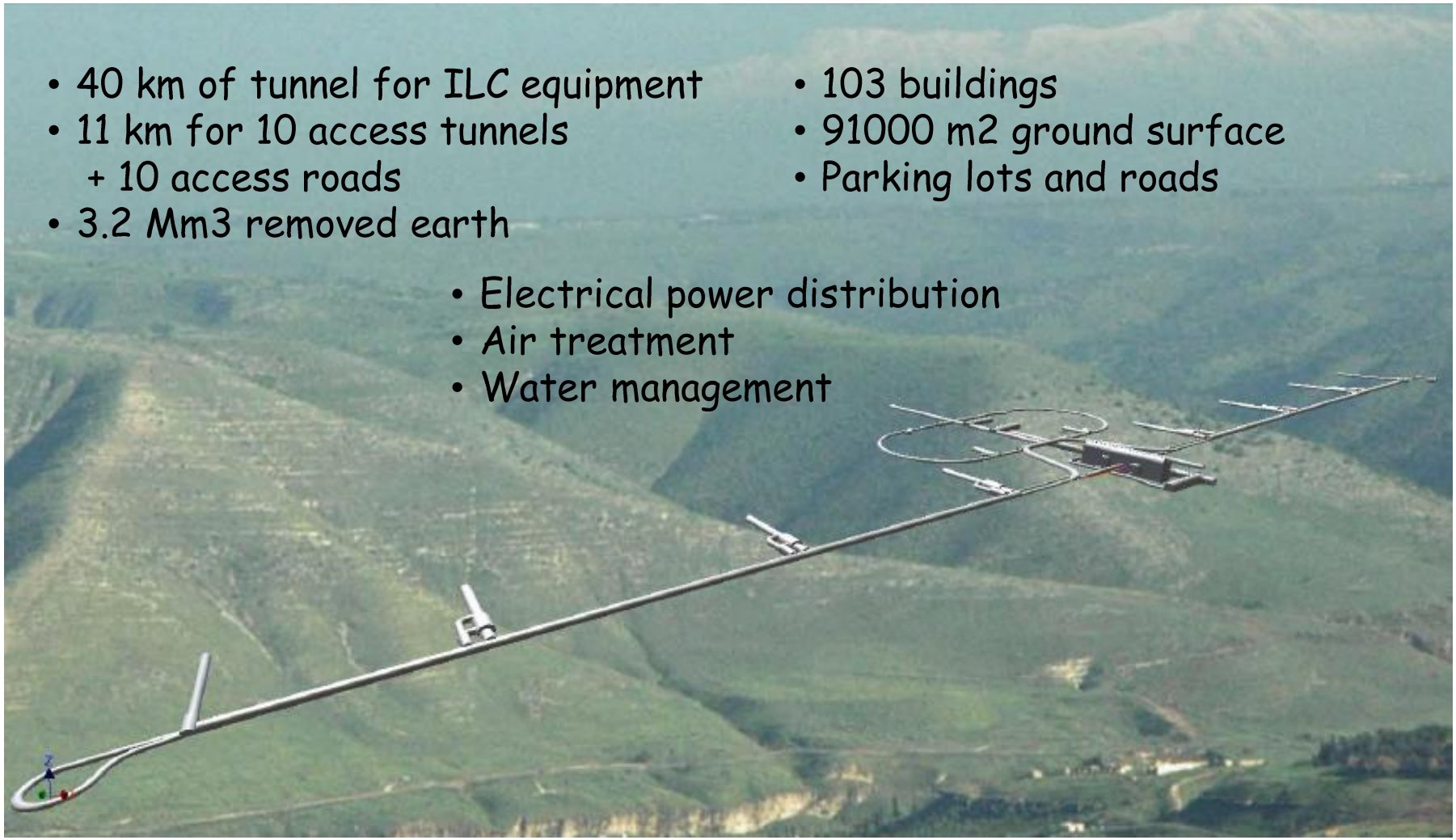
Courtesy of:

GRID4EU
INNOVATION FOR ENERGY NETWORKS

ILC in beautiful Kitakami
Make it Eco-Friendly



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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,

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LN2 Economy Update

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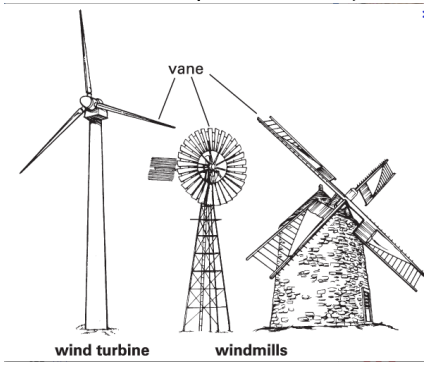
LN_2 process cycle

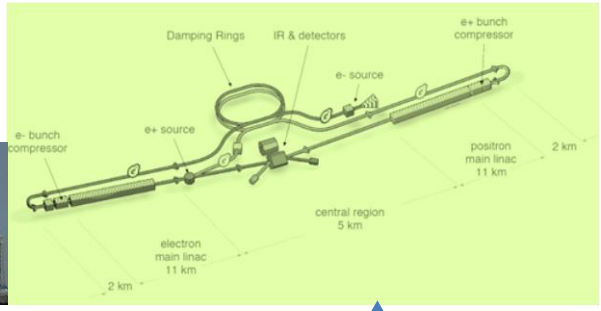
- May save 30-50% on cryocooler consumption
- HTc power transmission lines
- Cooling the cooling water
- Cooling electronics and computers

Compressor/liquefier inside



LN_2

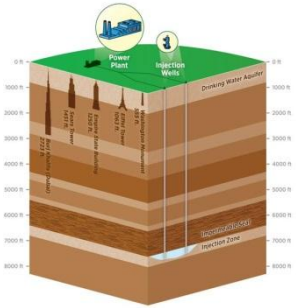
Energy storage



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 !!!

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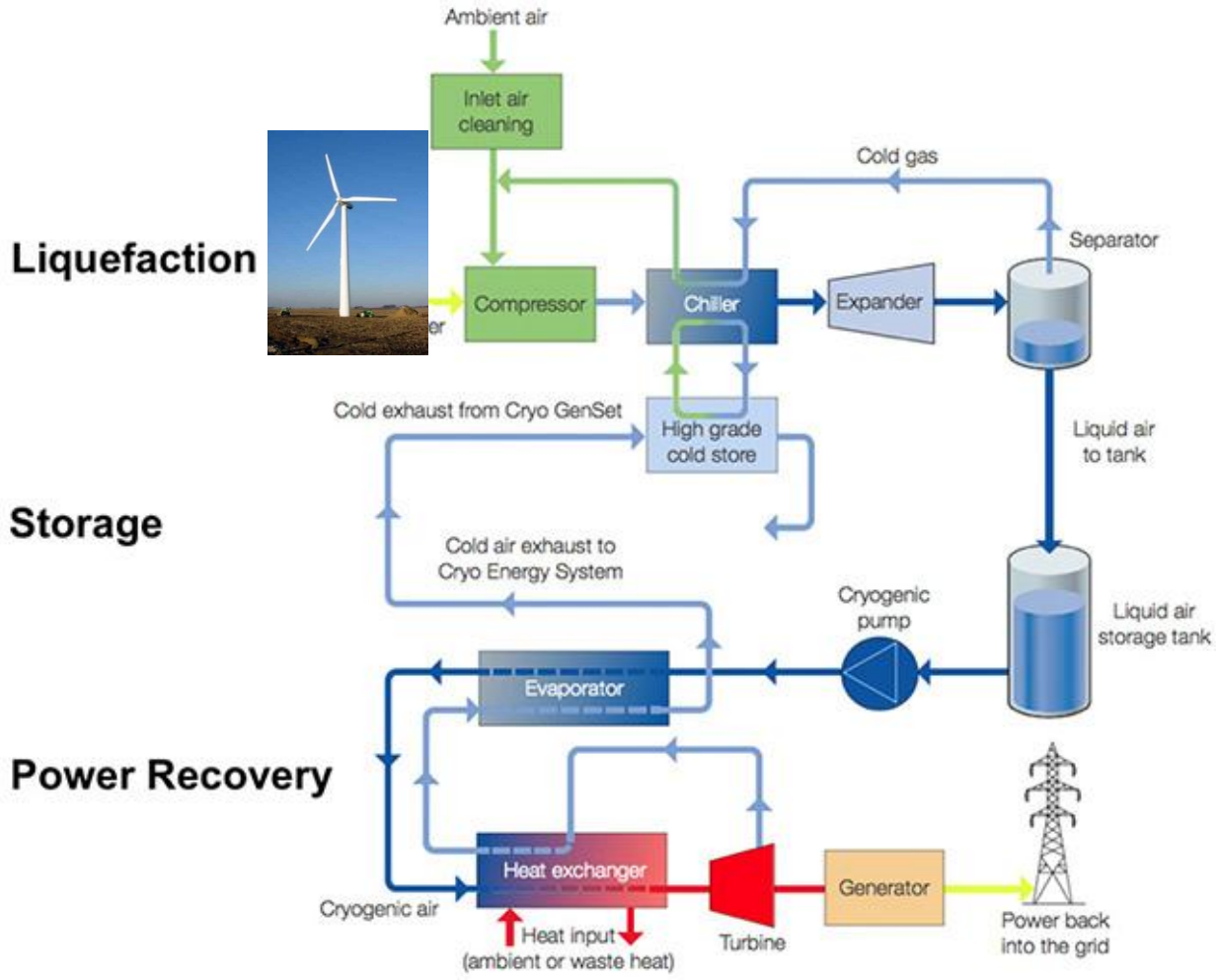
LN2 from Wind



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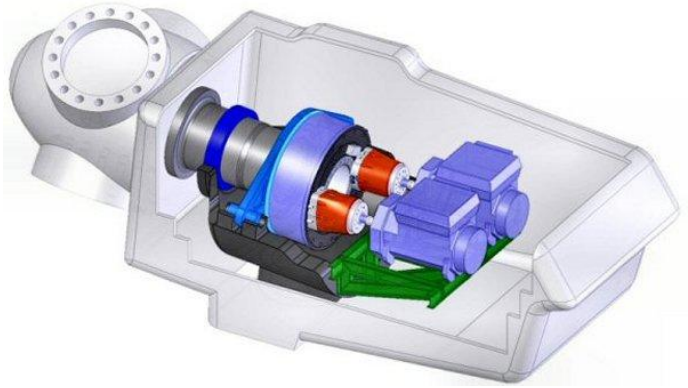
Hydraulic Wind engine

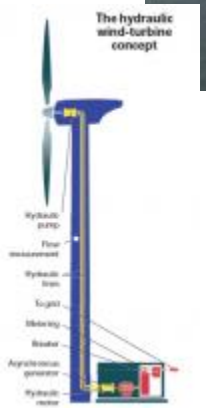
"Liquid nitrogen economy" update:

- 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

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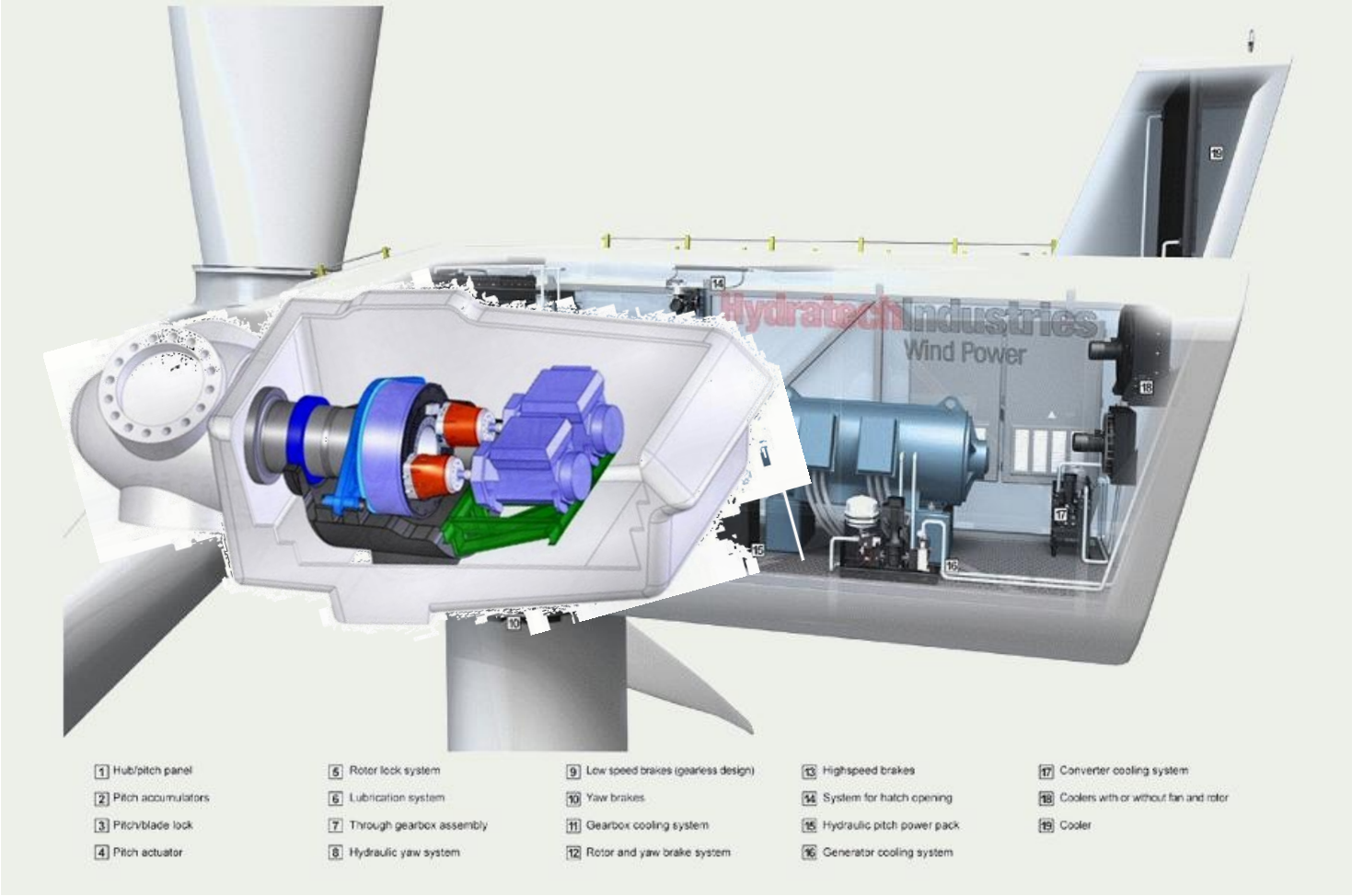

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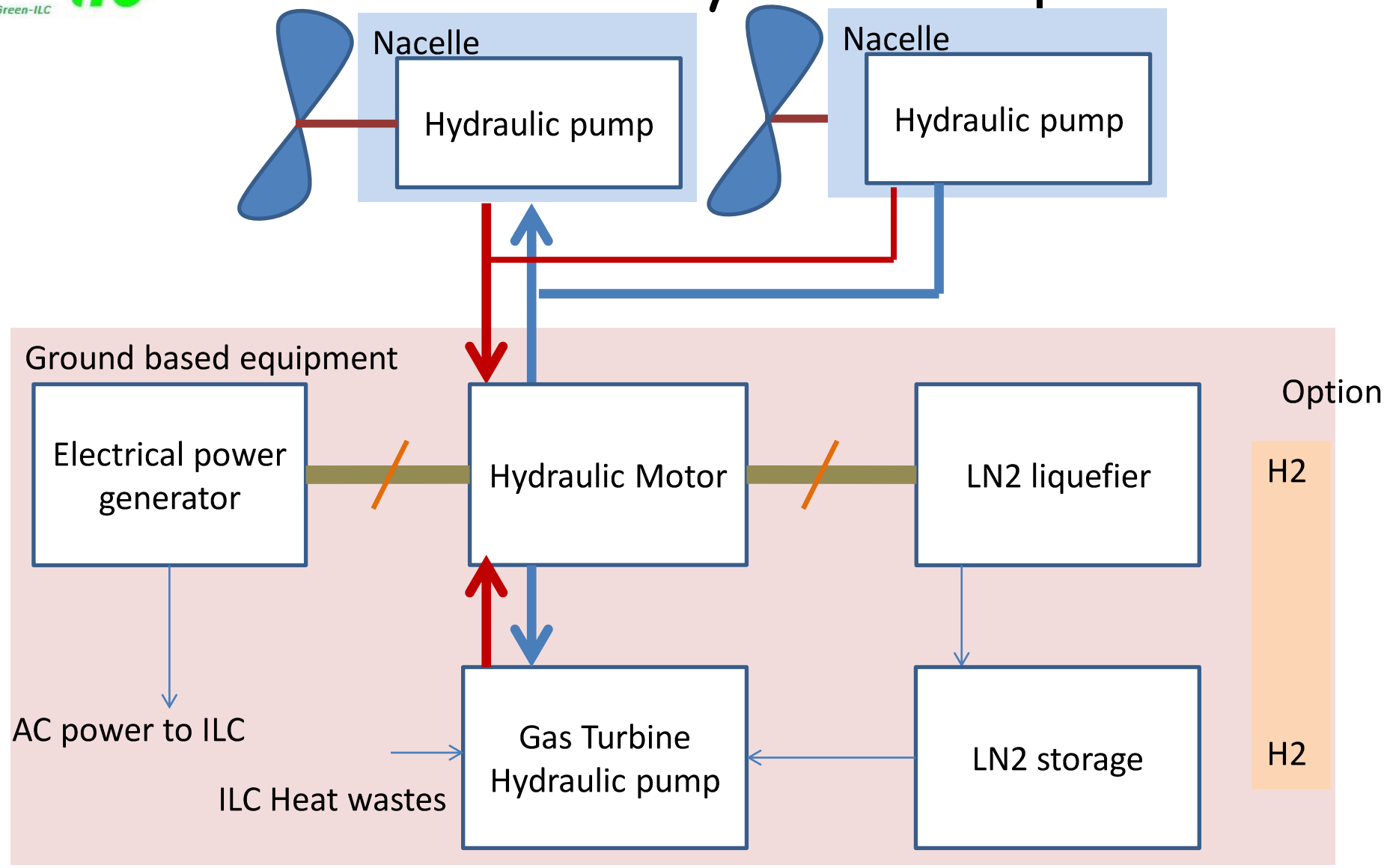
Ground based hybrid wind power



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Implementing Sustainable Power plants for ILC

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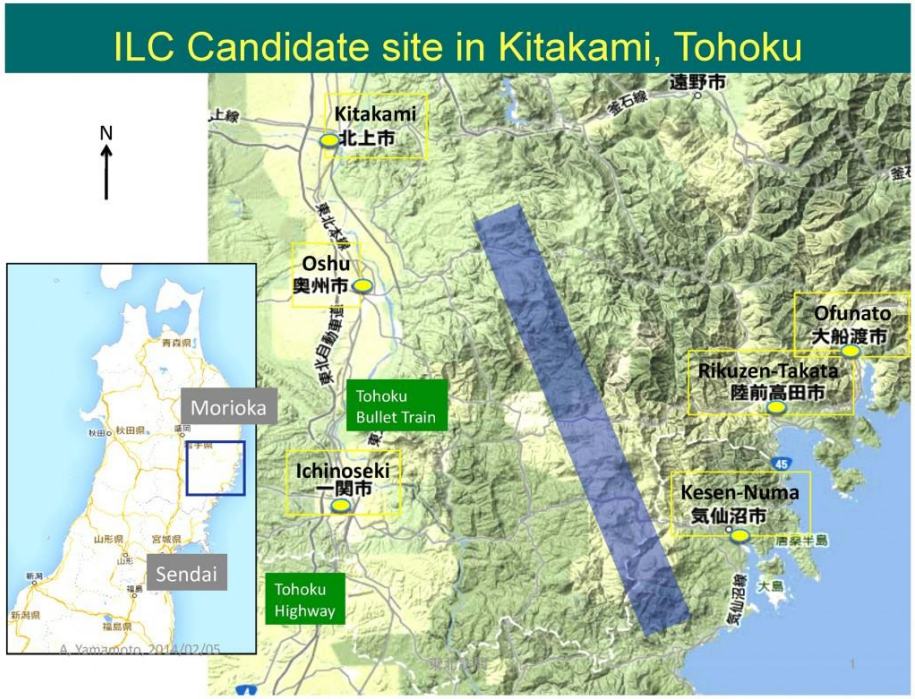
Access tunnels: Power plants

- 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



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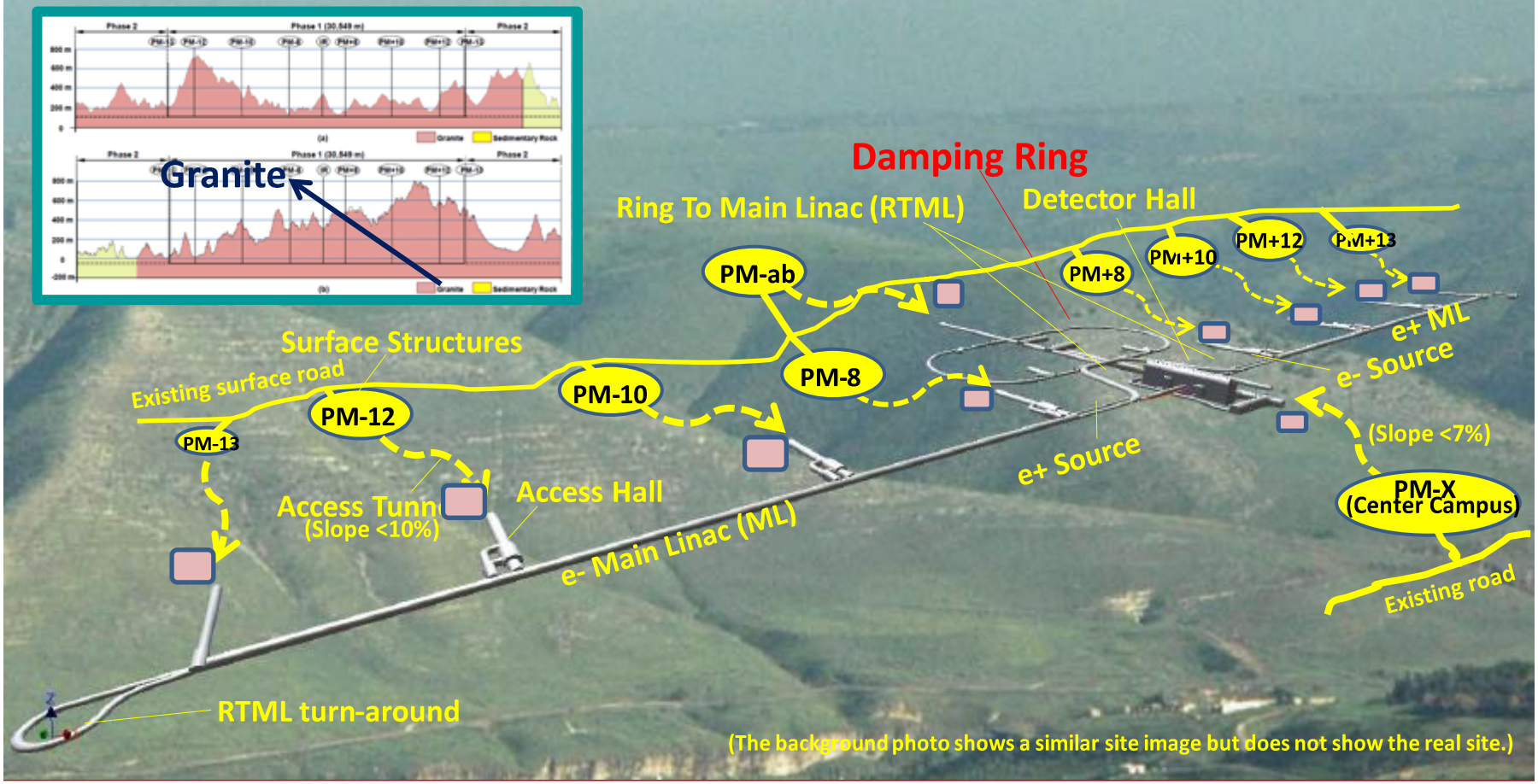
Asian Site Conventional Facility – Introduction

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



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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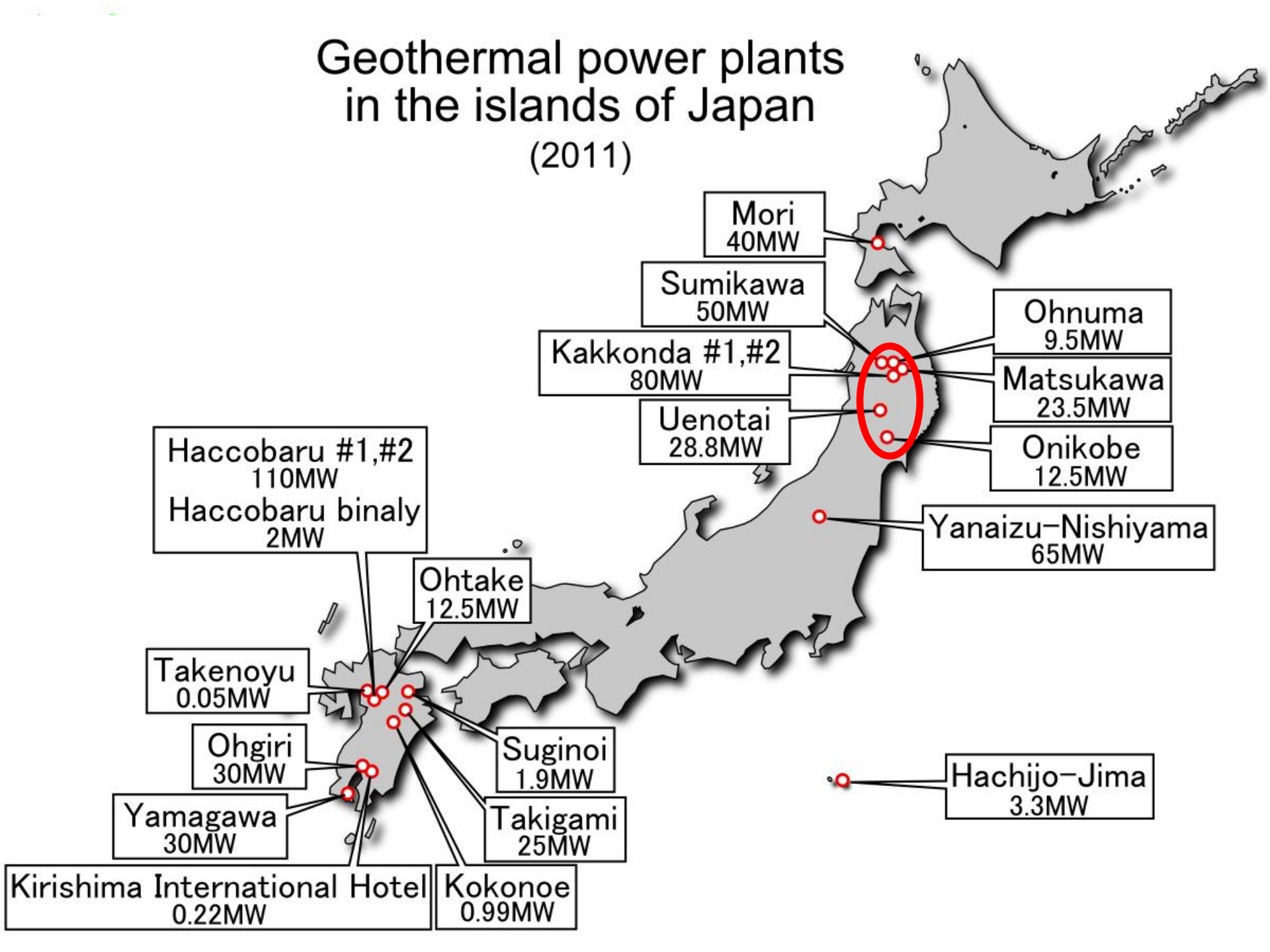
Geothermal power plants in the islands of Japan

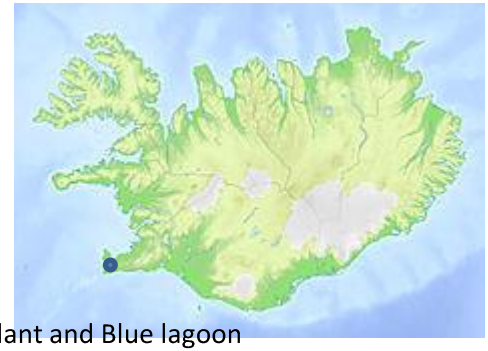
(2011)



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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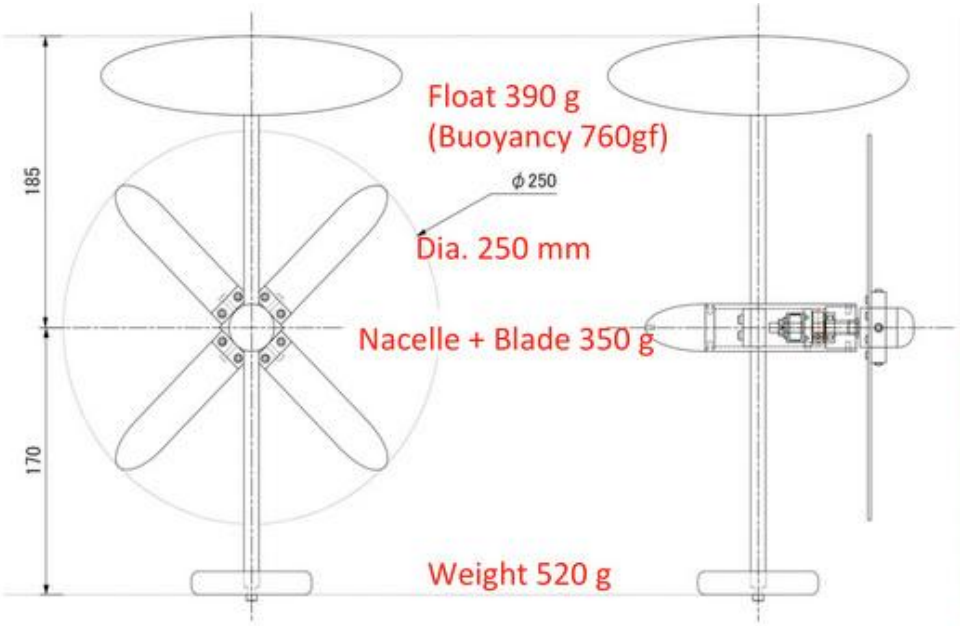
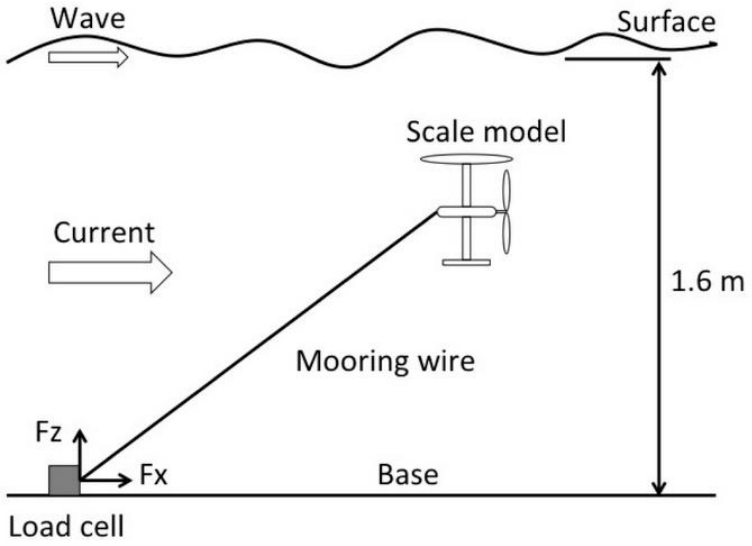
Ocean Power (by Tsumoru Shintake, OIST)



- 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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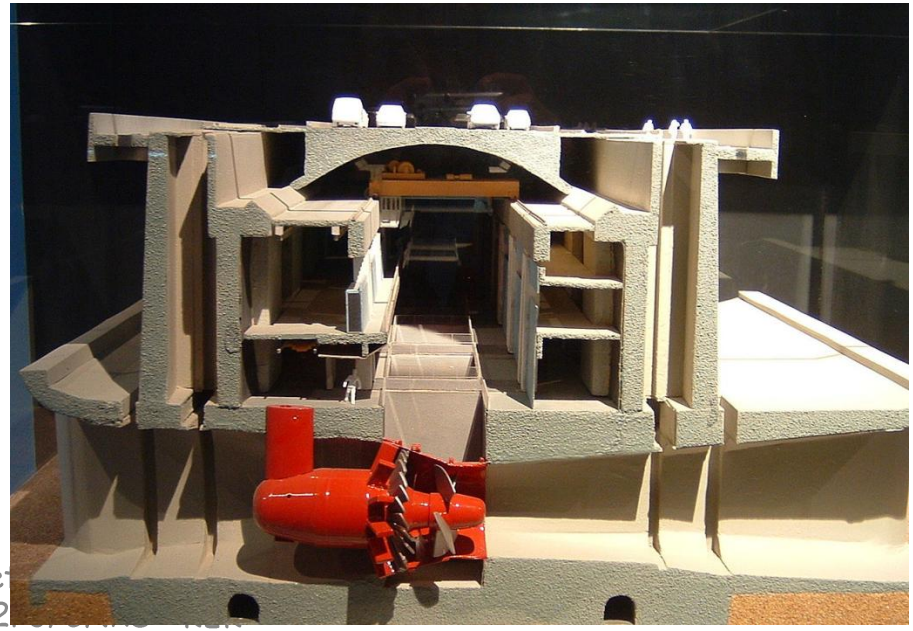
Tidal power

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



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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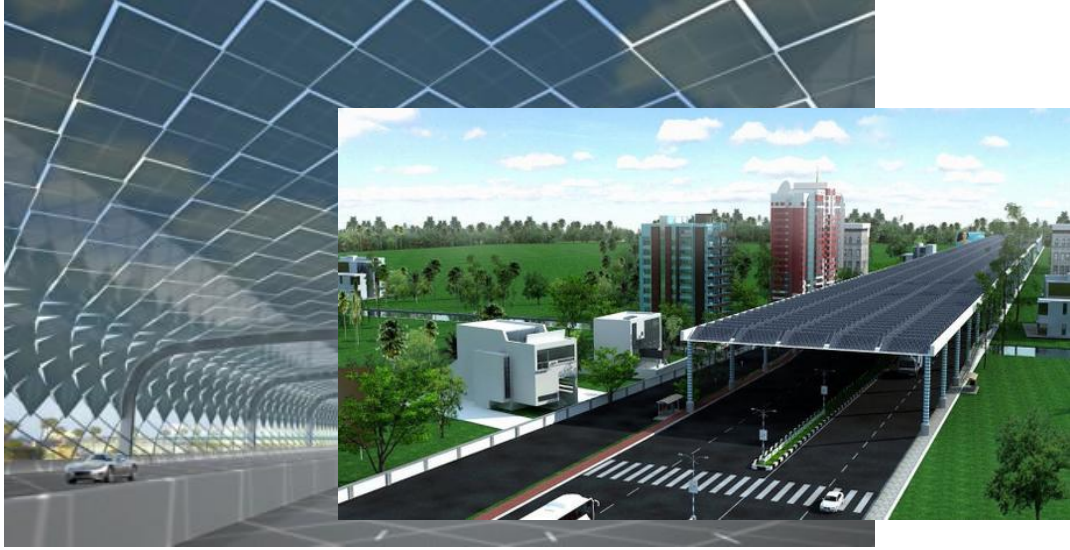
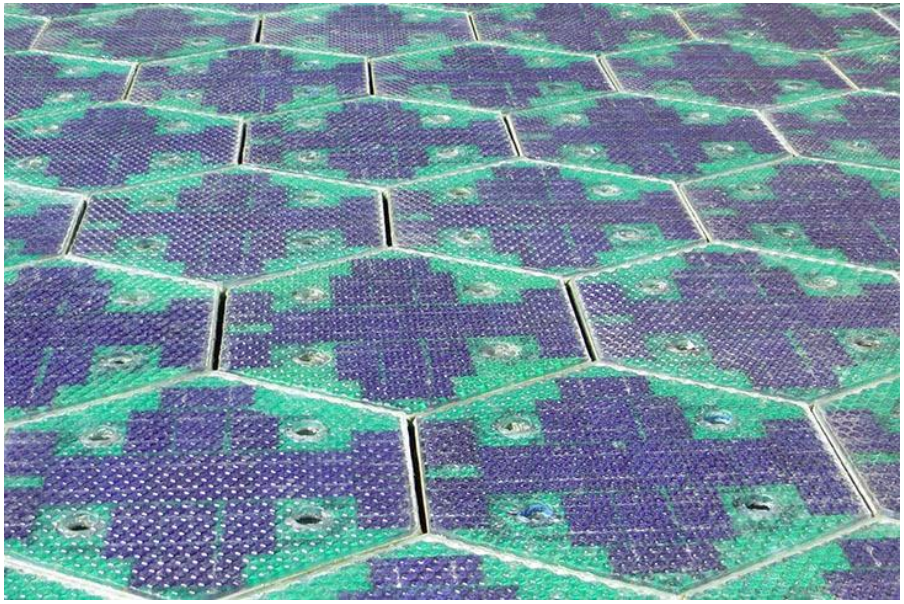


http://www.greenpepperenergy.com/index.php/roof-over-roads-to-tap-solar-power/



Solar roadways

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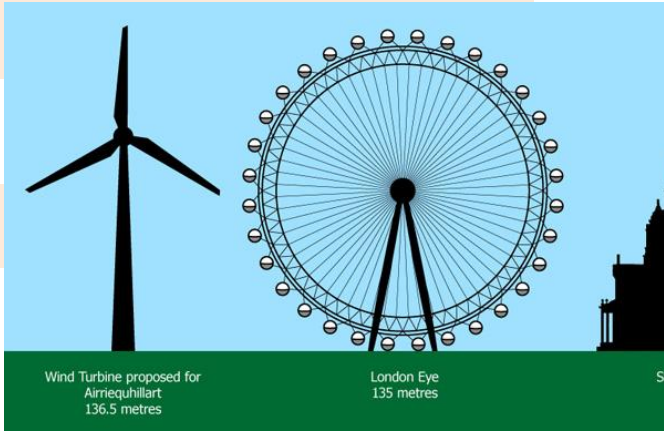
Visually disruptive equipements

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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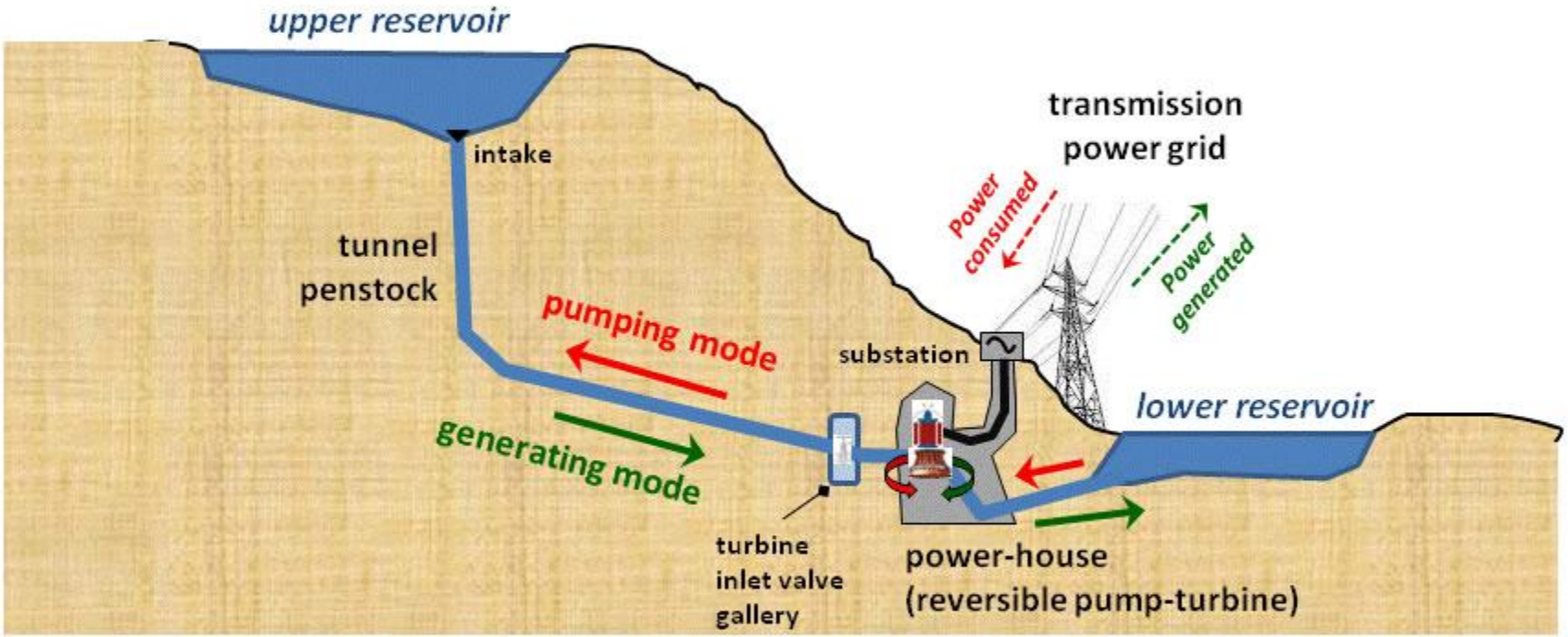
Principle of a pumped-storage power plant



Direction of water flows when generating

Direction of water flows when pumping

Rotation when generating

Rotation when pumping

Direction of power flows when generating

Direction of power flows when pumping

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

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

Green ILC

Energy for Innovation, Innovation in Energy

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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) ILC-Iwate

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 complex structure of the interacting particles, the protons compared to the elementary electrons.

Recent Posts

Green-ILC in LC Newsline
New Hydraulic Wind Turbine
Green Session at LCWS 2014
EUCARD2 EnEfficient
Liquid Air in the Energy and Transport Systems

Links

email: green.accelerators@gmail.com
Green-ILC wiki
Green-ILC group discussion

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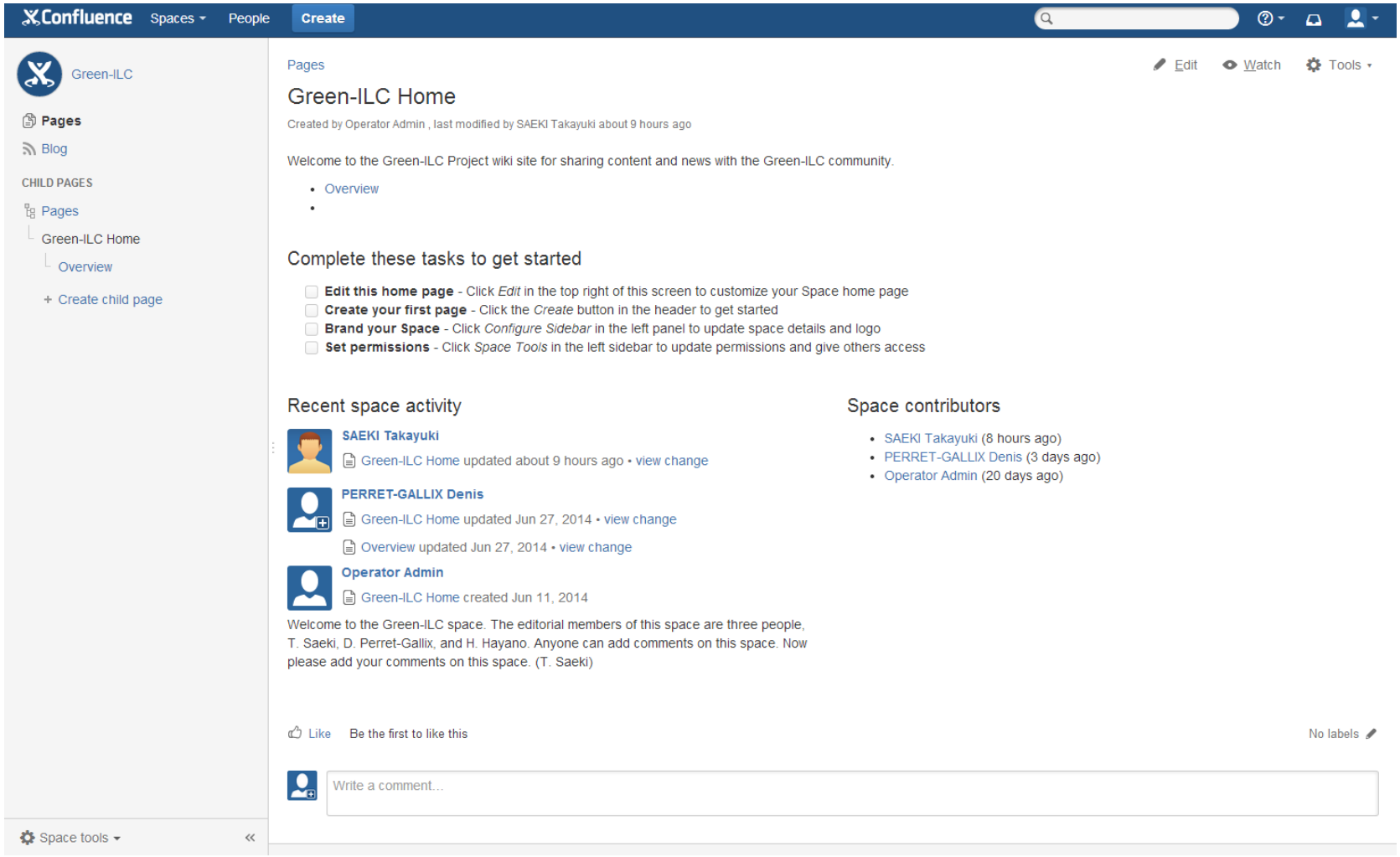
Wiki site for Green-ILC internal discussion:
http://wiki.kek.jp/ Space-> Green-ILC



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Thank you

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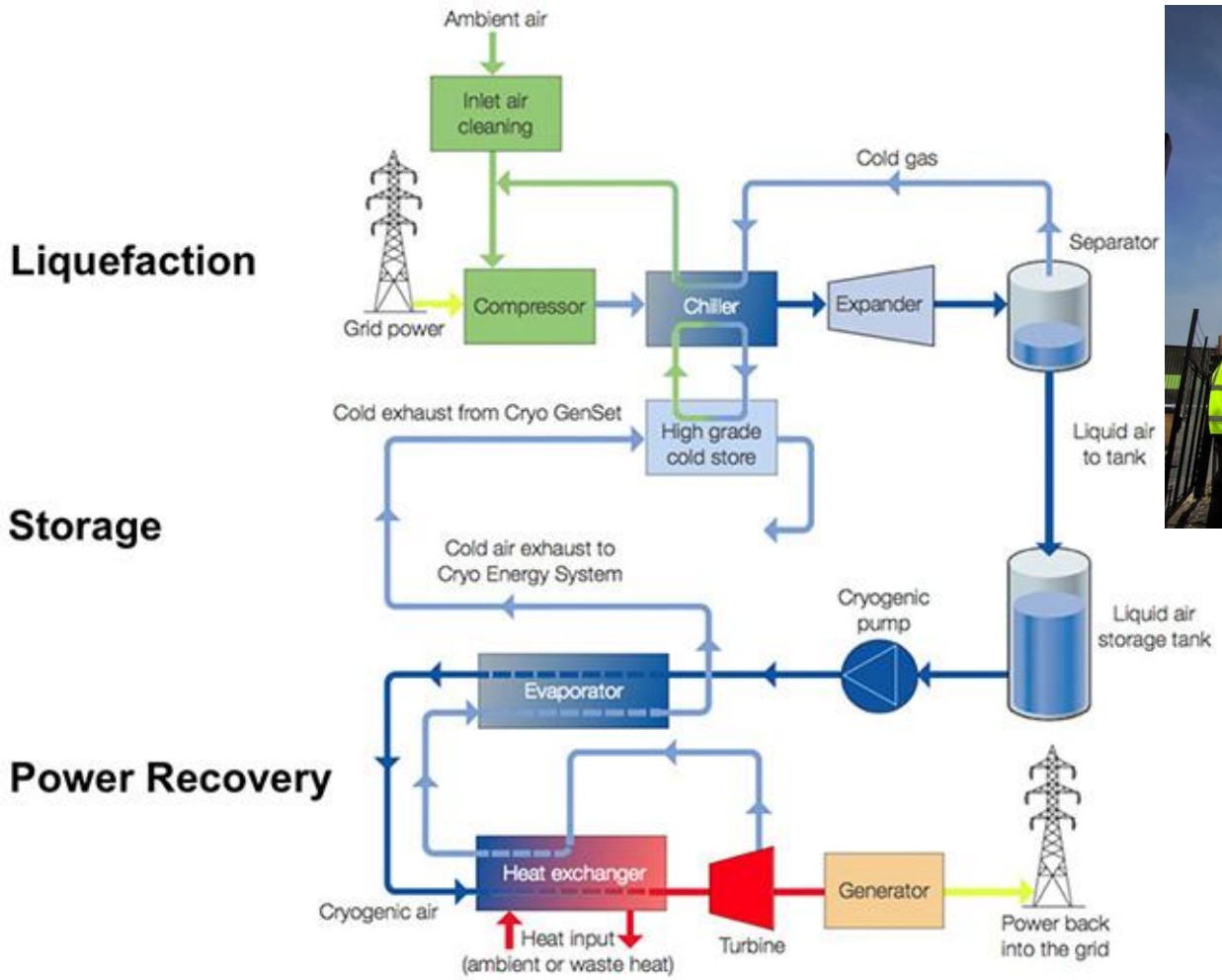
LN2 as energy storage



Highview Power Storage (UK)

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

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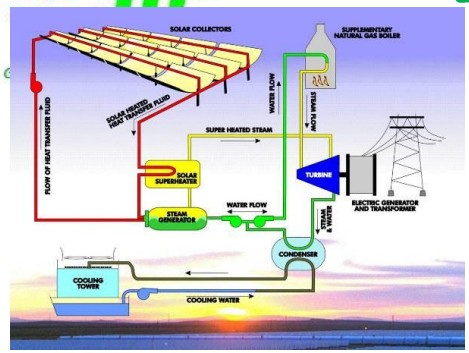
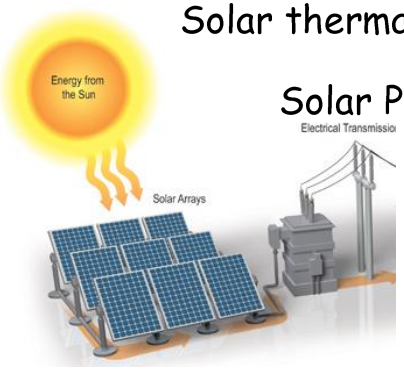
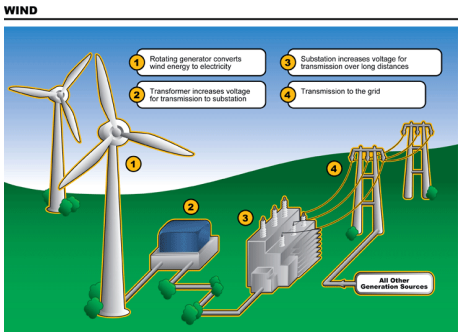
LN2 Electrical Production and Transport



Solar thermal



Solar PV

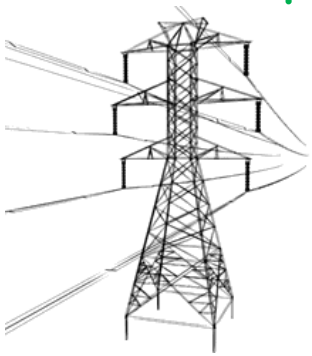


Wind,
Geothermal, biomass

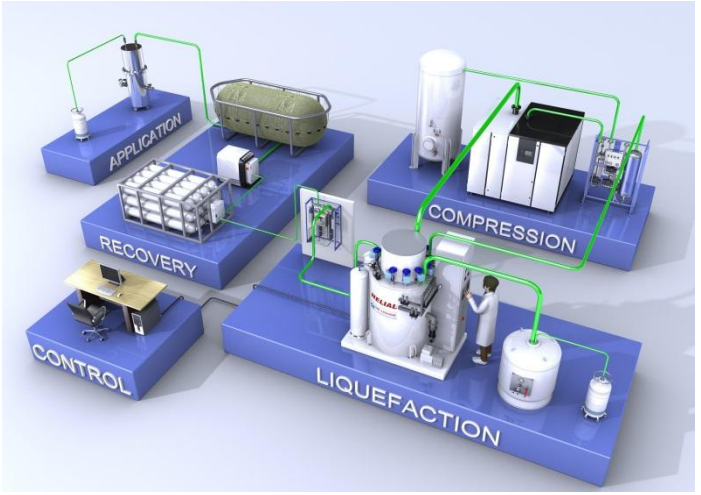
Electricity

OR .....

Grid/ILC



Make LN2



By Cryo Pipeline
Longest LNG ~ 5 km

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

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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

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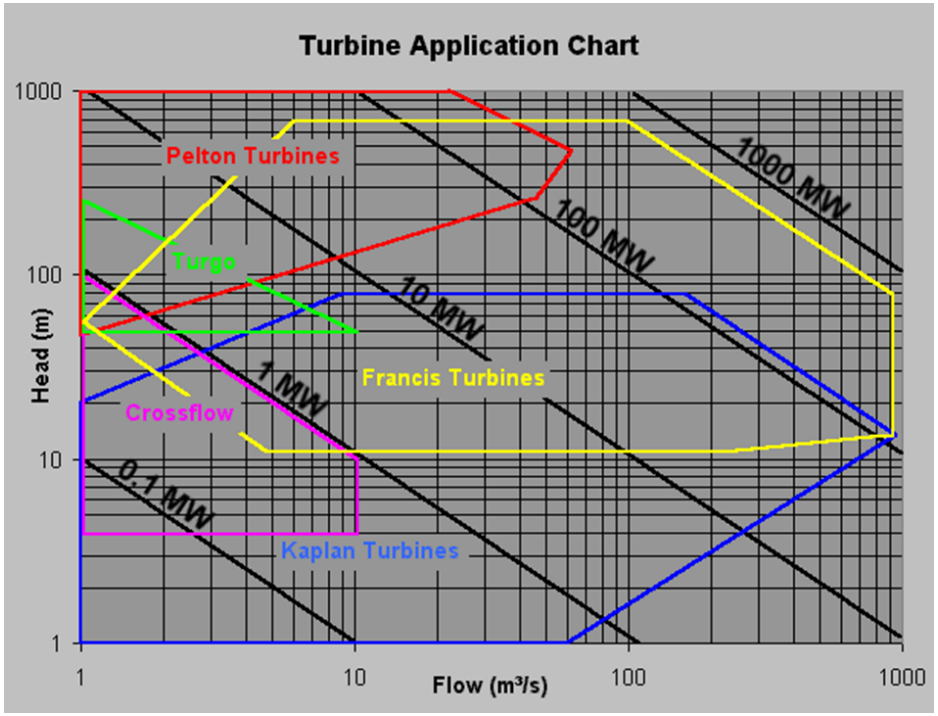
Underground water power ?

- 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



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