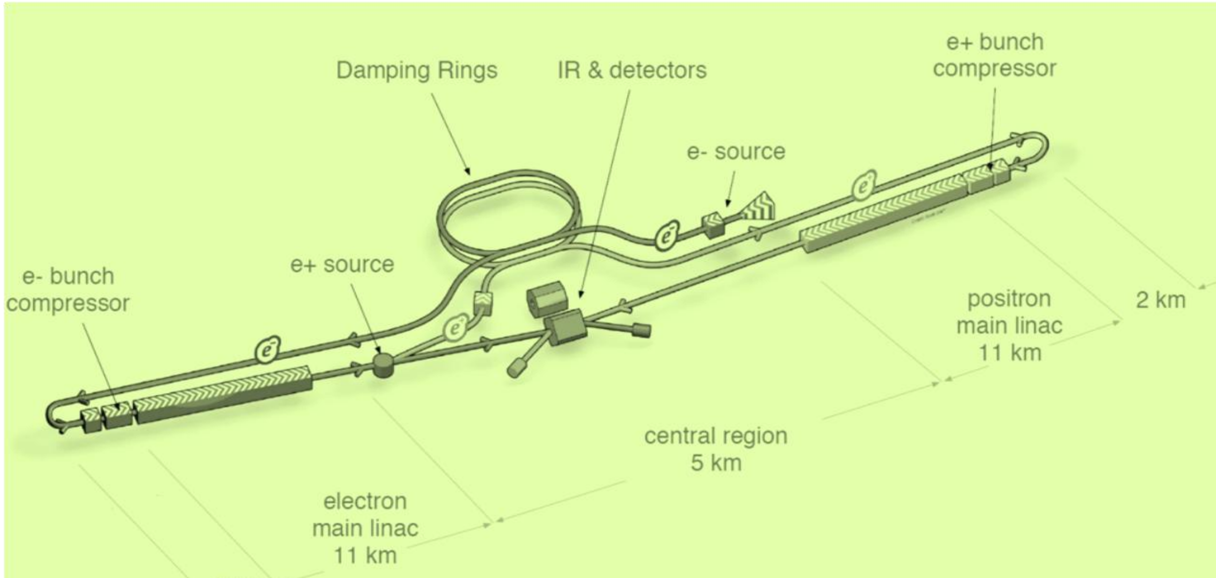

THE GREEN ILC

LN2 Economy

Energy for Innovation and Innovation in Energy

Air Liquide
Sassenage, Dec, 1st 2014

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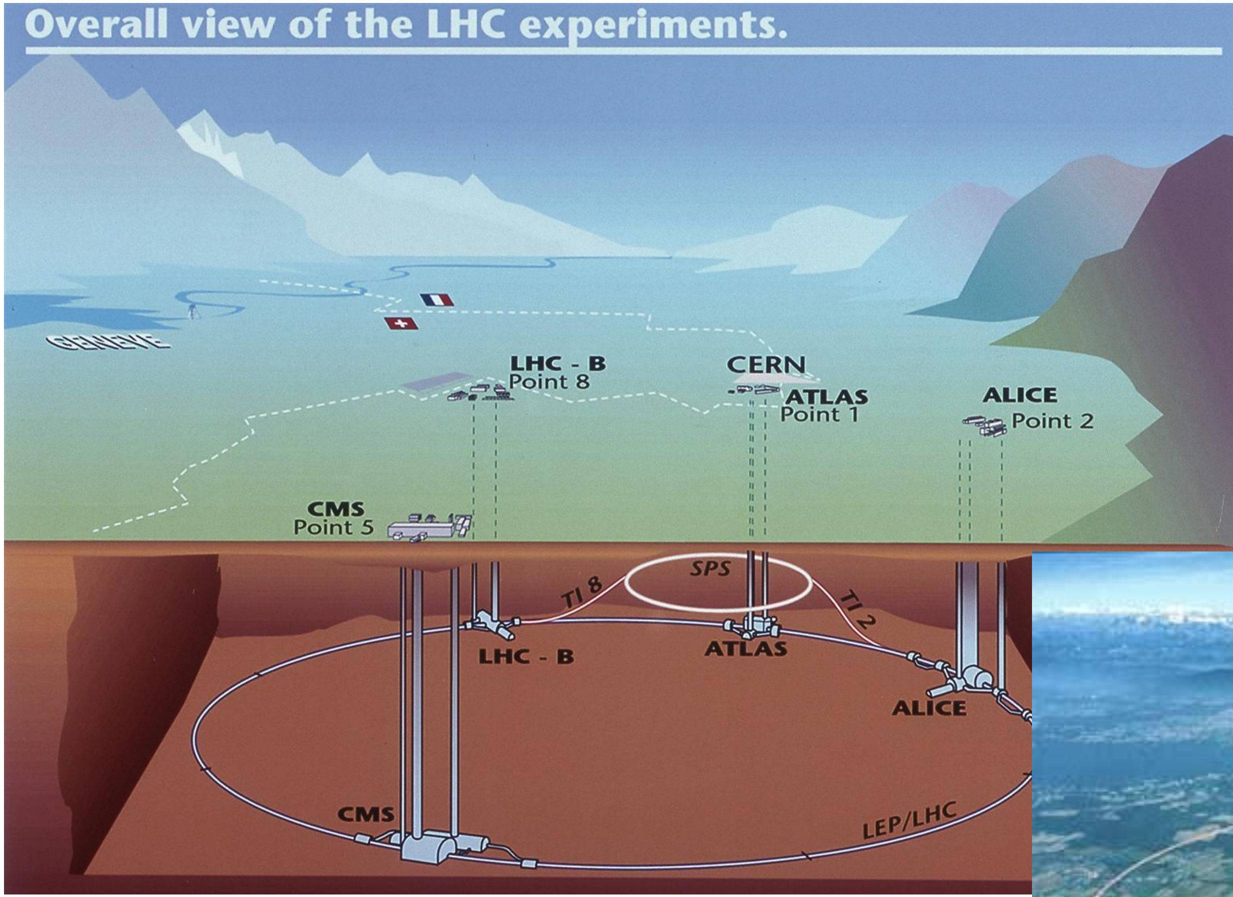
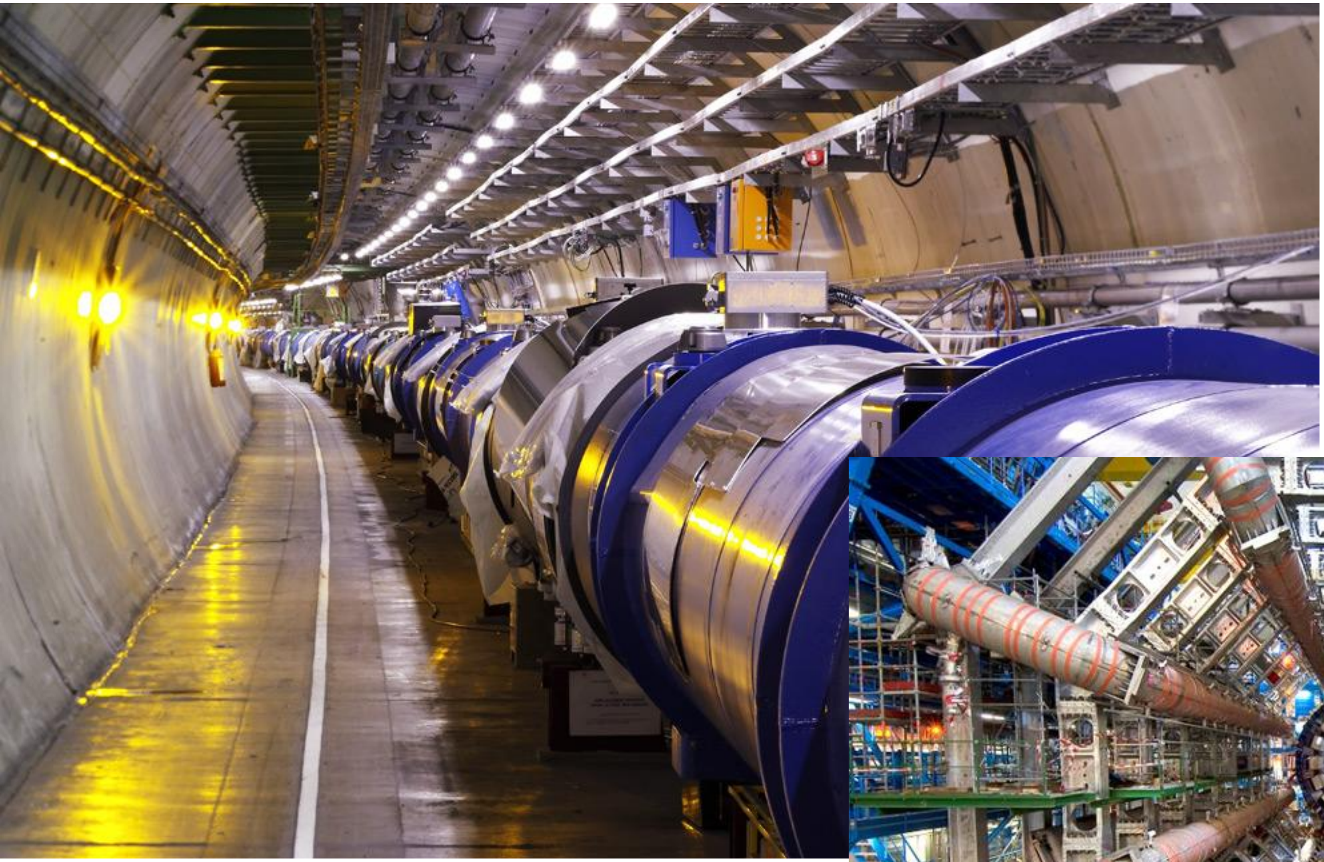
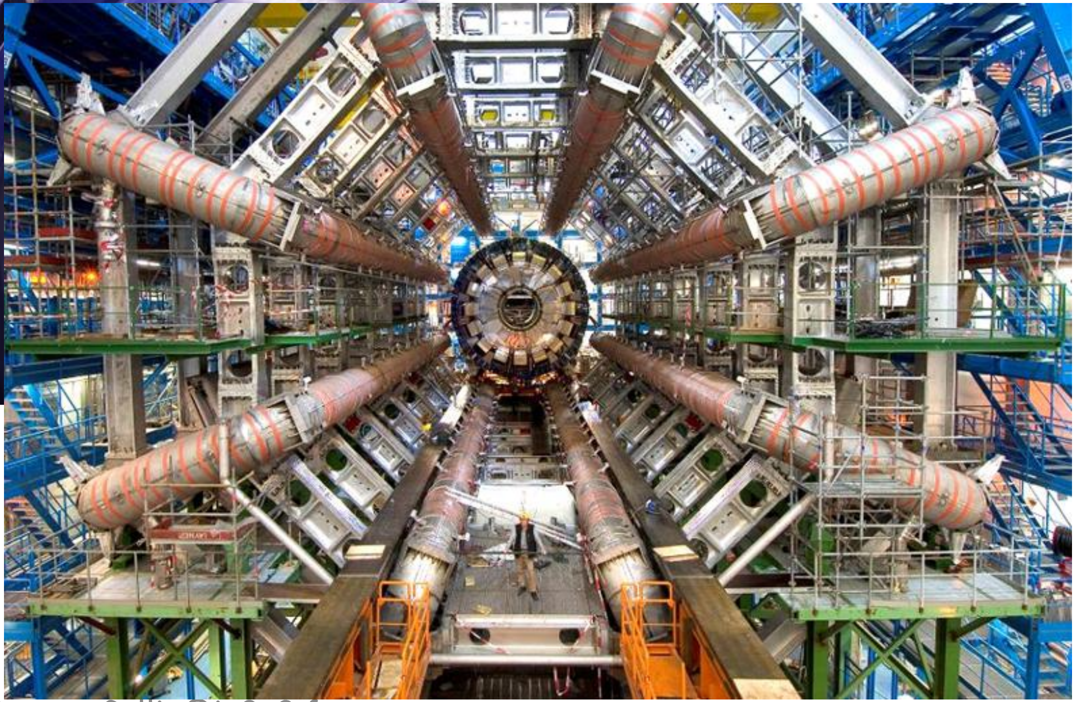
CNRS/IN2P3LAPP - KEK

CERN - LHC


Overall view of the LHC experiments.
GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC

LHC- ATLAS



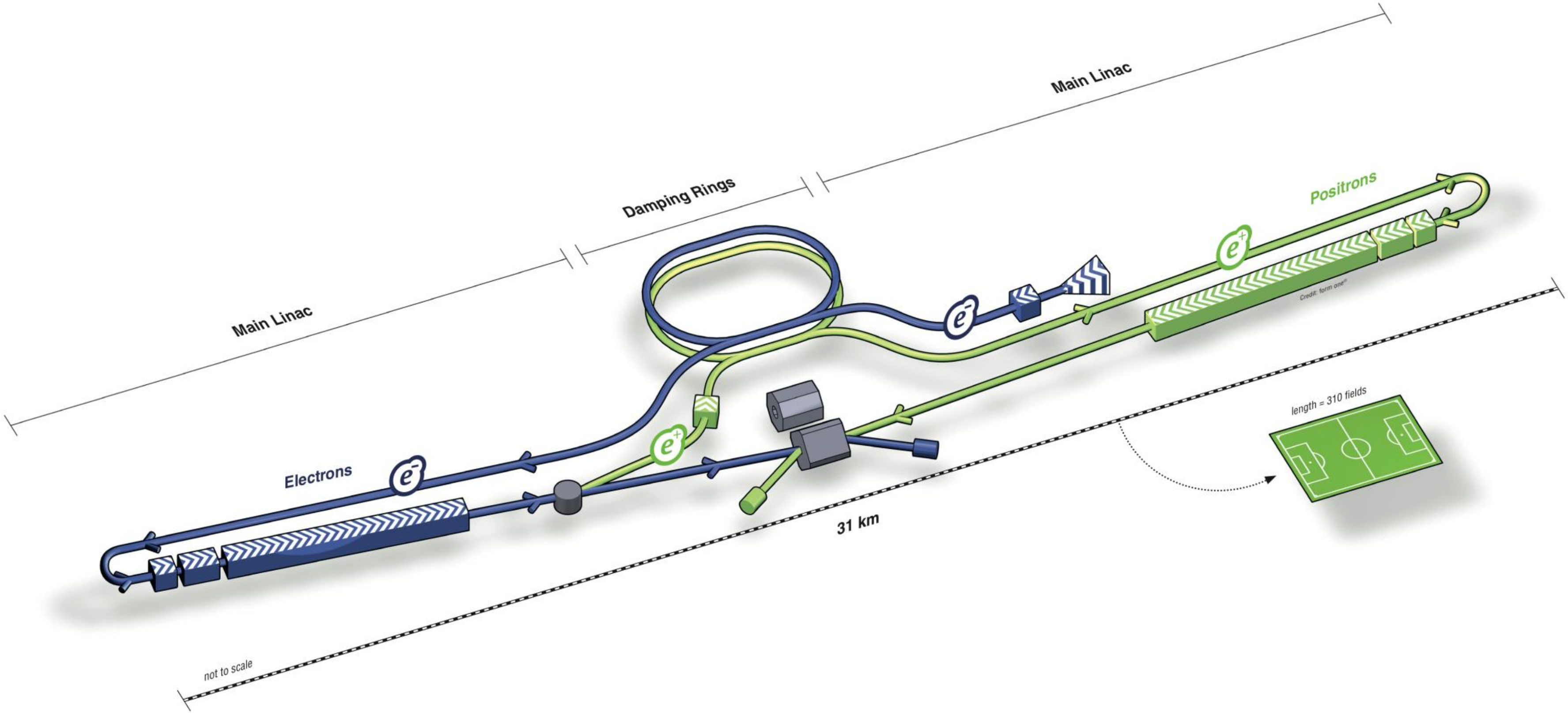


LHC Cryogenics

- 27 km SC magnets 36000 tons @1.9K
- 8 cryogenics plants each:
  - For a 3.3 km sector of the ring
  - 4.5K cooling capacity 18kW (600kW LN2 pre-cooler)
  - 1.8K cooling capacity 2kW
- Total: 32MW CC 144 kW @ 4.5 K – 40,000 Lhe/day.
- Total He inventory: 136 tons + 15 tons backup

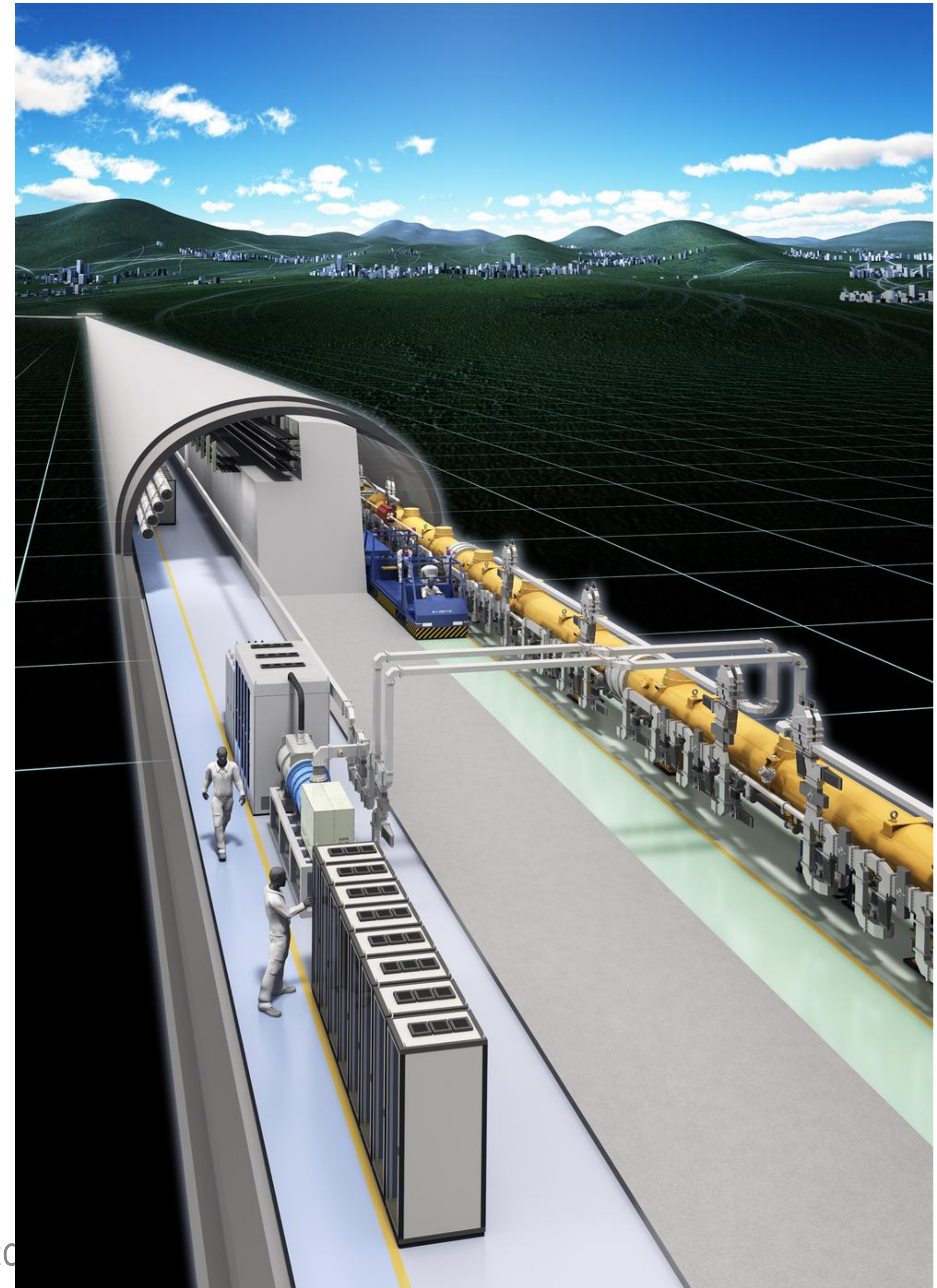
One of the 8 compressor units @4.5 K

ILC: International Linear Collider



2 x 10 km linac: SC cavities @ 500 GeV → 2 x 20 km @ 1000 GeV

Green-ILC



SCRF and Cryo cooling

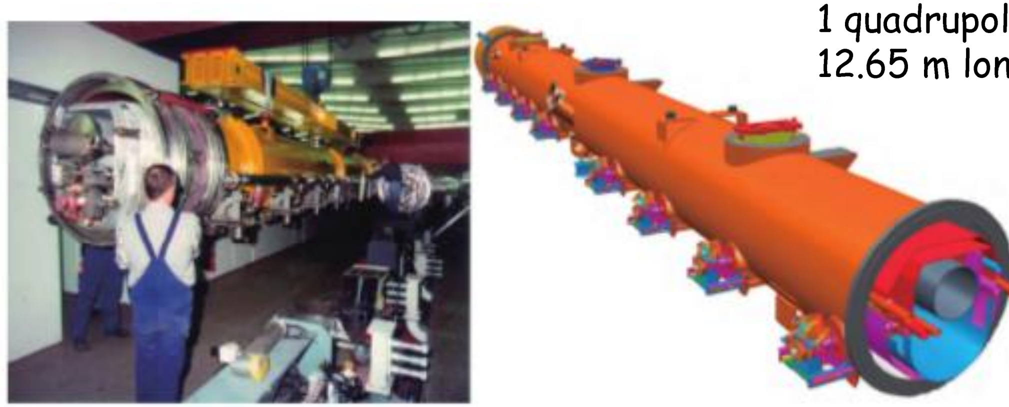
Total: 1853 cryomodules

SC cavity
9 cell
1.04 m long

Figure 2.2
A 1.3 GHz supercon-ducting nine-cell nio-bium cavity.

Cryomodule:
8-9 SC cavities
1 quadrupole SC magnet
12.65 m long

Figure 2.3
SCRF cryomodule. Left: a type-III mod-ule being installed at DESY's FLASH facility. Right: the ILC type-IV module.



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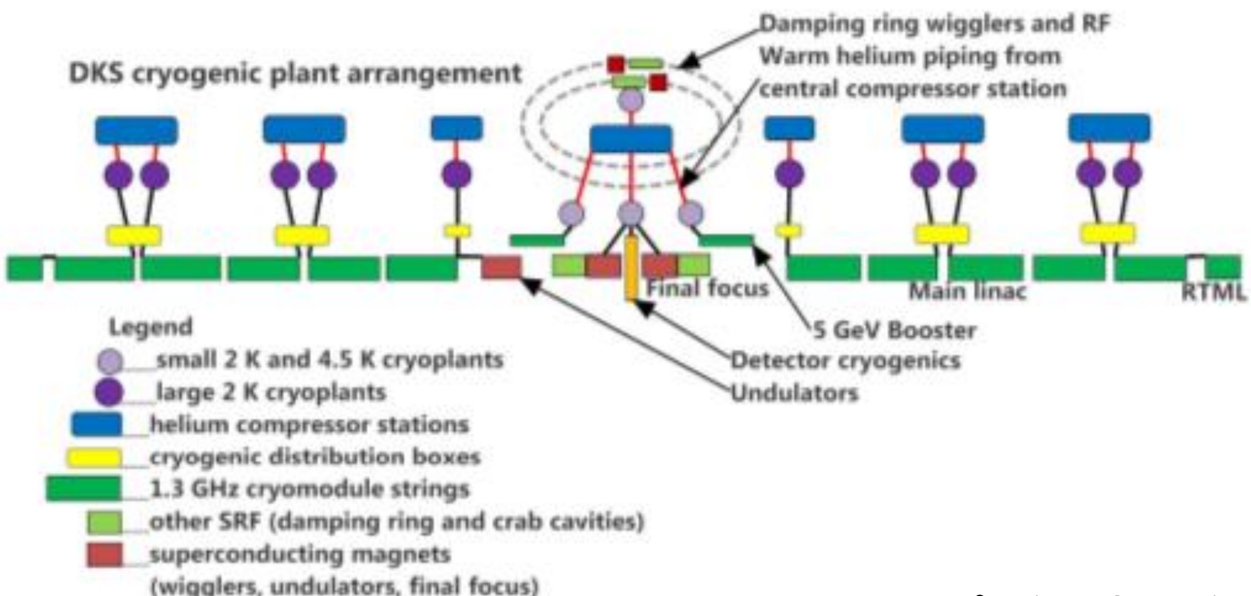
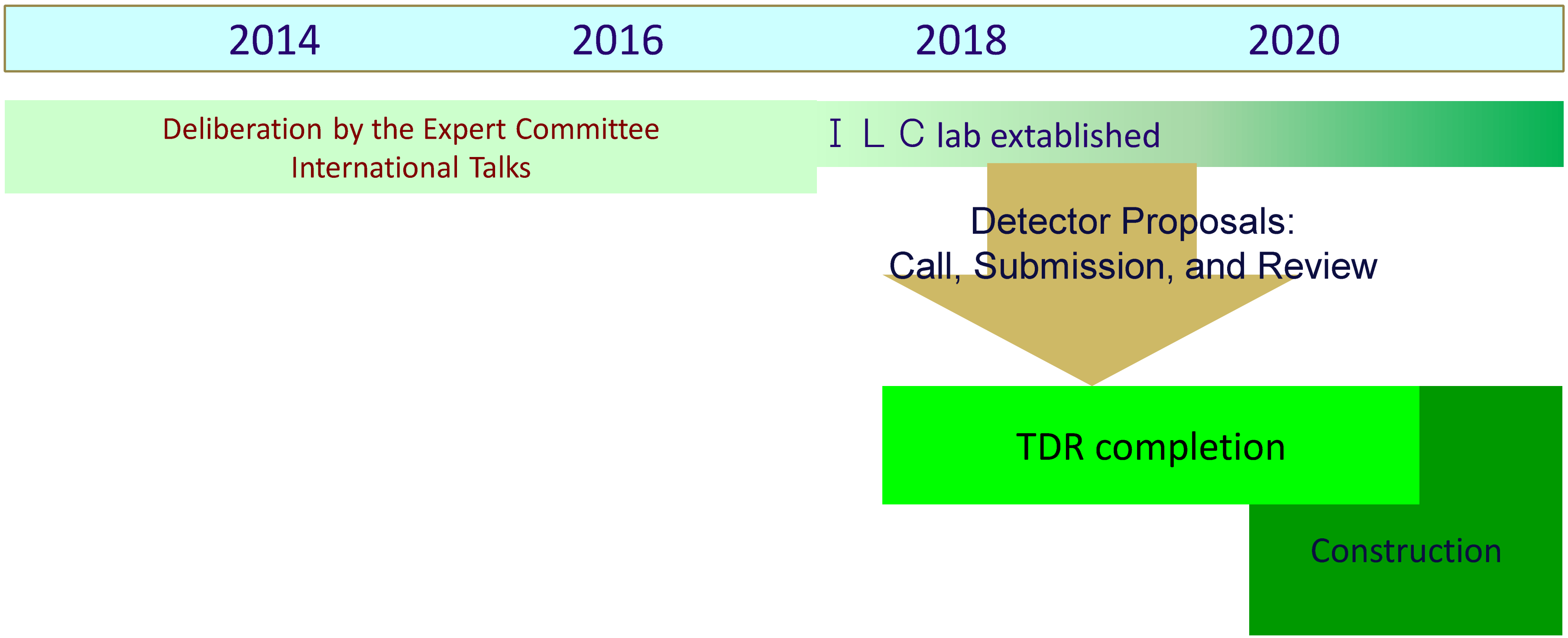
10 Cryo-plants

- Cavities at 2 K, immersed in a saturated He II bath
- helium gas-cooled shields at 5–8 K and at 40–80 K.
- Static and dynamic cryogenic heat loads at 2 K: 1.7 W and 9.8 W, no LN2
- 10 large cryogenic plants, each of with cooling power of ~20 kW at 4.5 K.



~ 630 000 ℓ Lhe for the main linac

Possible Timeline of ILC Detectors



Detector groups are preparing for this period by
Re-optimizing and re-organizing their detectors.


- Japanese Mountainous Sites -
Site-A
KITAKAMI
IWATE
TOHOKU district
SEBURI
Site-B
FUKUOKA
SAGA
KYUSHU district
Tokyo

Green-ILC Objectives

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

Revisiting all ILC components:

1. Energy Saving: improving efficiency …. 80% lost as heat waste
2. Operational saving
3. Energy Recovery and Recycling

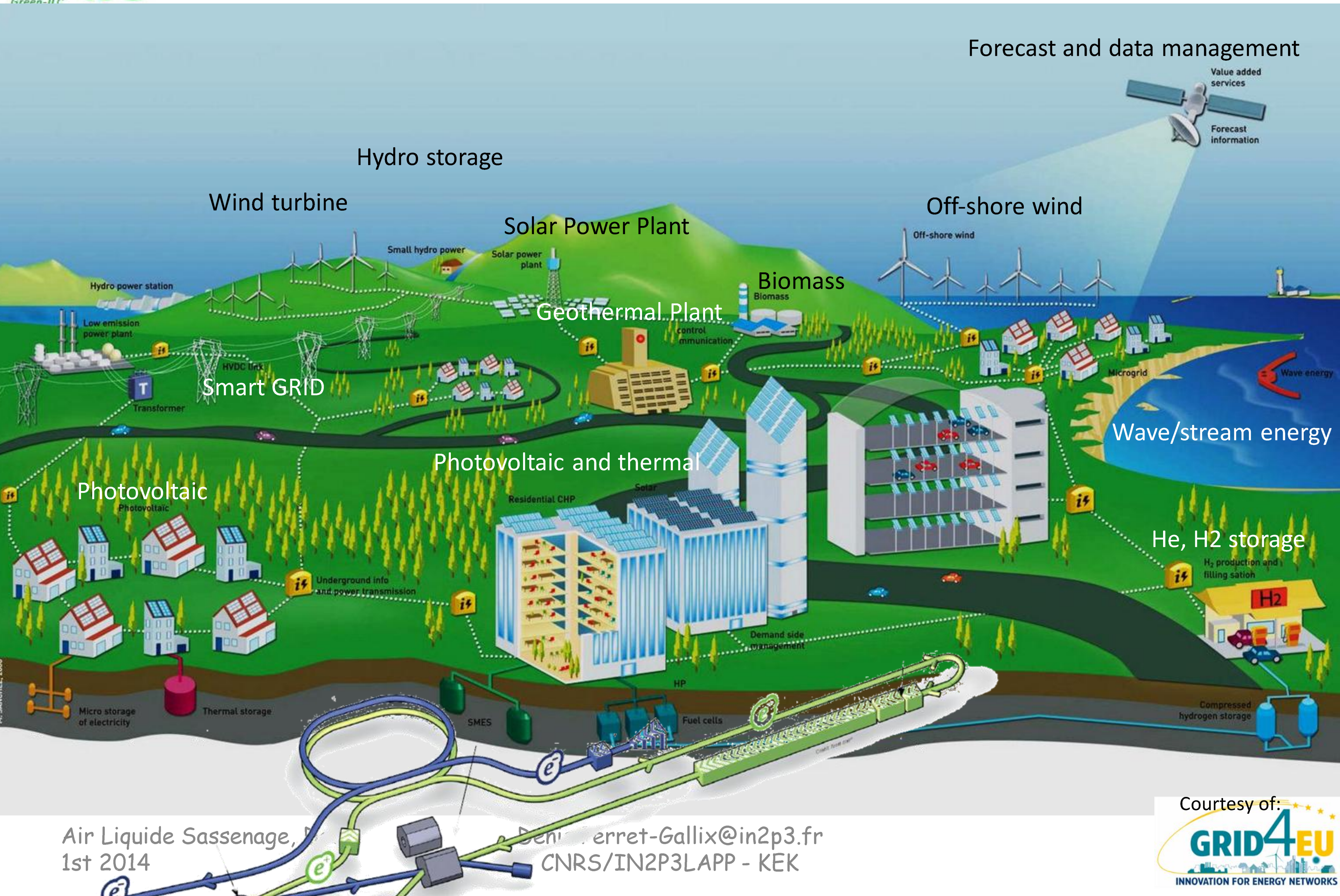
Alternative energies:

1. Renewable energy production, 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
2. Synergies: expertise (SC, magnets, beams, computing), photon, neutron factories
3. Technology innovation
4. ILC as a test bench: Pilot plants for ILC

ILC Energy center (artistic) view



An LN_2 Economy for ILC

The ILC cryogenics is consuming ~ 40 MW (25% of ILC AC power)

- In current design all cooling is done with LHe. LN_2 as a primary coolant -> 20 MW
- LN_2 cooling: HTc (MgB2) power transmission lines, NC magnets, electronics/computers,
- LN_2 could be used to recycle low grade heat waste (including beam dumps)
- And produce electricity with high-pressure gaz turbine

LN_2 could be produced by sustainable energies

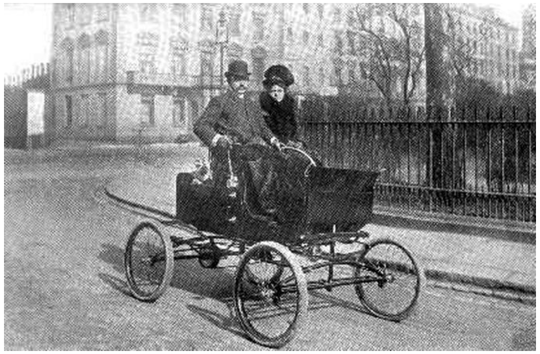
- Close to or at the ILC site (wind, solar, geothermal energy)
- Wind energy: from electricity or direct compression

LN_2 Energy storage

- With the heat waste, turbine produce electricity when needed. 70% efficiency

Sumimoto

First LN2 car



Liquid air energy network

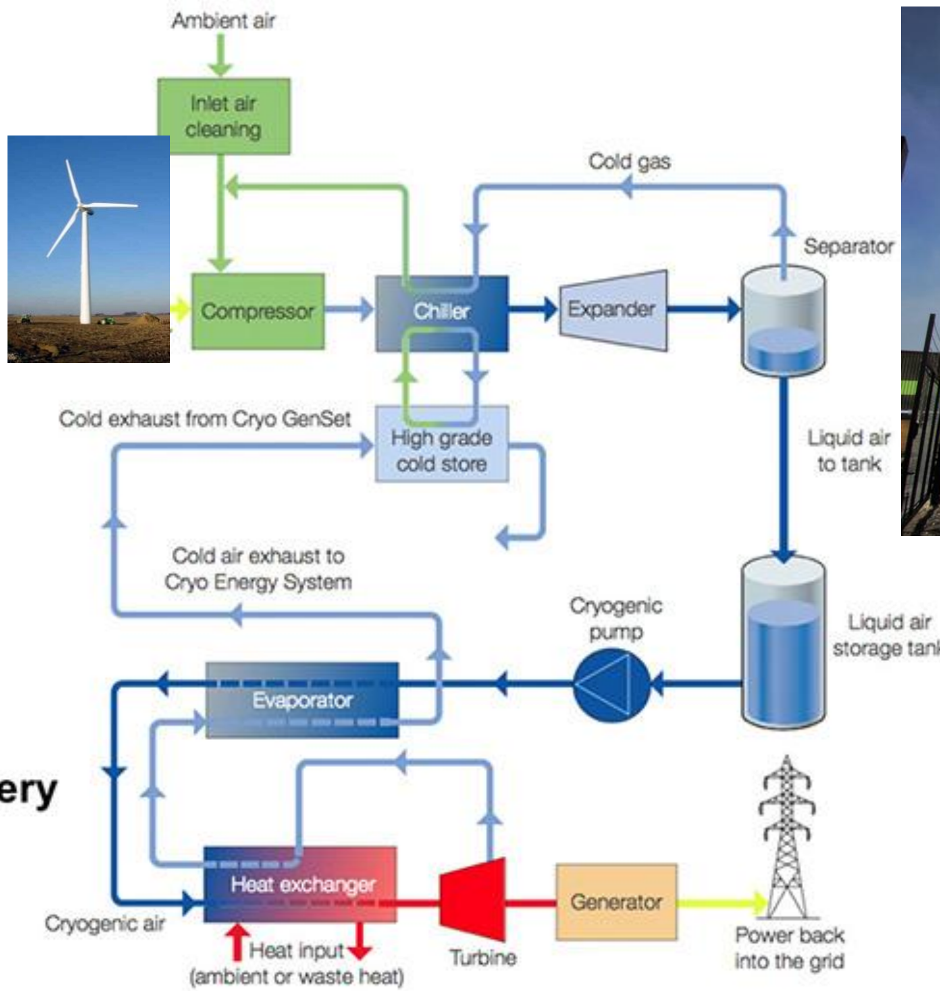
Green-ILC

LN2 as energy storage

Liquefaction

Storage

Power Recovery

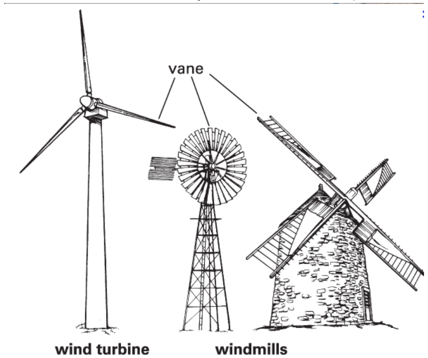


Highview Power Storage (UK)

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

LN2 process cycle

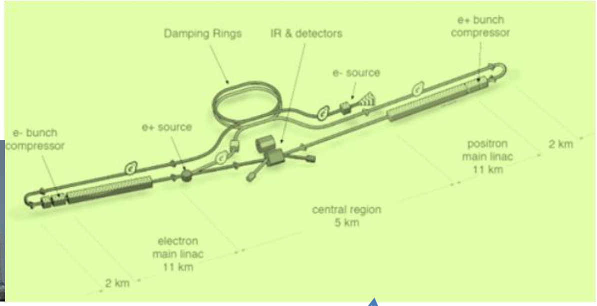
Compressor/liquefier inside



LN2

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

Energy storage



LN2 heat waste

Turbine → electrical generator

N2 gas applications

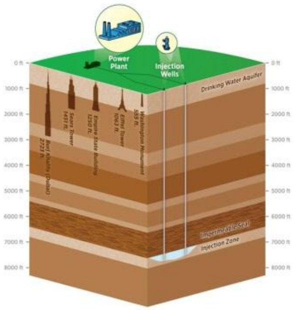
Electricity Back to ILC/GRID

i.e. Drying and preservation industry

LO_2, LAr, SCO_2 Dry ice

To Industry

For Cooling or Sequestration

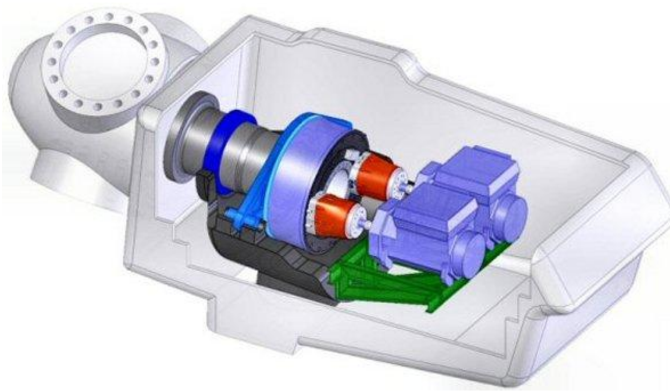


Air cleaning !!!

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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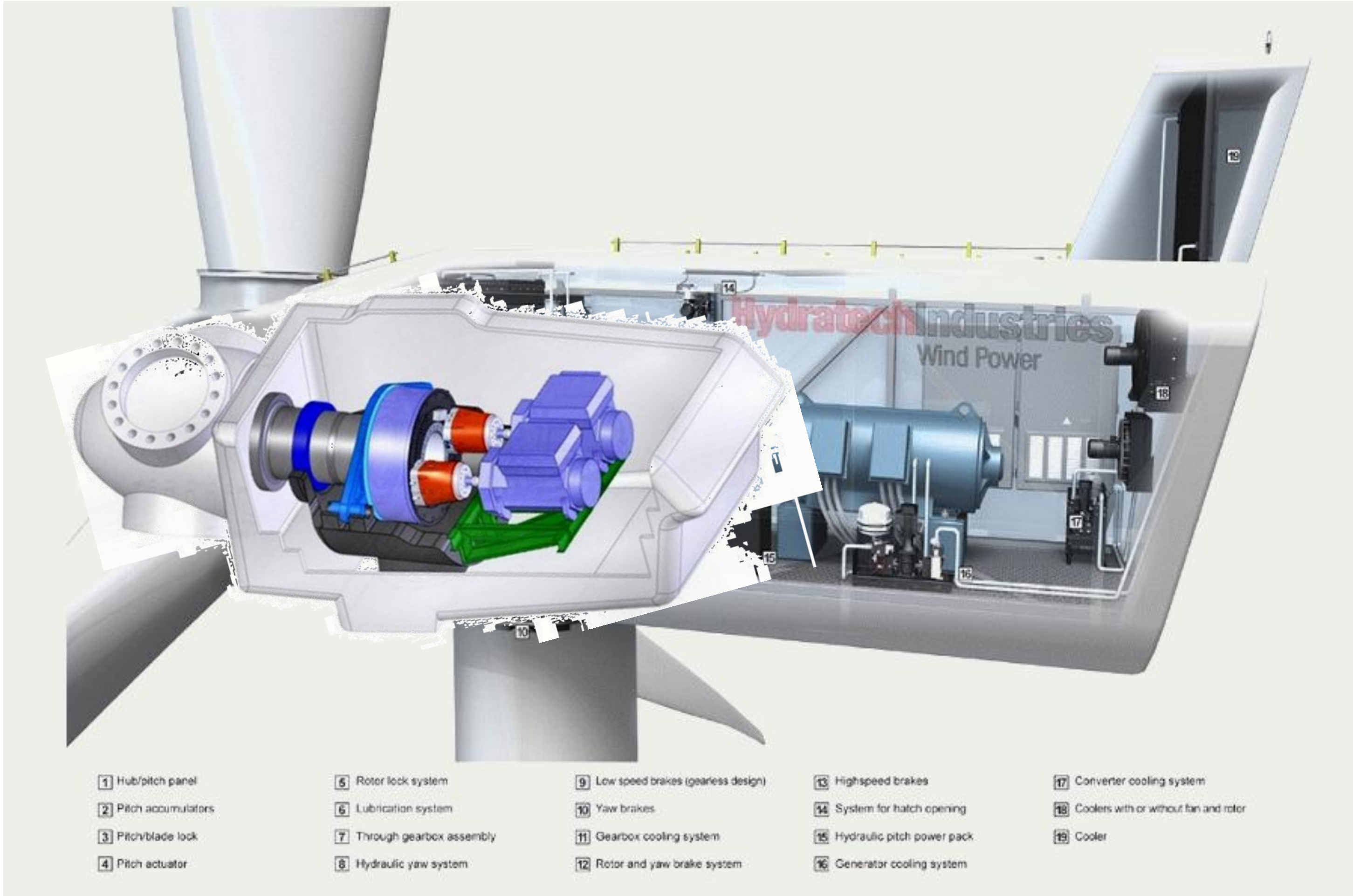
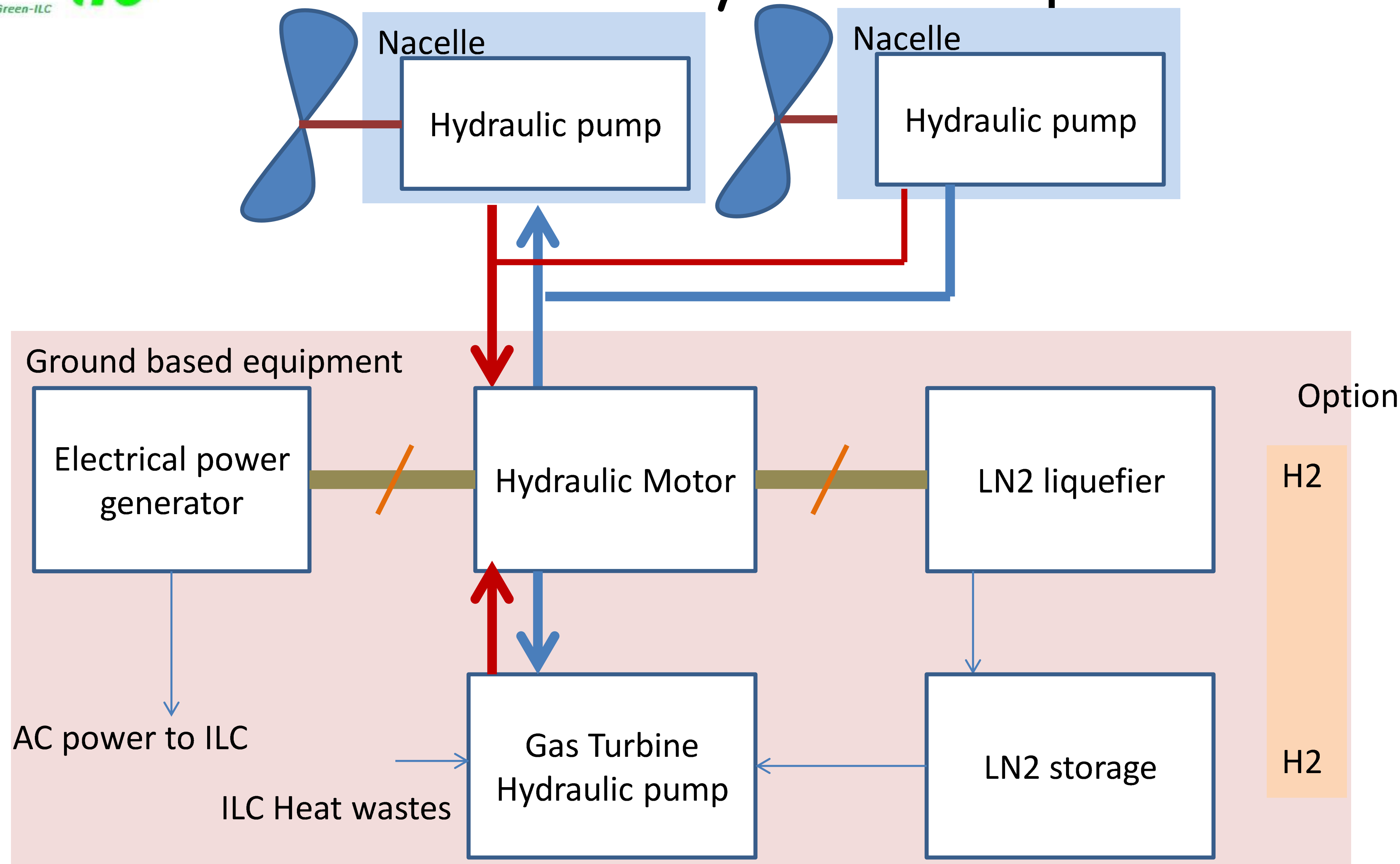

Hydratech Industries
Wind Power
1 Hub/pitch panel
2 Pitch accumulators
3 Pitch/blade lock
4 Pitch actuator
5 Rotor lock system
6 Lubrication system
7 Through gearbox assembly
8 Hydraulic yaw system
9 Low speed brakes (gearless design)
10 Yaw brakes
11 Gearbox cooling system
12 Rotor and yaw brake system
13 Highspeed brakes
14 System for hatch opening
15 Hydraulic pitch power pack
16 Generator cooling system
17 Converter cooling system
18 Coolers with or without fan and rotor
19 Cooler

Ground based hybrid wind power



http://green-ILC.in2p3.fr

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

Thank you

Table 3.11. Main-linac heat loads and cryogenic plant size [34]. Where there is a site dependence, the values for the flat / mountain topographies are quoted respectively. (The primary difference is in the choice the number of cryo-plants, specifically 6 and 5 plants for flat and mountainous topographies respectively.)

		40–80 K	5–8 K	2 K
Predicted module static heat load	(W/module)	75.04	10.82	1.32
Predicted module dynamic heat load	(W/module)	58.80	5.05	9.79
Number of cryomodules per cryogenic unit		156 / 189	156 / 189	156 / 189
Non-module heat load per cryo unit	(kW)	0.7 / 1.1	0.14 / 0.22	0.14 / 0.22
Total predicted heat per cryogenic unit	(kW)	21.58 / 26.40	2.61 / 3.22	1.87 / 2.32
Efficiency (fraction Carnot)		0.28	0.24	0.22
Efficiency in Watts/Watt	(W/W)	16.45	197.94	702.98
Overall net cryogenic capacity multiplier		1.54	1.54	1.54
Heat load per cryogenic unit including multiplier	(kW)	33.23 / 40.65	4.03 / 4.96	2.88 / 3.57
Installed power	(kW)	547/669	797/981	2028 / 2511
Installed 4.5 K equiv	(kW)	2.50 / 3.05	3.64 / 4.48	9.26 / 11.47
Percent of total power at each level		0.16	0.24	0.60
Total operating power for one cryo unit based on predicted heat (MW)			2.63 / 3.24	
Total installed power for one cryo unit (MW)			3.37 / 4.16	
Total installed 4.5 K equivalent power for one cryo unit (kW)			15.40 / 19.01	