Green ILC

Takayuki Saeki (KEK)

ILC IDT Physics group meeting

11 (Fri.) March 2022

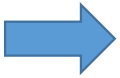
doc. numbers:
DESY, FERMILAB, IFIC, IRFU
JLAB, KEK Preprint 2021-61
PNNL-SA-160884, SLAC-PUB-17662
and more ...

March 10, 2022

The International Linear Collider: Report to Snowmass 2021

THE ILC INTERNATIONAL DEVELOPMENT TEAM AND THE ILC COMMUNITY

Please Visit here for more details and references.



4 ILC Accelerator **37**
4.1 ILC accelerator design 37
4.1.1 Design evolution since the TDR 39
4.1.2 Superconducting RF Technology 41
4.1.3 Accelerator design 51
4.1.4 Operation at the *Z*-pole 61
4.1.5 Civil engineering and site 63
4.1.6 Green ILC 65
4.1.7 ILC cost and schedule 71

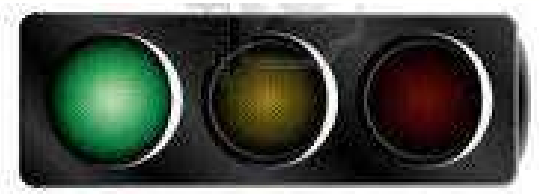
Contents

- Introduction.
- Collaboration of Industry and Academia: Advanced Accelerator Association promoting science & technology (AAA) in Japan.
- Efforts on communications with international LC teams, other projects and other regions.
- Efforts on the components and sub-systems of ILC.
- Efforts on the ILC city.
- Efforts on communications with Kitakami site.
- Summary.

Introduction

ILC design for more efficient energy consumption (in accelerator operation)

We need Green ILC



to have the green sign for ILC !

Serious issue for the realization of ILC

The total energy consumption of ILC is 111 MW at 250-GeV initial phase, 163 MW at 500-GeV phase and 300 MV at 1-TeV phase. The improvement of energy efficiency is the crucial issue for the realization of ILC.

2nd ESS WS (Oct. 2013) triggered our activities !

2nd Workshop
Energy for Sustainable Science
at Research Infrastructures

CERN, GENEVA, SWITZERLAND, 23-25 OCTOBER 2013

ILC: an amazing energy transformer

FROM eV TO TeV:

THE GREEN ILC

2nd Energy for Sustainable Sciences, CERN Oct 2013 — Denis Perret-Gallix, LAPP/IN2P3.CNRS (France) — 1

Energy Management in Japan, Consequences for Research Infrastructures

Masakazu Yoshioka (KEK)

1. Electric power supply in Japan, before and after March 11, 2011 earthquake
   - High efficiency and "almost" environmental pollution-free electricity generators can save Japan, and contribute to reduce global CO_2 problem
2. KEK Electricity contract as an example of large-scale RIs
3. Accelerator design by considering optimization of luminosity/electricity demand
   - Example: Super-KEKB
   - ILC
4. Accelerator component design by considering high power-efficiency
   - Klystron
   - Availability based on MTBF and MTTR
5. Summary

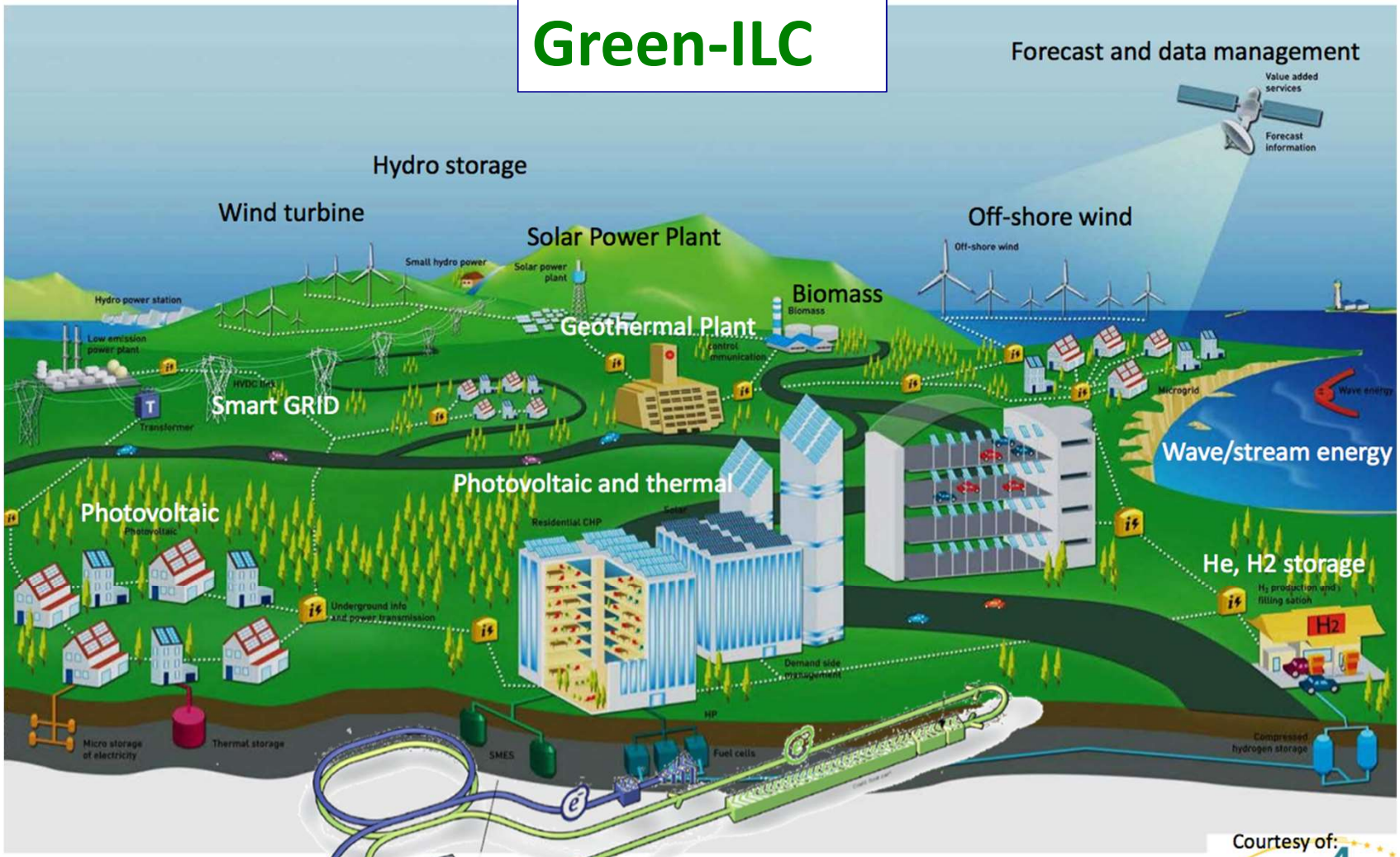
Energy Management at KEK, Strategy on Energy Management, Efficiency, Sustainability

Atsuto Suzuki (KEK)

INTER-UNIVERSITY RESEARCH INSTITUTE CORPORATION
HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION

ILC center futuristic view

Green-ILC



AAA Green ILC 25/2/1
Den . erret-Gallix@in2p3.fr
APP/IN2P3.CNRS (France)

Courtesy of: GRID4EU INNOVATION FOR ENERGY NETWORKS

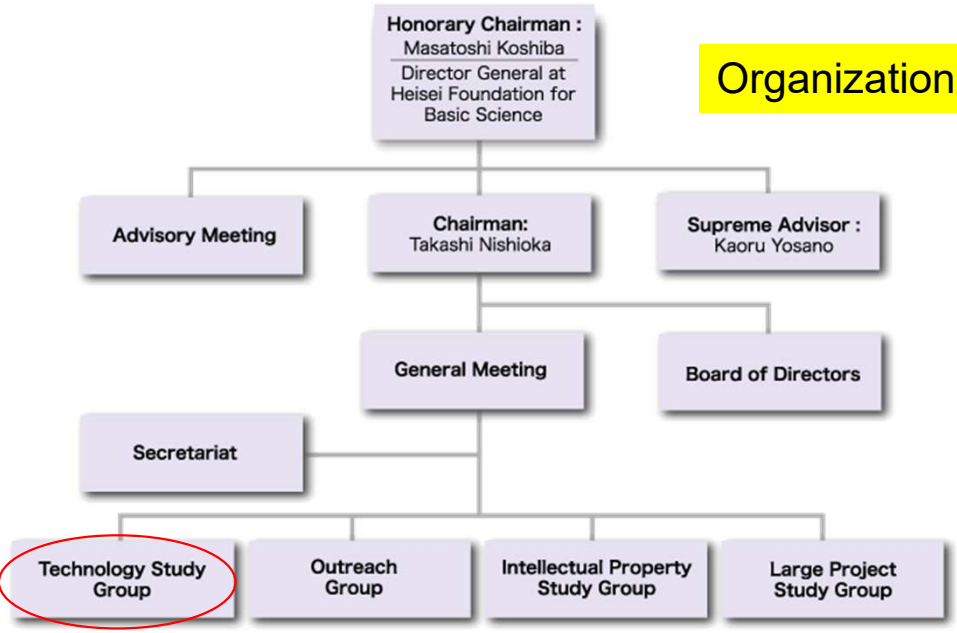
Advanced Accelerator Association promoting science & technology (AAA) in Japan

Association by industries and scientists established in 2008

- 102 corporate organizations involved from industries（MHI, Toshiba, Hitachi, Mitsubishi Electric, etc.) as of Nov. 2017.
- 41 institutional organizations involved from universities and laboratories（KEK, Univ. of Tokyo, Univ. of Tohoku, Univ. of Kyoto, Riken, etc.) as of May 2021.

Green-ILC WG started in Technology Study Group on 25th Feb. 2014.

Organization of AAA



Activities for Green ILC

- Three presentations were given (by A. Suzuki, D. Perret-Gallix, and M. Yoshioka) in 2nd WS "Energy for Sustainable Science at Research Infrastructure" at CERN in Oct. 2013.
- A session (four presentations) was organized for Green-ILC activities in LCWS 2013 at Tokyo in Nov. 2013. A. Suzuki also presented Green-ILC activities in the plenary session in LCWS 2013.
- Green-ILC Working Group was organized in "Advanced Accelerator Association promoting science & technology (AAA) in Tokyo/Japan. The 1st meeting for the Green-ILC WG of AAA was held on 25th February 2014. (AAA home page = https://aaa-sentan.org/en/about_us.html)
- 2nd – 15th Green-ILC WG meetings were held on May 2014 – until now in Tokyo/Japan.
- Various realistic technologies of energy-saving for ILC were proposed and discussed by industries and scientists. More details in Green-ILC WG (AAA) Report 2016, which includes 25 subjects (Report of Green Accelerators in the world: 3 subjects, Green components for ILC: 10 subjects, Energy Recovery and Storage for ILC: 6 subjects, Plans of Green-ILC city: 6 subjects) in 168 pages.
- D. Perret-Gallix, T. Saeki, and H. Hayano opened the interactive home page for Green-ILC activities. Please visit http://green-ilc.in2p3.fr/ and http://green-ilc.in2p3.fr/documents/ . Green-ILC WG (AAA) Report 2016 is on this page.

International Panel on "Sustainable colliders and accelerators"

Started in 2015.

ICFA: International Committee on Future Accelerators
has setup a panel: ~ 20 people headed by Mike Seidel (PSI, Switzerland)

Denis Perret-Gallix, Takayuki Saeki (ILC group)

- strategy & coordination
- energy efficient accelerator concept
- energy efficient and sustainable accelerator technology
- energy management for large research facilities

Also providing close and active communications among various projects.

2022/03/10 18:20 ILC Workshop on Potential Experiments (ILCX2021) (26-October 29, 2021): Overview · ILC Agenda (Indico)

Asia/Tokyo | English (United States) | Login

ILCX2021 ILC Workshop on Potential Experiments

ILC Workshop on Potential Experiments (ILCX2021)

Oct 26 – 29, 2021
Fully online format
Asia/Tokyo timezone

Enter your search term

- Overview
- Scientific Program
- Timetable
- Sessions and Timezone
  - Zoom Connection
  - SpatialChat Lounge
- Contribution List
- Speaker List
- Participant List
- Workshop Poster
- Information from Iwate

Thank you to all speakers and all participants for joining ILCX2021!

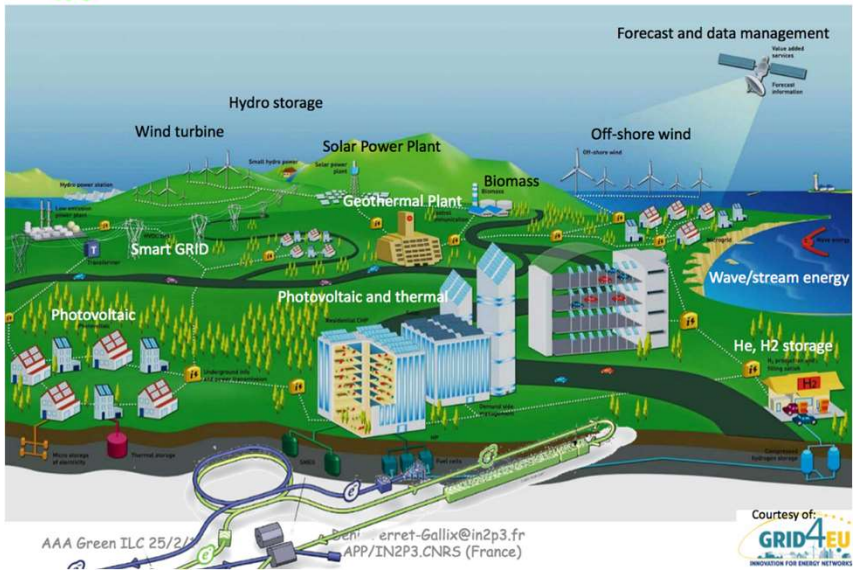
The ILC International Development Team (IDT) will hold the ILC Workshop on Potential Experiments (ILCX) in a fully-online format from October 26 to 29, 2021.

[Important] Zoom passcode has been sent to all participants (sender address: ilcx2021@ml.post.kek.jp). If you don't receive the passcode, please contact the local organizing committee immediately!

Currently, we are experiencing a problem with "Detailed view" of the timetable, and IT team is already aware of that. Instead of using the detailed view feature, another timetable format might be helpful to you.

Green-ILC

ILC center futuristic view



The ILC workshops (LCWS, AWLC and so on) always involved a Green-Accelerator session for the ILC-CLIC community to exchange the information about the sustainable and efficient technologies.

Green-ILC session in ILCX2021

Room#1, 13:00 – 15:00 W-1 session, 15:30 – 17:30 W-2 session on 28th (Thu.) Oct.

Green-ILC session / W-1 / Room #1,
13:00 - 15:00 (JST)

13:00 - 13:30 (JST)
Prof. Masakazu Yoshioka
Basic policy of Green ILC activities at Kitakami ILC candidate site

13:30 - 14:00 (JST)
Prof. Valery Telnov
A high-luminosity SC e+e- collider with energy recovery and multiple use of beams

14:00 - 14:30 (JST)
Takeyoshi Goto
Development of hydrofluoric acid-free EP treatment of Nb cavities at KEK

14:30 - 15:00 (JST)
Discussions

15:00 – 15:30 (JST) Break

Green-ILC session / W-2 / Room #1
15:30 - 17:30 (JST)

15:30 - 15:50 (JST)
John Andrew Osborne
Tunnel Heat Recovery - Green ILC

15:50 - 16:10 (JST)
Benno List
Sustainability issues

16:10 - 16:30 (JST)
Mr Riichiro Kobana
RF power system of ILC by all solid-state amplifiers.

16:30 - 16:55 (JST)
Igor Syratchev
High Efficiency Klystrons development.

16:55 - 17:30 (JST)
Discussions

Green ILC

Energy for Innovation, Innovation in Energy

http://green-ILC.in2p3.fr

Home | Blog | Archives | ▸ Research | Conferences | Documents | Links | Contacts | Search | RSS

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

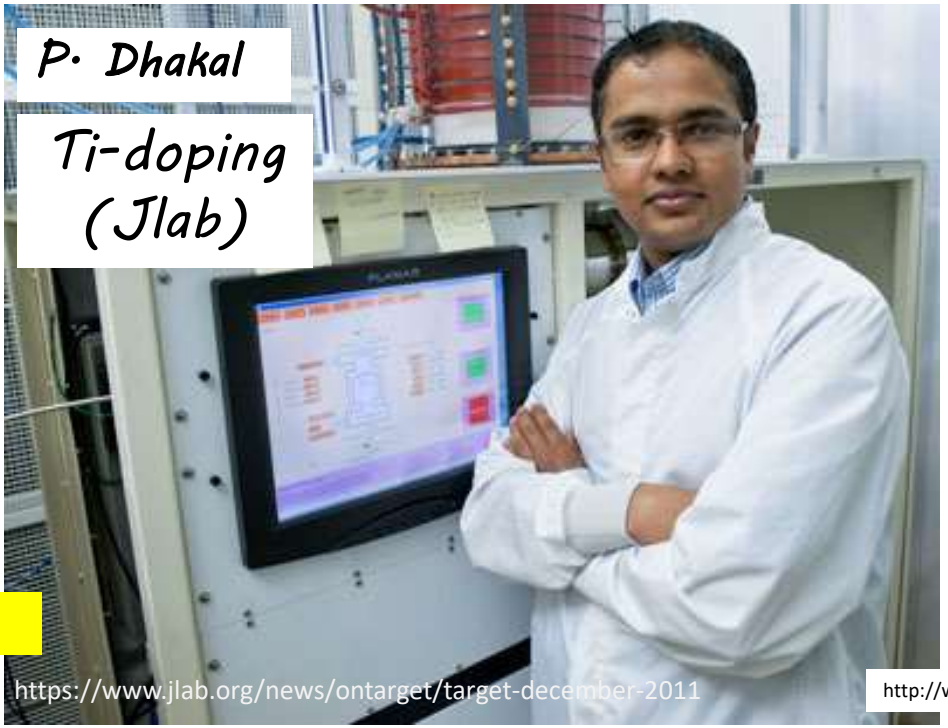
email: green.accelerators@gmail.com
Green-ILC wiki
Green-ILC group discussion

Green-ILC WG (AAA) report-2016 in English and all presentations related to Green-ILC are found on http://green-ILC.in2p3.fr/documents/.

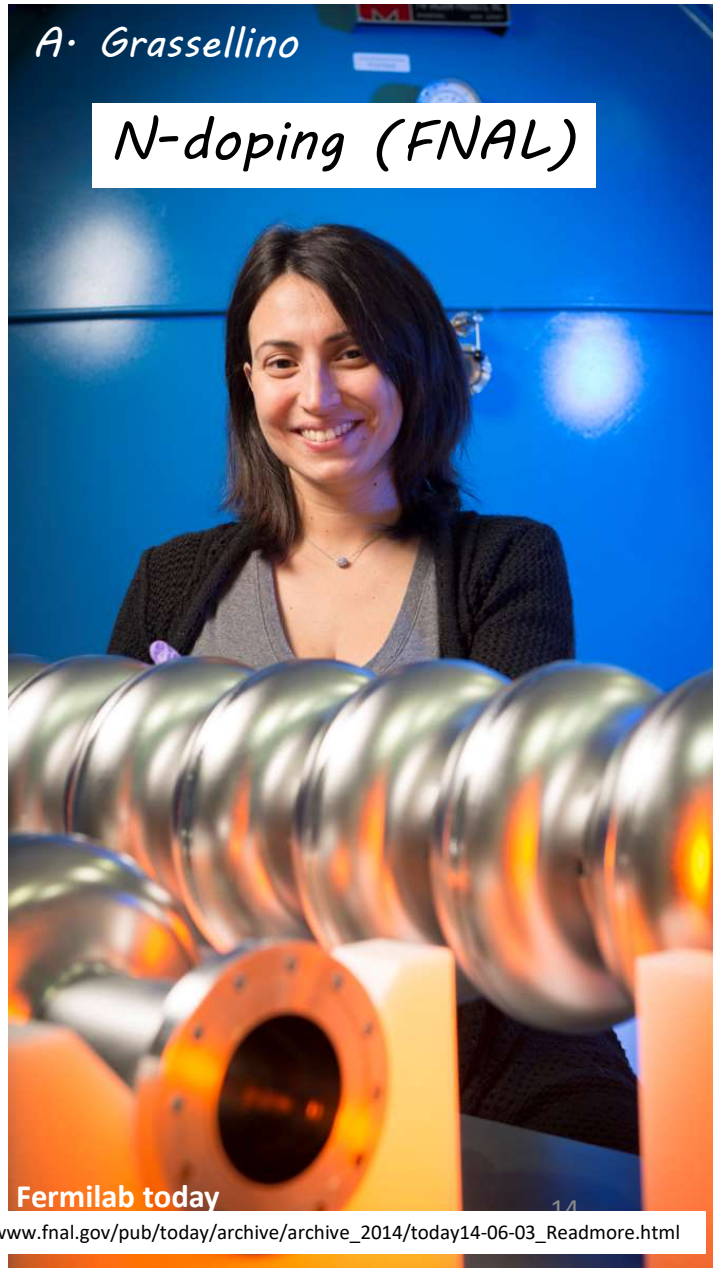
Efforts on components / sub-systems

International efforts in academia: Nitrogen doping for SRF cavity

Good technology for ILC ?



https://www.jlab.org/news/ontarget/target-december-2011

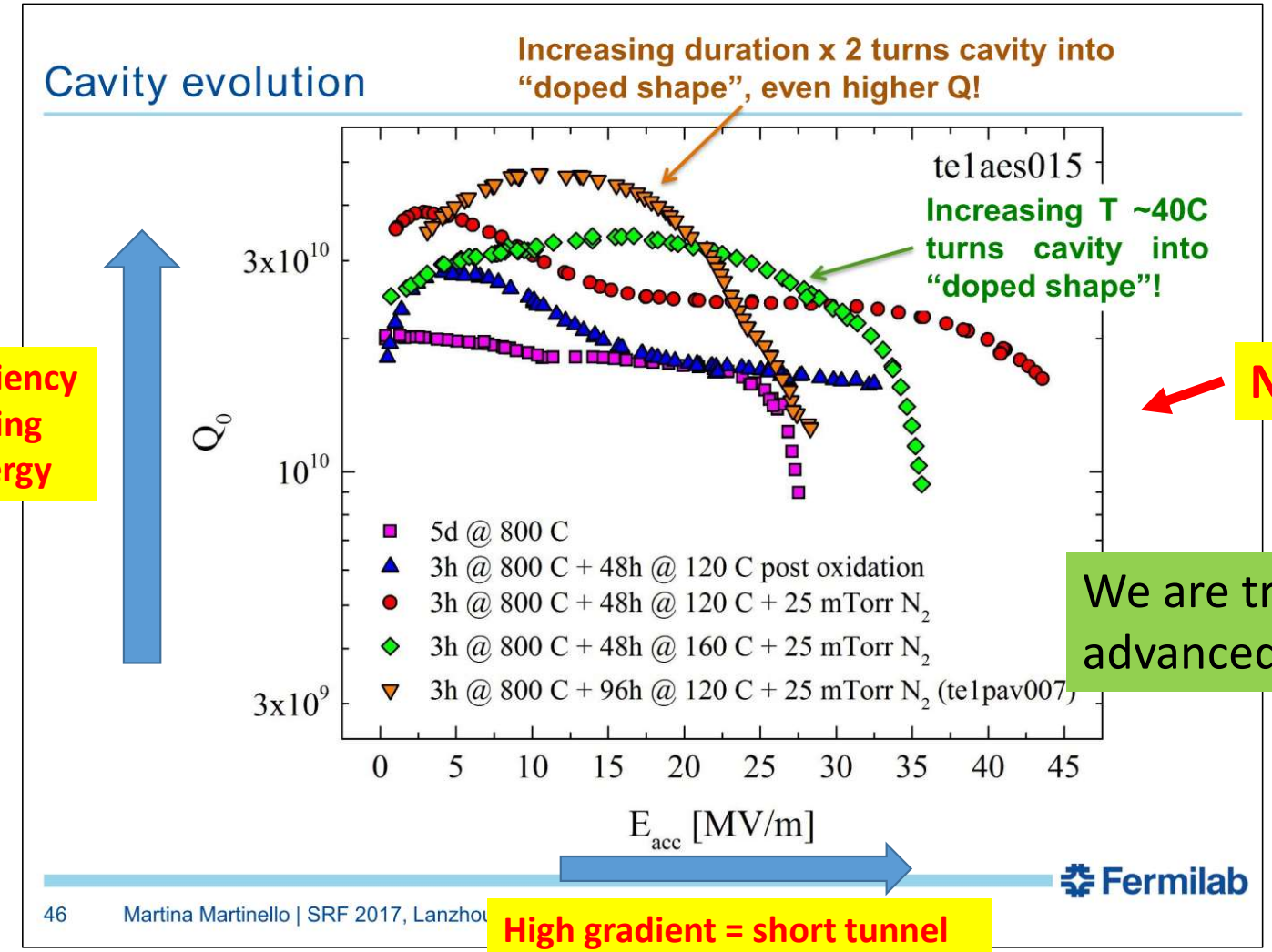


Fermilab today

http://www.fnal.gov/pub/today/archive/archive_2014/today14-06-03_Readmore.html

Slide by T. Kubo

Then "high-Q & high gradient" are realized



High efficiency
Low running cost / energy

N infusion

We are trying to involve advanced recipes in ILC.

High gradient = short tunnel

A. Grassellino et al.,
arXiv:1701.06077 to be published in Supercond. Sci. Technol.

More details in Green-ILC WG (AAA) Report 2016

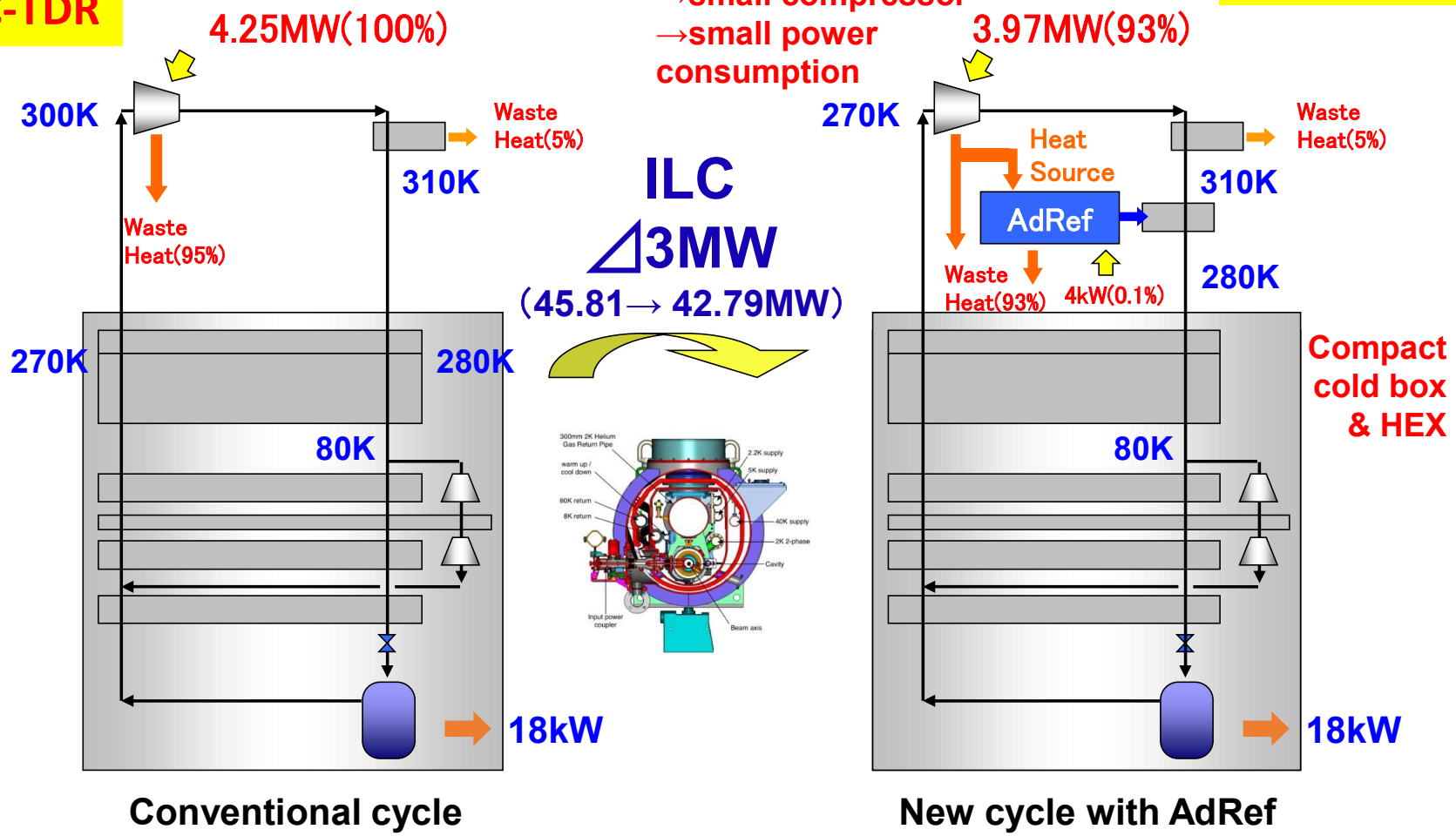
Example of effort by industry
New refrigeration cycle with AdRef

MAYEKAWA

New proposal
Energy reduction by 7%.

ILC-TDR

Low suction temp.
→small compressor
→small power consumption

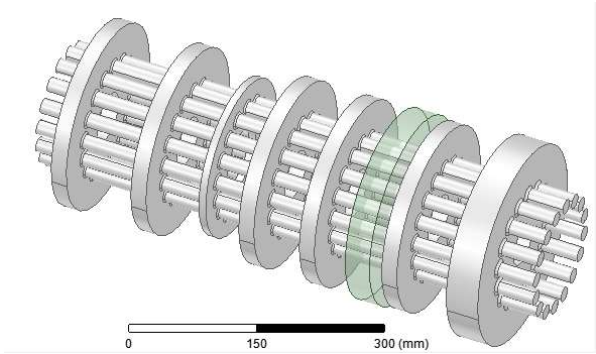


High Efficiency Klystrons Development by Igor Syratchev (ILCX2021)

Efficiency ~ 70%

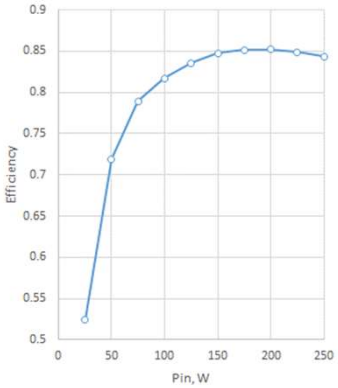
High power L-band Multi Beam Klystrons (MBK). Commercial tubes.

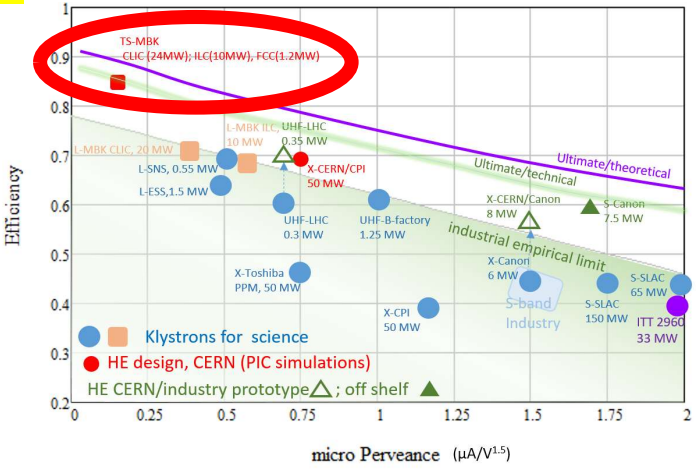
Efficiency ~ 65%



High Efficiency 10 MW, 1.3 GHz, ILC TS MBK (scaled from TS CLIC MBK+2nd harmonic)

Efficiency ~ 85%





RF power system of ILC by all solid-state power amplifiers (ILCX2021)

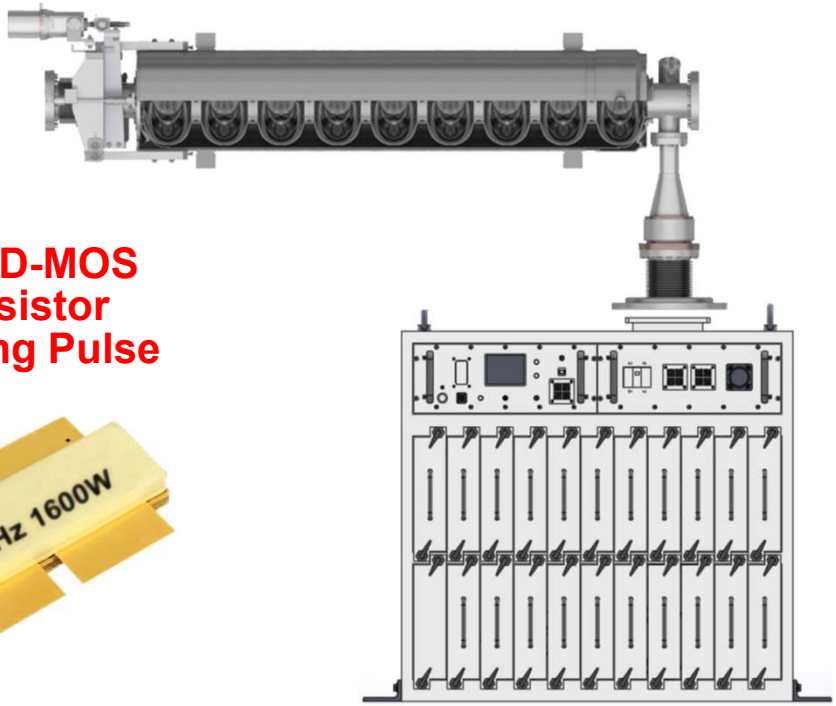
by R. Kobana (R&K company)

You don't need any of the following below----------

Power for Heater, Power for Solenoid, Marx Generator, Waveguide Assy and complex components,
Warm-up operation >>> Redundancy avoid Sudden Death.

No High Voltage is Less dangerous, High Mean Time between Failure (MTBF) and Short Mean Time to Repair (MTTR),

Quick Electrolytic capacitor PCB exchange, Affordable Cost for SSPA.



NXP LD-MOS Transistor For Long Pulse

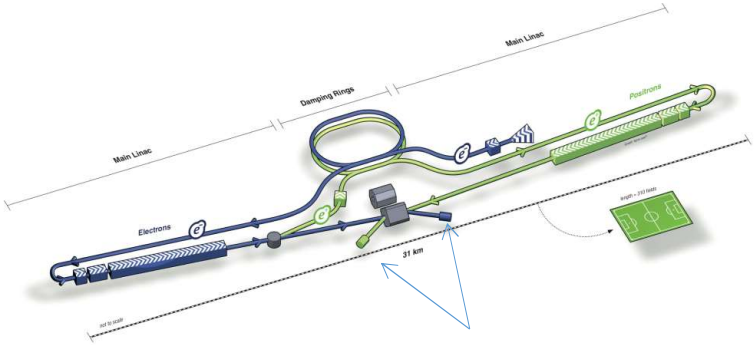
R&K – SSPA
@1300MHz
＞200kW,
PW＞1.6m sec
@10pps max.

SSPA = Solid-State Power Amplifier

R&D on Plasma Beam Dump

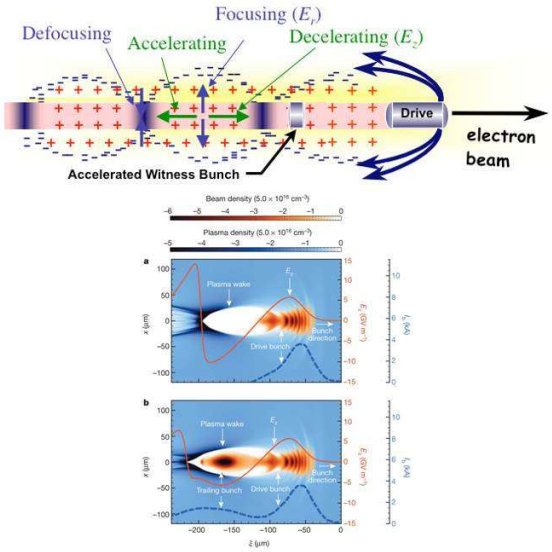
- Beam dump
- 14 MW (1TeV) @5 hertz
- 10 m Water 155°C, 1000m gas

Wakefield deceleration for beam dump project



Main Beam dumps
10m water, or1000m gas

Plasma Acceleration, wakefield acceleration



Study on the International Linear Collider Beam Dump by plasma-wakefield deceleration

T. Saeki, J. Fujimoto, H. Hayano, K. Yokoya (KEK/Sokendai)
T. Tajima, D. Farinella, X. Zhang (University of California at Irvine)
M. Zeng (ELI-NP, Romania)
A. W. Chao (SLAC)
D. Perret-Gallix (LAPP/IN2P3 – KEK)

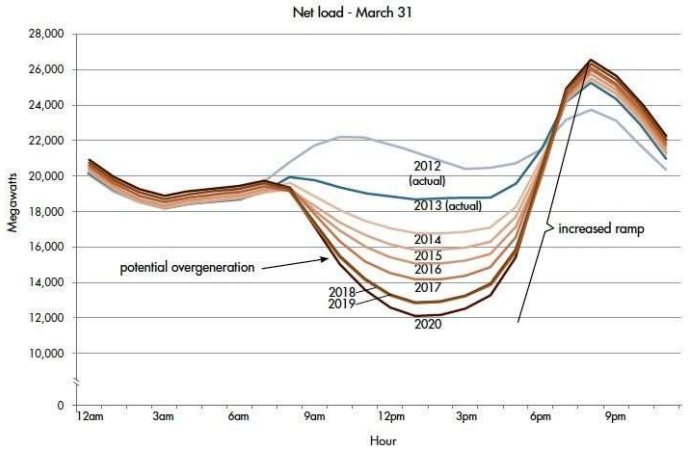
1st Nov. 2016
Academia meets industry forum
IEEE-NSS/MIC
Strasbour, France

1

Inter-University Research Institute Corporation High Energy Accelerator Research Organization
高エネルギー加速器研究機構
KEK
2016/10/30

ILC Sustainability Issues by Benno List / DESY (ILCX2021)

	500 TDR	250-A	250-A' w/R&D	250 2.5 Hz	250 2.5 Hz w/R&D	Standby (RF off)
Rep-Rate / Hz	5	5	5	2.5	2.5	0
Bunches / Pulse	1312	1312	1312	1312	1312	0
Lumi / 10^{34}	1.8	1.35	1.35	0.68	0.68	0
Gradient / MV/m	31.5	31.5	35	31.5	35	
Q_0/1E10	1.0	1.0	1.6	1.0	1.6	
ML E-gain / GeV	470	220	220	220	220	
ML Power / MW	107.1	50.1	49.3	30.1	29.1	10.0
e- Src / MW	4.9	4.9	4.9	5.6	4.9	5.6
e+ Src / MW	9.3	9.3	9.3	10.2	9.3	10.2
DR / MW	14.2	14.2	14.2	14.2	14.2	14.2
RTML / MW	10.4	10.4	10.4	10.4	10.4	10.4
BDS / MW	12.4	9.3	9.3	9.3	9.3	9.3
Dumps / MW	1.2	1.2	1.2	1.2	1.2	1.2
IR / MW	5.8	5.8	5.8	5.8	5.8	5.8
Campus / MW	2.7	2.7	2.7	2.7	2.7	2.7
Gen. Margin/MW	5.1	3.3	3.2	2.7	2.6	2.1
Total	**173**	**111**	**110**	**91**	**90**	**70**



- ILC sustainability increases with use of regenerative energy sources
- RES availability varies with season and time of day
- ILC can modulate power consumption according to RES availability
  -> Possible approaches:
  - Modulate beam power
  - Buffer energy – use pre-chilled water and/or liquid helium as buffer?

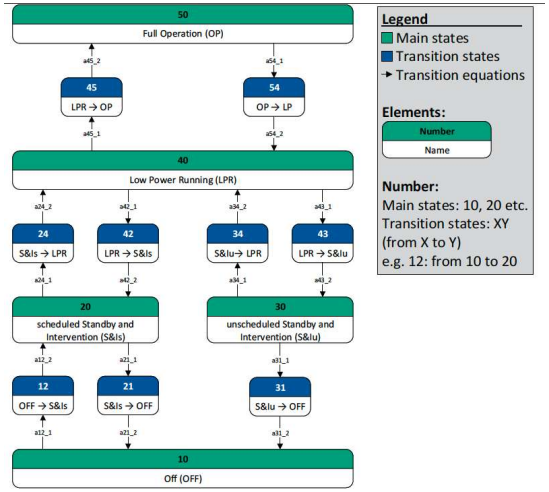
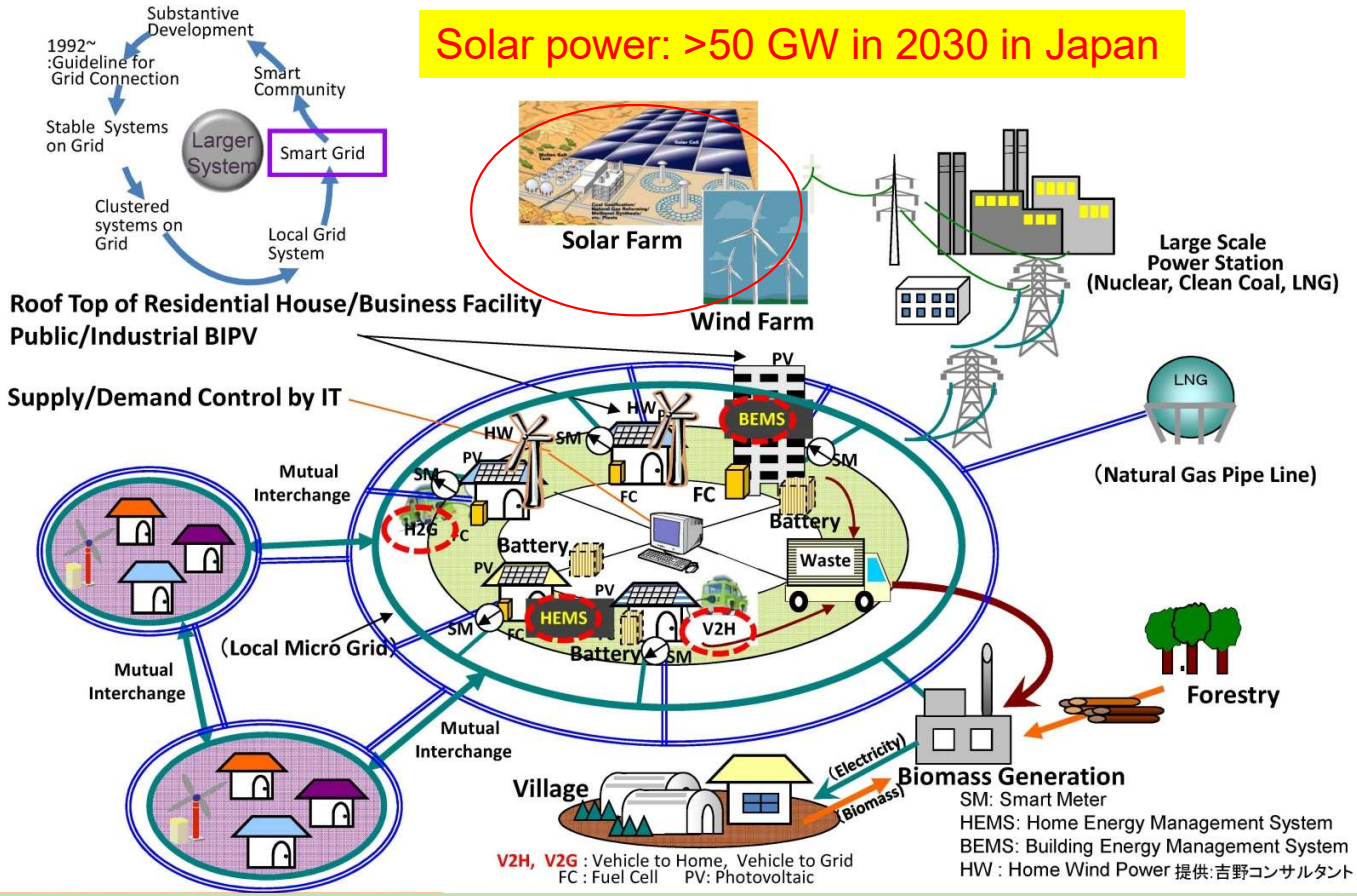


Figure 1-1: Schematic representation of the finite state machine

Efforts on ILC city

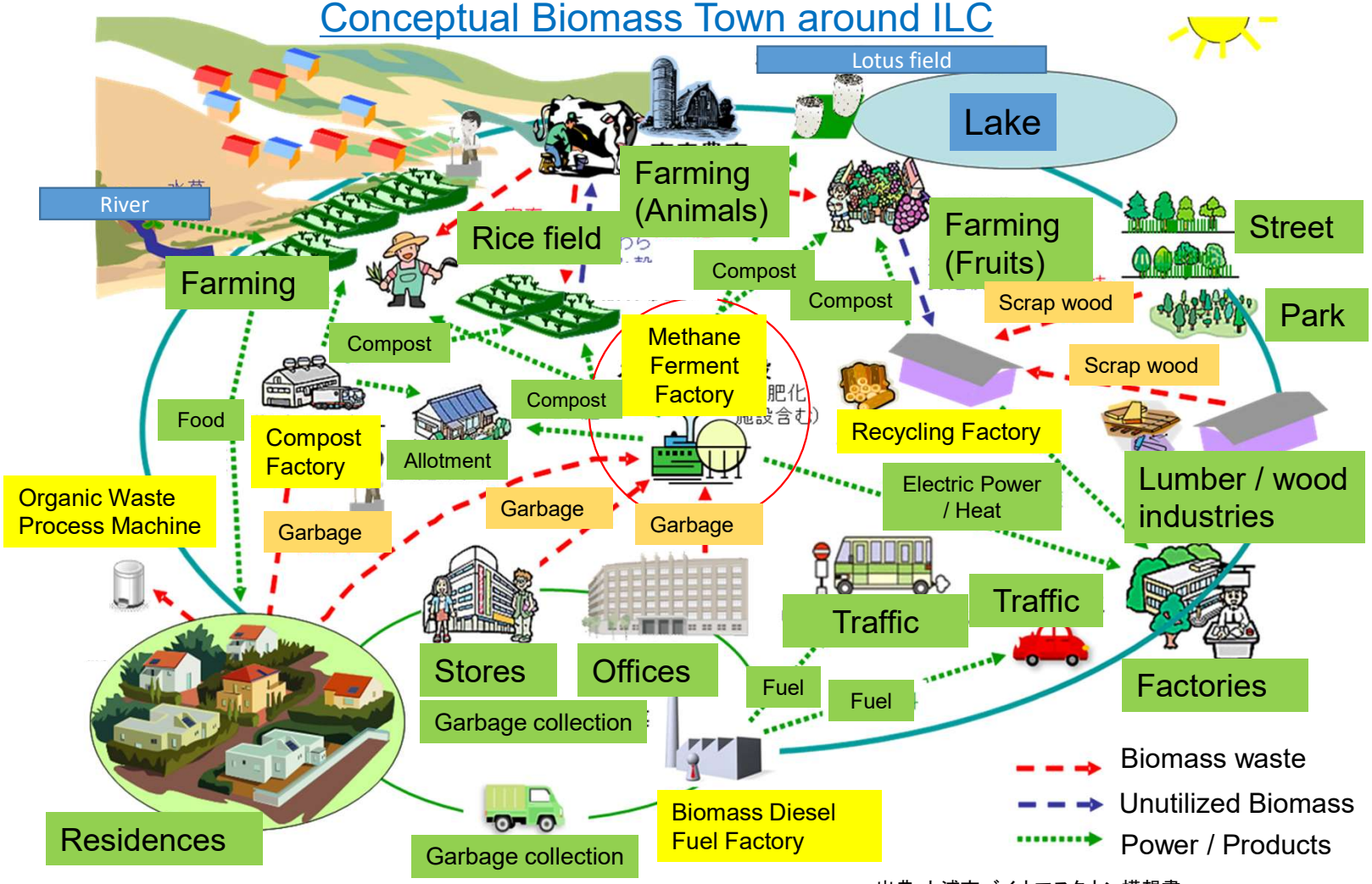
Smart ILC-City by Smart GRID



The proposal of smart GRID network for the ILC city. In the network, solar power farm and biomass power station are included. The ILC is connected to the smart GRID of ILC city and the operation modes of ILC will be organized with the smart GRID of ILC city [Green-ILC WG (AAA) Report 2016].

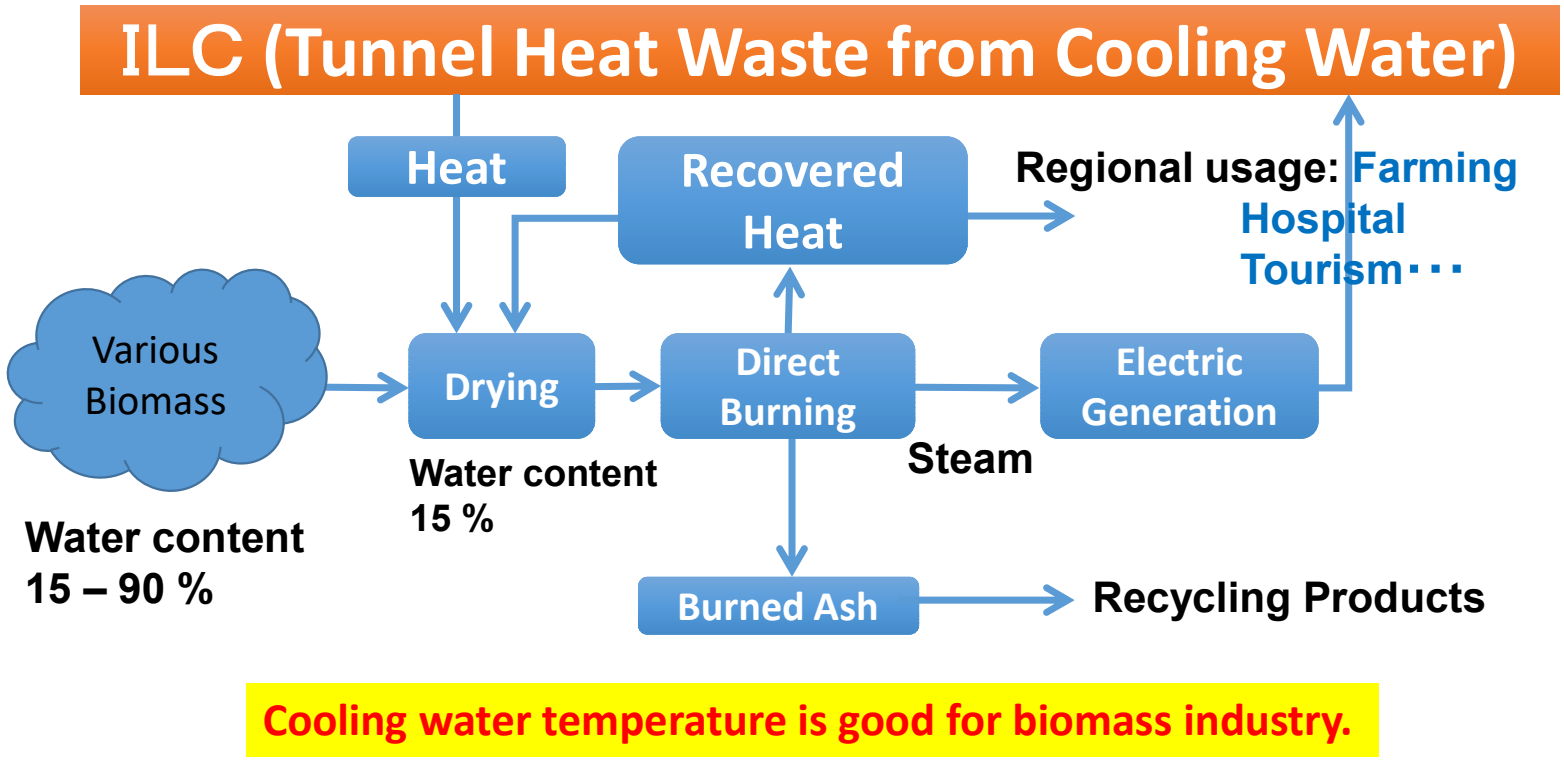
Biomass Power Network using Organic Waste

Conceptual Biomass Town around ILC



出典:土浦市バイオマスタウン構想書

❑ Biomass Power with ILC tunnel



Cooling water temperature is good for biomass industry.

The recycling of waste heat of cooling water in ILC tunnel is proposed by a company, where the waste heat is used to drying the biomass and the burning biomass produces power as heat and electricity [Green-ILC WG (AAA) Report 2016].

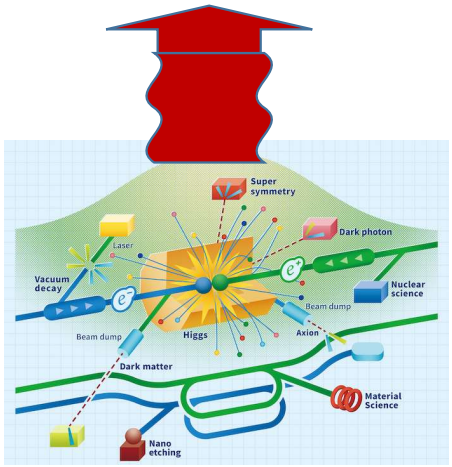
Tohoku ILC project Development Center was established in June 2020.

Realizing the close communications between ILC group and local community (Kitakami-site)

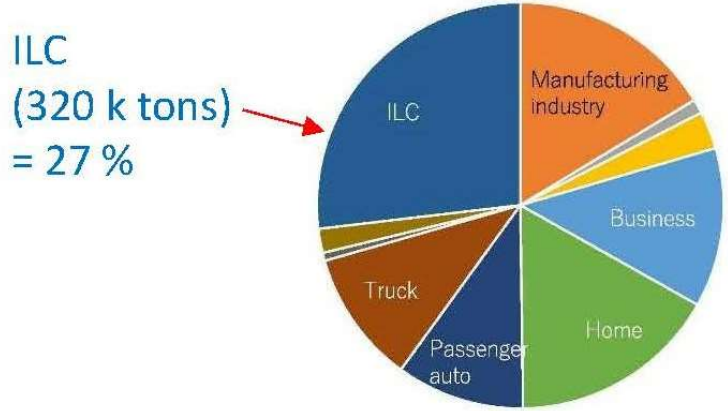
Basic Policy of Green ILC at Kitakami ILC candidate site (ILCX2021)

Masakazu Yoshioka (Iwate/Iwate Prefectural/Tohoku University)

320ktonCO2/year

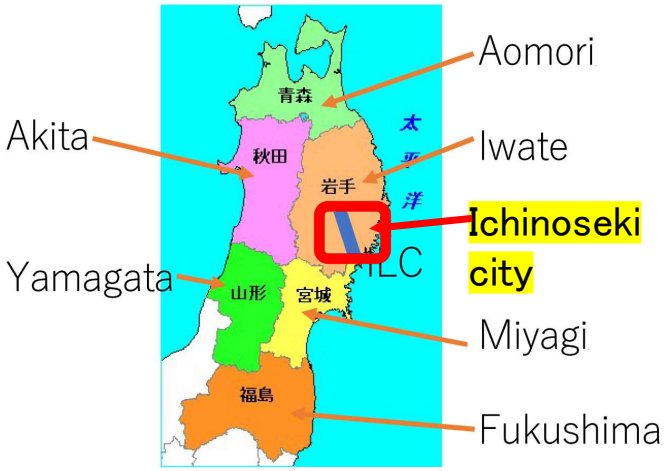


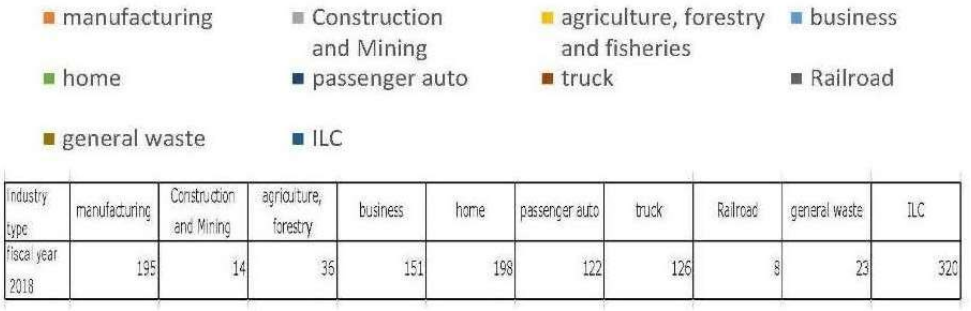
- The ILC is a facility that will produce many important physical results, but will also release 320 kilotons of CO2 per year.



Breakdown of CO2 emission for Ichinoseki city with ILC.

Total: 1191 k tons.





Industry type	manufacturing	Construction and Mining	agriculture, forestry	business	home	passenger auto	truck	Railroad	general waste	ILC
fiscal year 2018	195	14	35	151	198	122	126	8	23	320

Summary

- The total energy consumption of ILC is 111 MW at 250-GeV initial phase, 163 MW at 500-GeV phase and 300 MW at 1-TeV phase. The improvement of energy efficiency is the crucial issue for the realization of ILC.
- The 2nd ESS WS (Oct. 2013) triggered the Green-ILC activities. The 1st meeting for the Green-ILC WG in AAA was held on 25th February 2014 to launch the Green-ILC activities in collaboration between industry and academia.
- The series of Green-ILC meetings have been held since then, and various technologies of energy-saving for ILC were proposed and discussed. LC WS always had a Green-Accelerator session for LC community to exchange sustainable technologies.
- The energy-saving technologies in Green-ILC are ranging from the components, sub-system, ILC operations and to ILC city.
- Green ILC activities are on the web page now. Please visit http://green-ILC.in2p3.fr .
- Efforts on communications is very important, because we have limited budget, man-power, and resources. This is the reason why the Green-ILC WG is interacting with international LC teams, other projects, other regions, and the local community of Kitakami site.