A Site Specific Green ILC Design in Kitakami

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Iwate, Iwate Prefectural, and Tohoku University
Tohoku ILC Promotion Council/Tohoku ILC Preparation Office

May 28, 2018

Motivation of my presentation is based on
"Social obligation of accelerator researchers"

↓

Accelerator consumes an enormous amount of energy

↓

Accelerator researchers must consider **SUSTAINABILITY**

① Accelerator parameter design	→	Maximize performance/AC power
② Accelerator component	→	Improve power efficiency
③ Wall plug power for accelerator	→	Use sustainable (renewable) electricity
④ Waste heat of accelerator	→	Waste heat recovery and utilization

In addition

Make innovations of energy-related industries
by using the ILC as a trigger

By making wide utilization of ①unused waste heat, and ②biomass for society

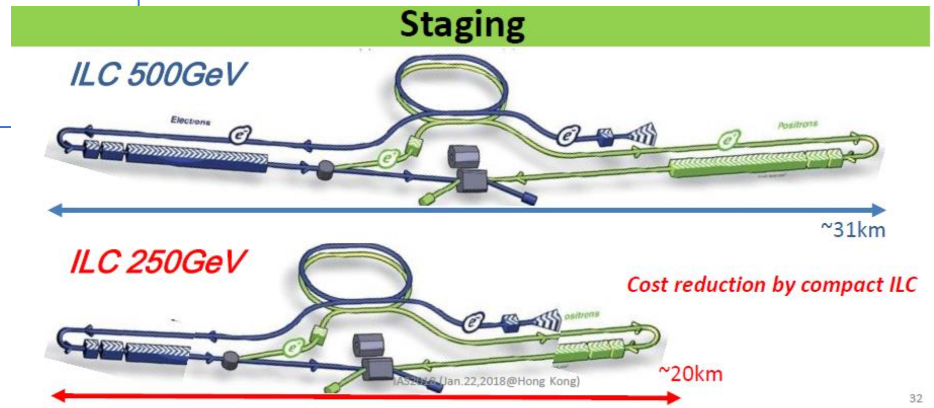
Quick remind about ILC in Kitakami candidate site

Basic policy of the ILC construction: **Staging scenario**

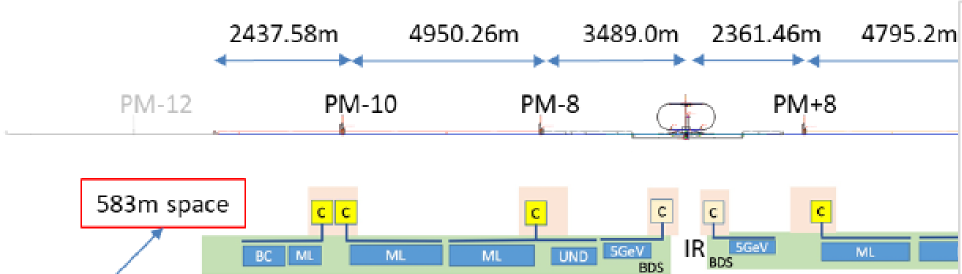
20.5km ⇒ 31km ⇒ 50km

250GeV⇒ 500GeV⇒ 1 TeV

The Kitakami candidate site has an enough potential to accept the 50km ILC



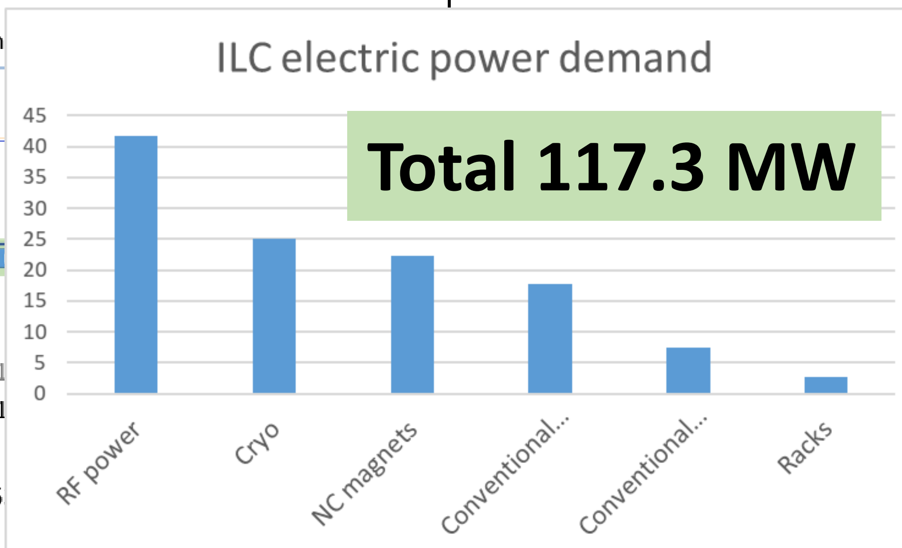
Option A | ECM=250GeV | SRF 31.5MV/m



module space margin for option C, 31.5MV/m

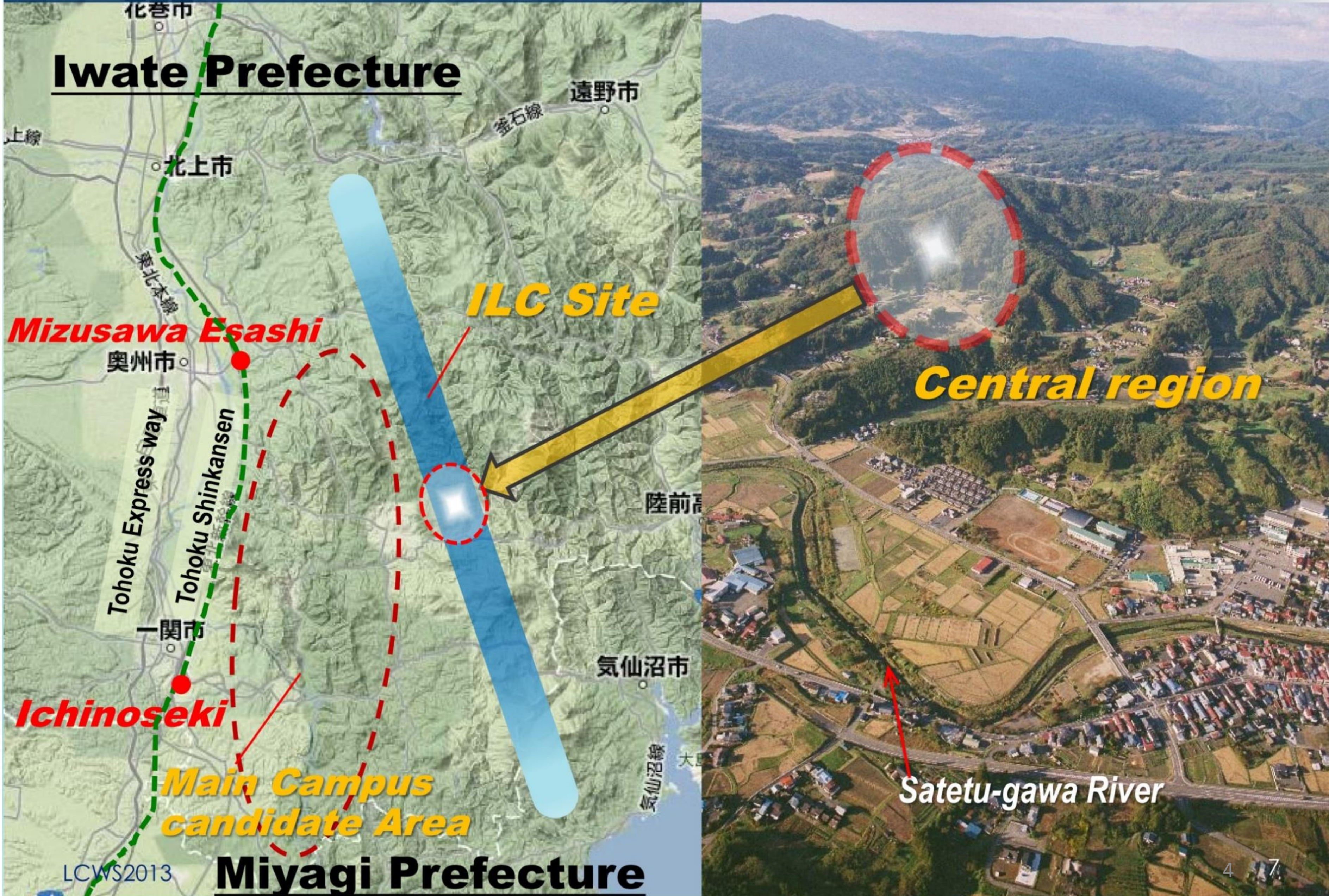
BC				e+inj	Ecm=250GeV	e-inj		
51	90	189	189	24	module space	24	180	1
51	45	189	189	24	cryomodules	24	180	1
17	10	42	42	8	RF unit	8	40	
e- 134.8GeV = 10.0	12.8	53.5	53.5	5.0	E gain (GeV)	5.0	51.0	5

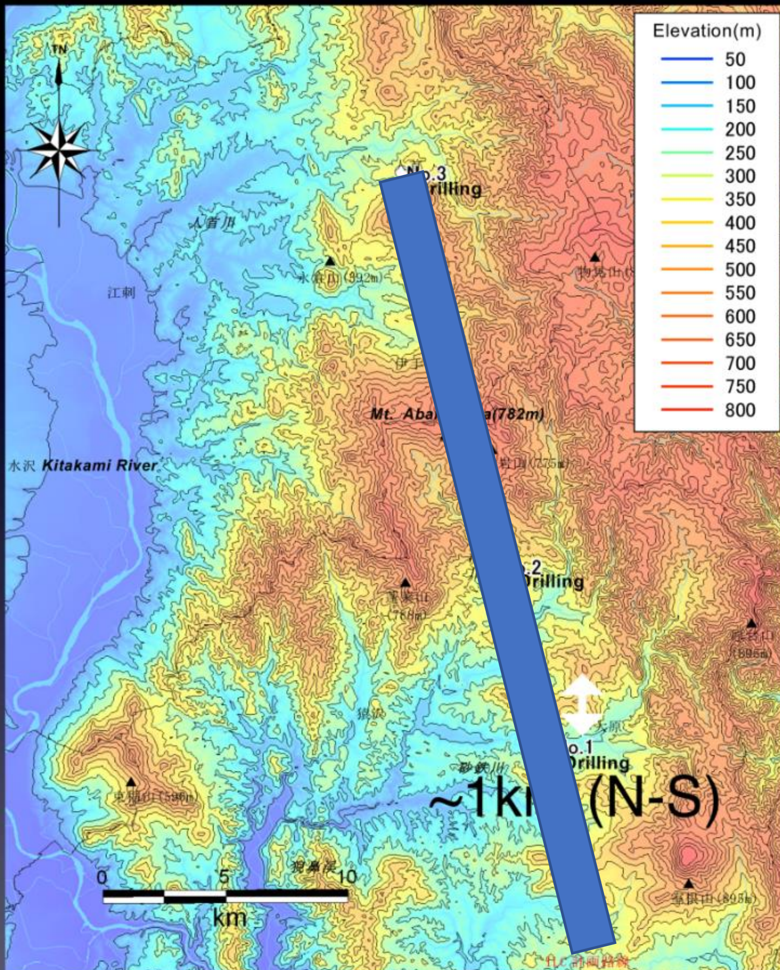
(note: 1 ML unit = 2 RF unit = 9 CMs (in TDR))

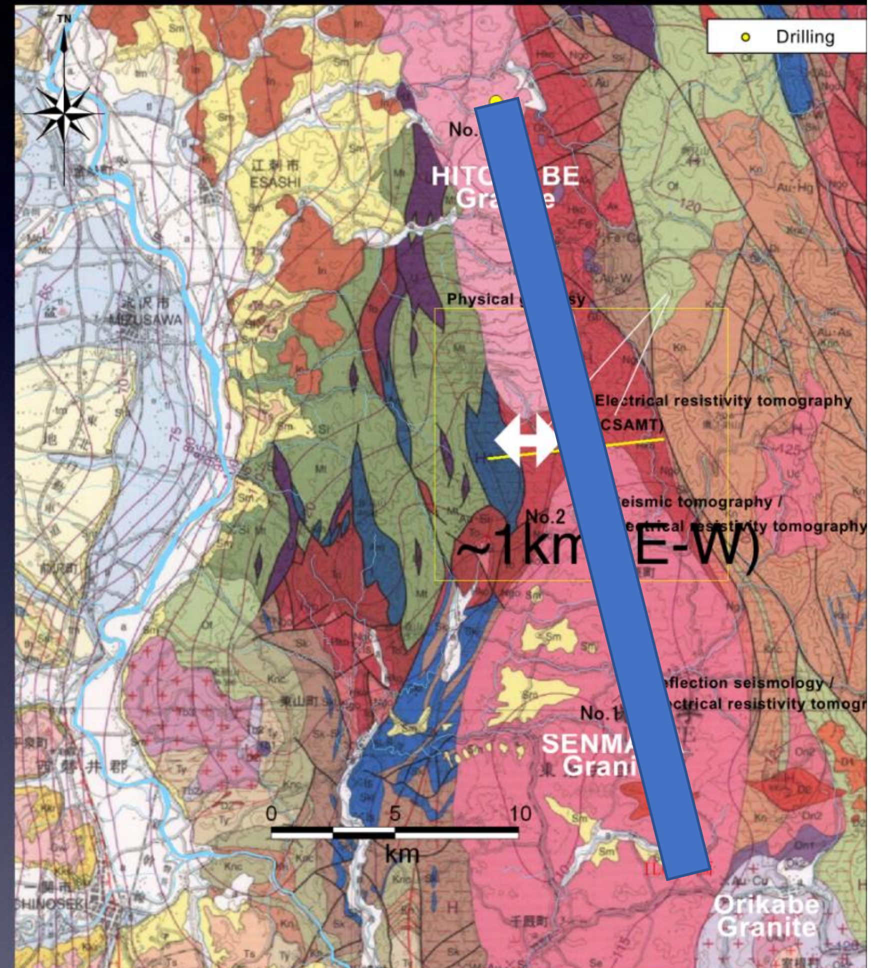


Total tunnel length = 20549.5m (20.5km)

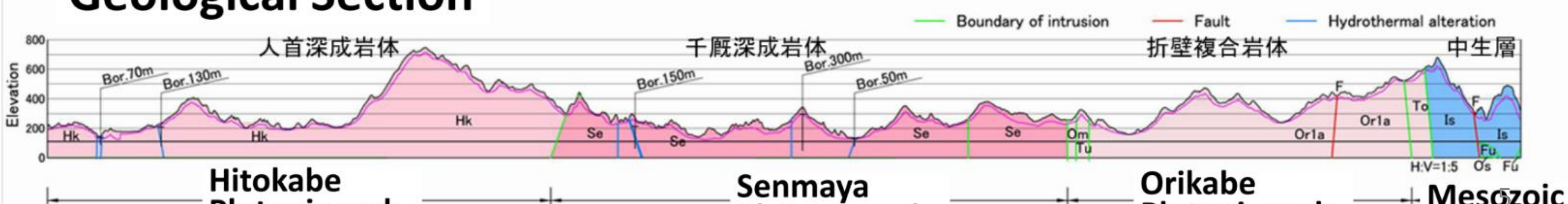
Location


Iwate Prefecture
花巻市
遠野市
釜石線
北上市
東北本線
ILC Site
Mizusawa Esashi
奥州市
Tohoku Express way
Tohoku Shinkansen
一関市
気仙沼市
気仙沼線
Ichinoseki
Main Campus candidate Area
Miyagi Prefecture
Central region
Satetu-gawa River



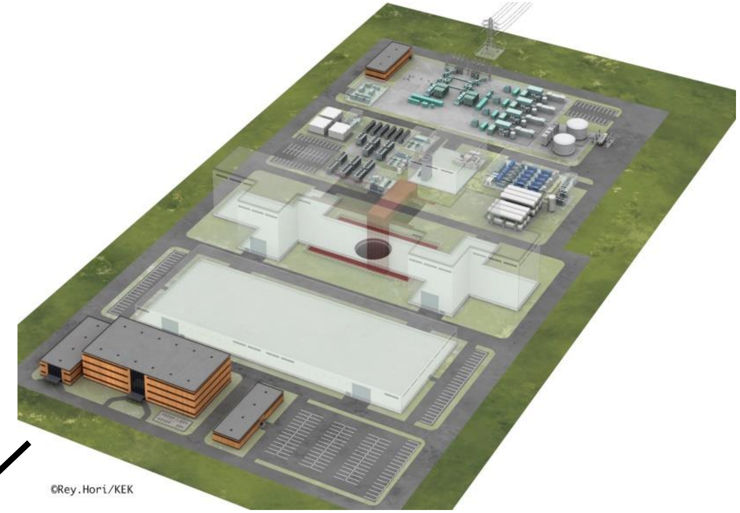


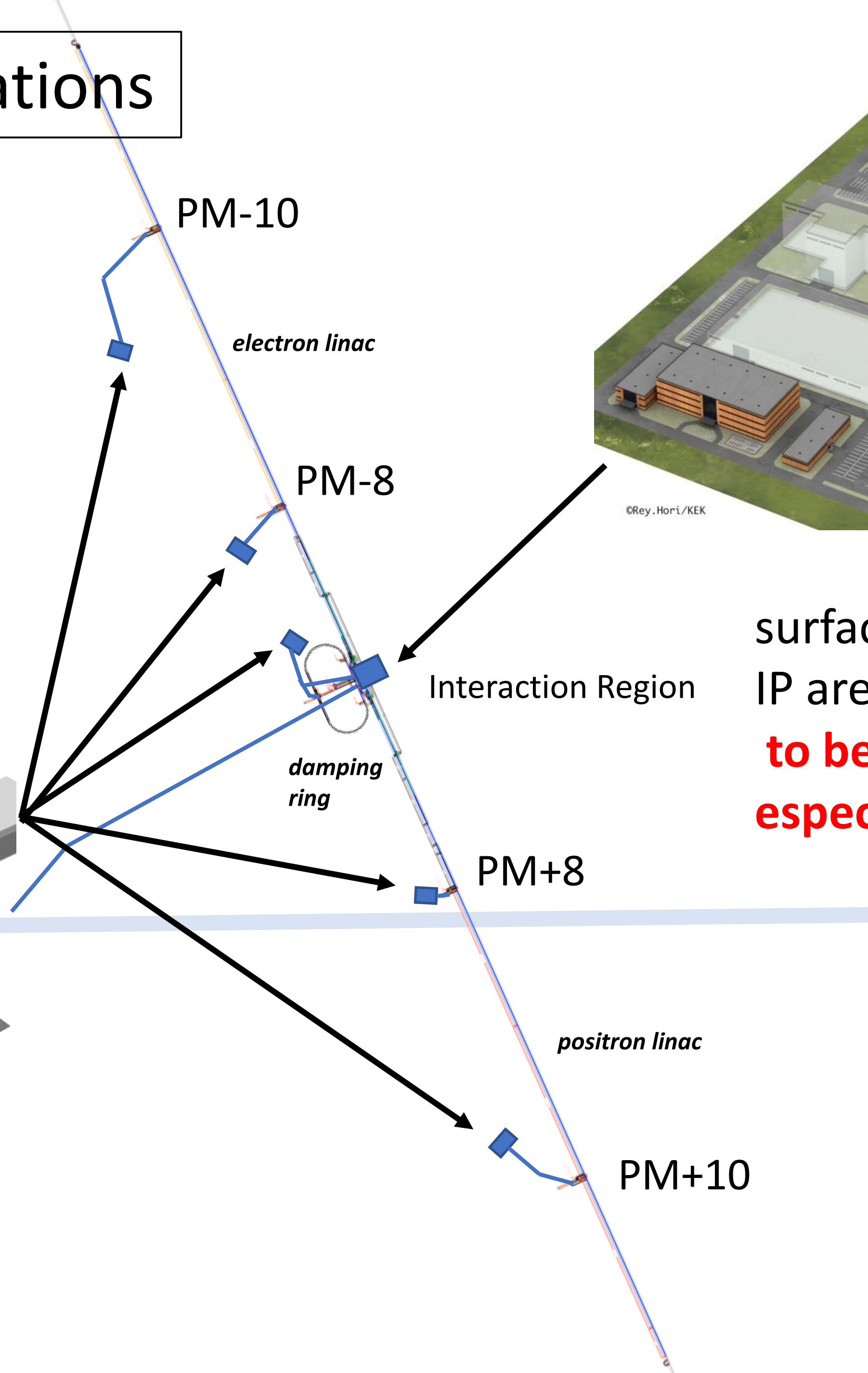
Geological Section



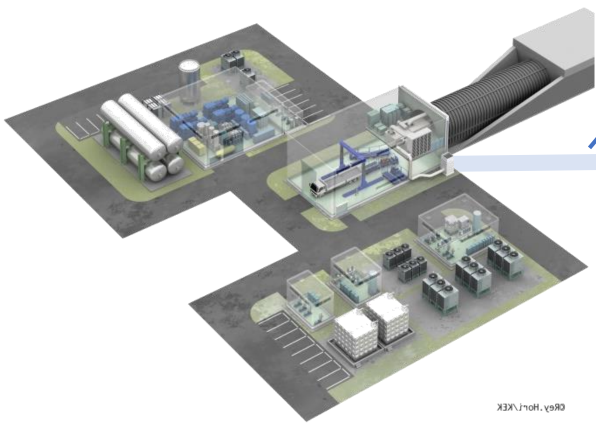
Surface Access Stations

A proposal of
site-specific design of
Surface Access stations.





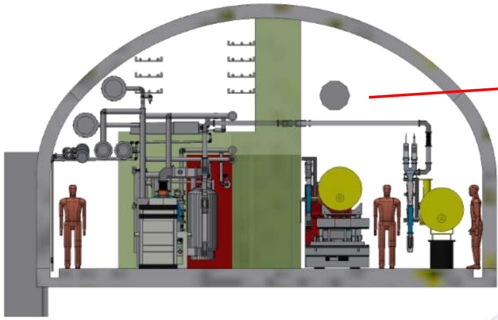
surface design
access stations
16,600m^2 × 5 area
to be further discussed.



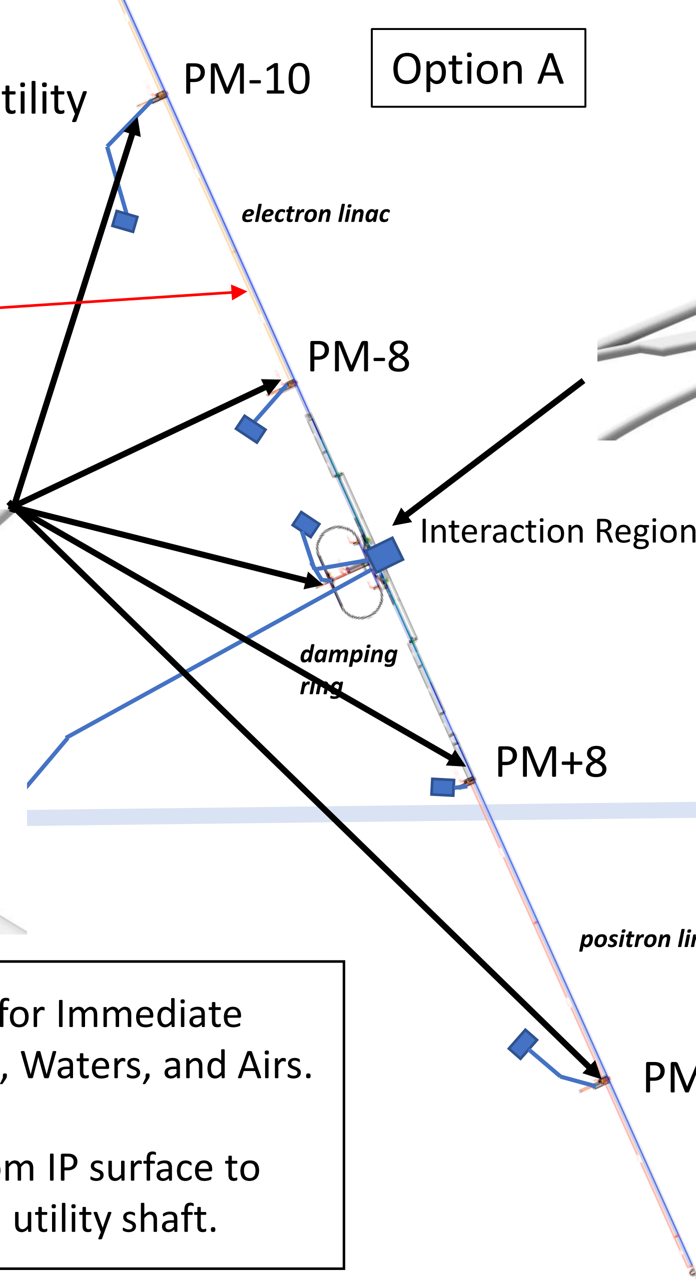
surface design
IP area 78,500m^2
to be further discussed
especially with LCC-MDI.

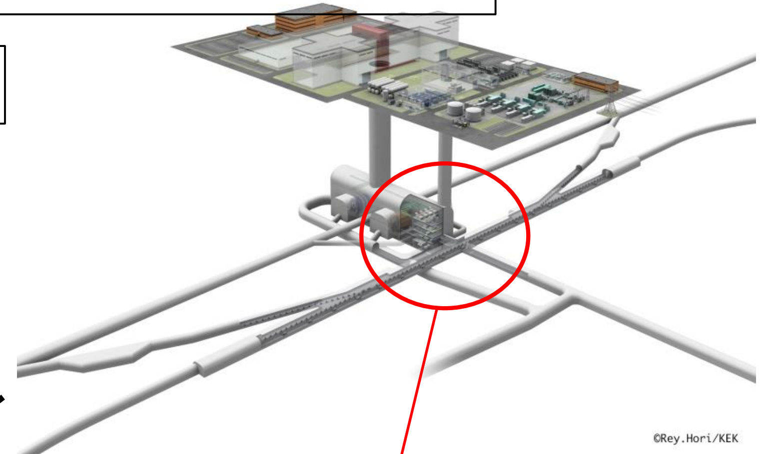
A proposal of Basic Design of Underground Facilities

Site-specific design of Access Halls with detailed utility design.

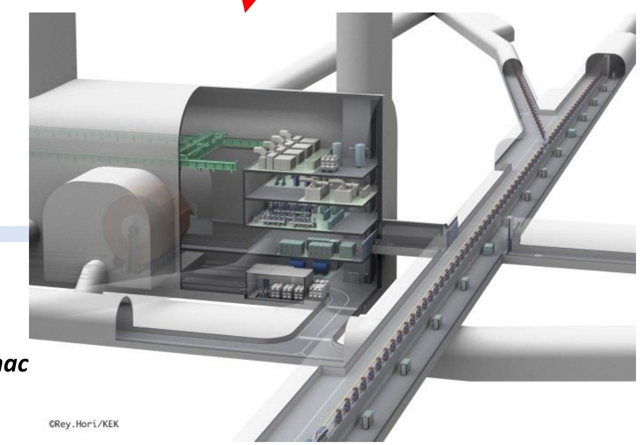


Option A





To be further discussed with LCC-MDI



Utility Hall next to the detector hall

5-floor construction is different from just a cavern. It will be applied the control of "building standards law". Need to clear the inspection of design, proof of strength. Can we clear them?

Underground access halls for Immediate access of Helium, Electrics, Waters, and Airs.

Direct access of utlities from IP surface to underground hall, through utility shaft.

①	**Accelerator parameter design**	→	**Maximize performance/AC power**
②	Accelerator component		Improve power efficiency
③	Wall plug power for accelerator		Use sustainable (renewable) electricity
④	Waste heat of accelerator		Waste heat recovery and utilization

Table 5-1: New beam parameters optimized for ILC250GeV.

			TDR		New
Center-of-mass energy	E_{CM}	GeV	250	500	250
Bunch population	N	e10	2	2	2
Bunch separation		ns	554	554	554
Beam current		mA	5.78	5.78	5.78
Number of bunches per pulse	Nb		1312	1312	1312
Collision frequency		Hz	5	5	5
Electron linac rep rate		Hz	10	5	5
Beam power (2 beams)	P_B	MW	5.26	10.5	5.26
r.m.s. bunch length at IP	σ_z	mm	0.3	0.3	0.3
relative energy spread at IP (e-)	σ_E/E	%	0.188	0.124	0.188
relative energy spread at IP (e+)	σ_E/E	%	0.15	0.07	0.15
Normalized horizontal emittance at IP	ε_{nx}	μm	10	10	5
Normalized vertical emittance at IP	ε_{ny}	nm	35	35	35
Beam polarization (e-)		%	80	80	80
Beam polarization (e+)		%	30	30	30
Beta function at IP (x)	β_x	mm	13	11	13
Beta function at IP (y)	β_y	mm	0.41	0.48	0.41
r.m.s. beam size at IP (x)	σ_x	nm	729	474	516
r.m.s. beam size at IP (y)	σ_y	nm	7.66	5.86	7.66
r.m.s. beam angle spread at IP (x)	θ_x	μr	56.1	43.1	39.7
r.m.s. beam angle spread at IP (y)	θ_y	μr	18.7	12.2	18.7
Disruption parameter (x)	Dx		0.26	0.26	0.51
Disruption parameter (y)	Dy		24.5	24.6	34.5
Upsilon (average)	Y		0.020	0.062	0.028
Number of beamstrahlung photons	n_γ		1.21	1.82	1.91
Energy loss by beamstrahlung	δ_{BS}	%	0.97	4.50	2.62
Geometric luminosity	Lgeo	$e34/cm^2s$	0.374	0.751	0.529
Luminosity	L	$e34/cm^2s$	0.82	1.79	1.35

The International Linear Collider Machine Staging Report 2017

Addendum to the International Linear Collider Technical Design Report published in 2013

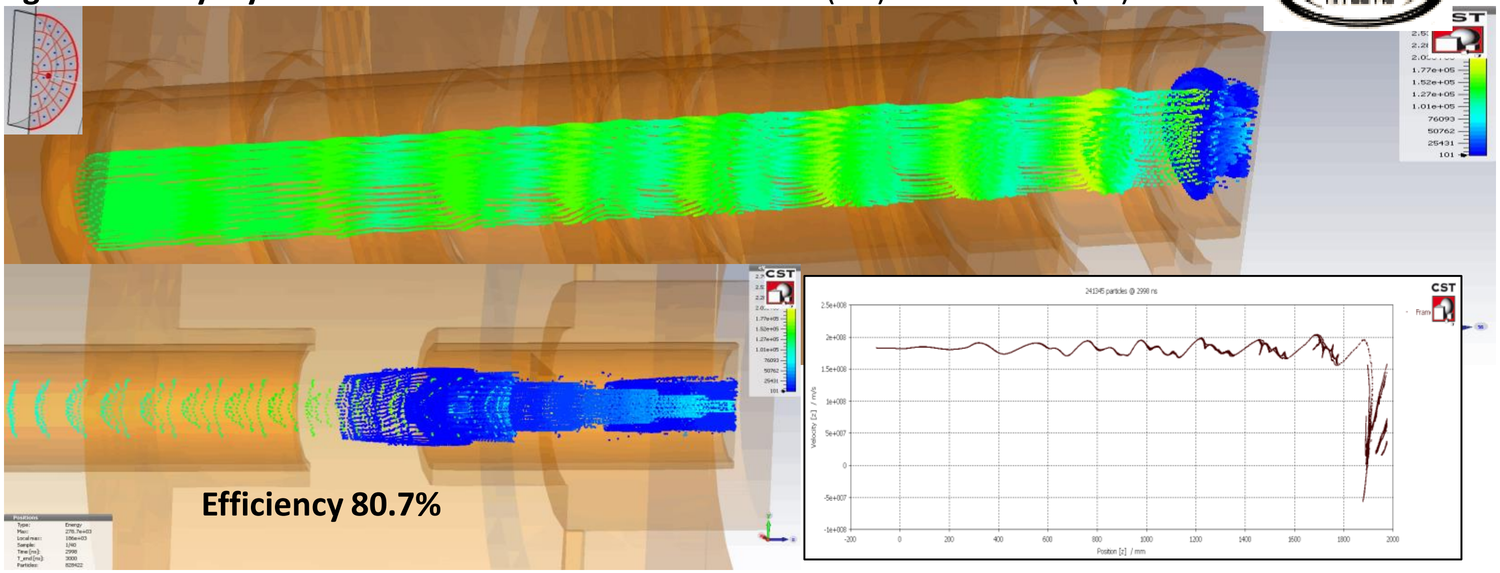
KEK 2017-3
DESY 17-180
CERN-ACC-2017-0097

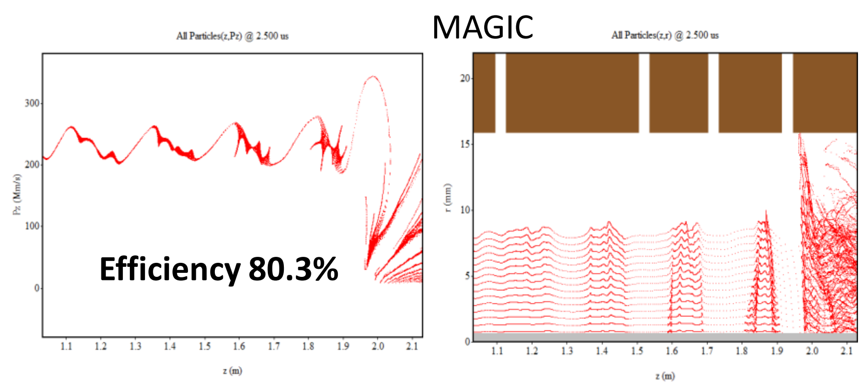
E_{cm} 250 GeV
Luminosity **$1.35\ e34/cm^2/s$ with beam polarization**
Beam power 5.26 MW (2 beams)
Wall plug power 117.3 MW
Luminosity/power **$0.011e34/cm^2/s/MW$**

①	Accelerator parameter design	Maximize performance/AC power
②	**Accelerator component**	**Improve power efficiency**
③	Wall plug power for accelerator	Use sustainable (renewable) electricity
④	Waste heat of accelerator	Waste heat recovery and utilization

Walter Wuensch, CERN, LCWS2017 Strasburg, 26 Oct, 2017

High efficiency klystron for FCC. PIC simulations with CST(3D) and MAGIC (2D)

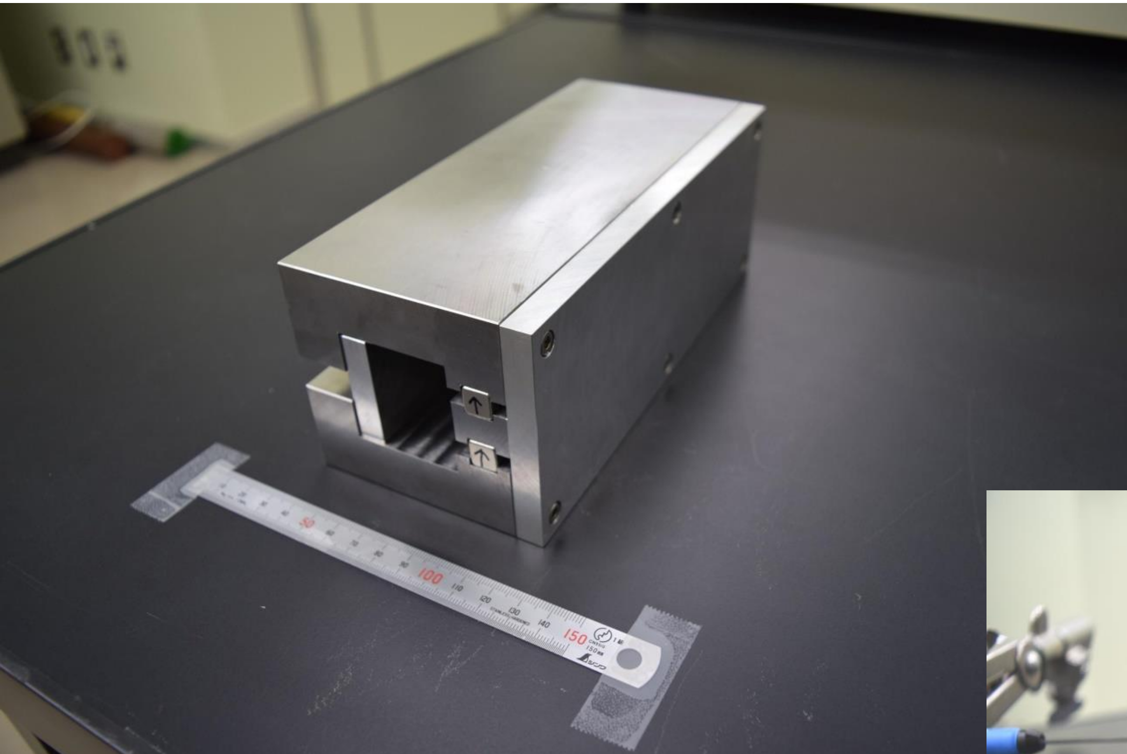




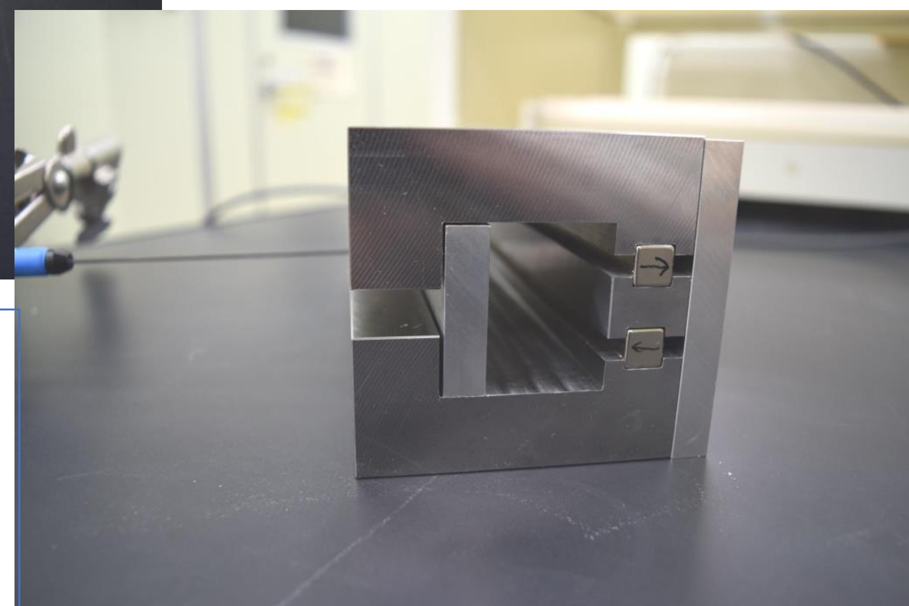
HE compact (1.7 m) L-band, 1.4 MW, CW klystron for FCC has been design within HEIKA using CSM bunching technology.

I. Syratchev

Effort in Iwate prefecture
to develop tunable permanent magnets



A companies alliance is created in Iwate prefecture (see industrial session, tomorrow)



- This is the first prototype of a dipole magnet.
- This year, we will make advance the R&D by collaboration with KEK

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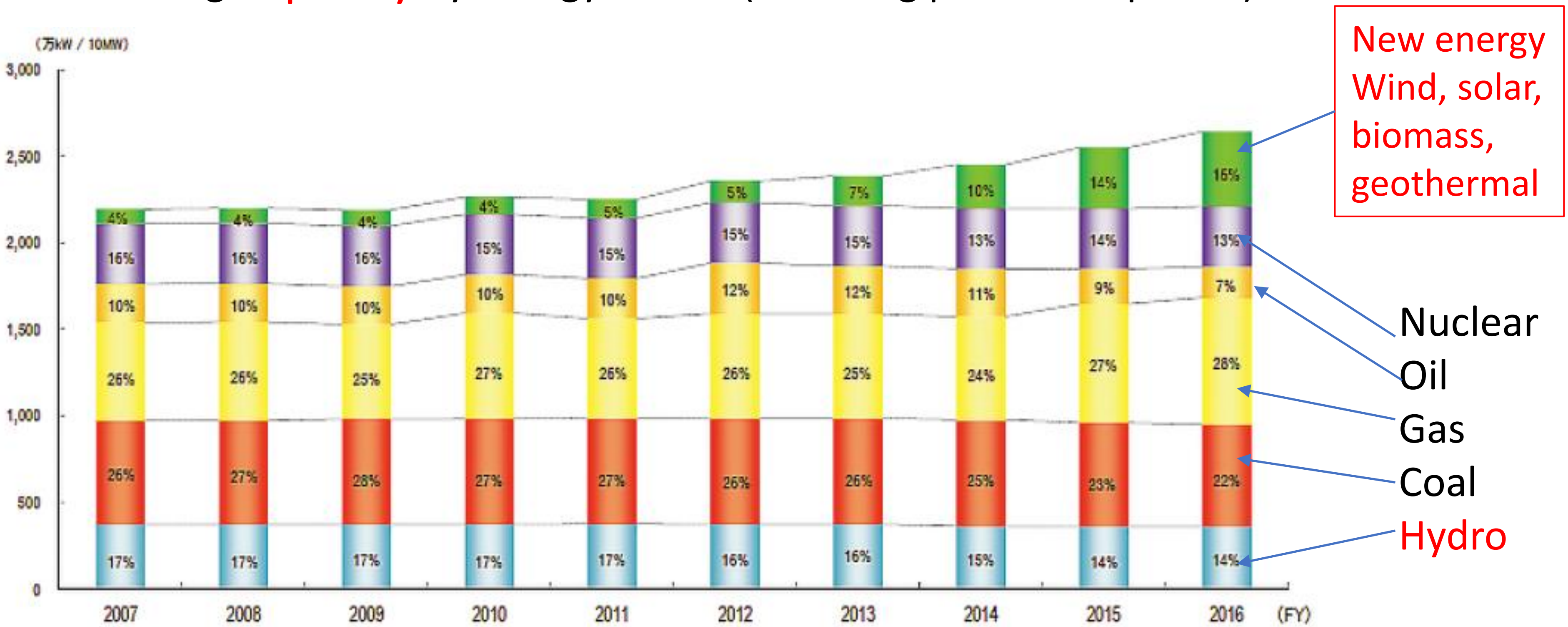
②	Accelerator component	Improve power efficiency
③	**Wall plug power for accelerator**	**Use sustainable (renewable) electricity**
④	Waste heat of accelerator	Waste heat recovery and utilization

電力供給 Electric Power Supply

Generating capacity by energy source (including purchased power) in Tohoku



① Generating capacity by new energy and hydro is 29 %

② Real generating power by new energy and hydro is 19 %

③ Total wall plug power for ILC is 1 % of total amount of power generation in Tohoku

④ As a result, the ILC electricity << available sustainable electricity in Tohoku

新仙
LNG タンク
3-1号ボ
3-2号ボイラ
o stage power ge
rcial grid consis
type generato
岩手県·岩洞第一ダム·41 メガワット
岩手県·松川地熱発電·23 メガワット
ILC
Wind
GS
Solar
青森県·六ケ所村·30 メガワット
大船渡市·18 メガワット
s

① Accelerator parameter design → Maximize performance/AC power

② Accelerator component → Improve power efficiency

③ Wall plug power for accelerator → Use sustainable (renewable) electricity

④ Waste heat of accelerator → Waste heat recovery and utilization

経済産業省 Ministry of Economy, Trade and Industry

産総研 国立研究開発法人 産業技術総合研究所 NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Collaboration between

Iwate University,

National Institute of Industrial Science and Technology,

Takasago Thermal Engineering Co., Ltd. (Tokyo)

高砂熱学工業株式会社 Takasago Thermal Engineering Co.,Ltd.

and

Higashinihon Kiden Kaihatsu Ltd. (Iwate)

東日本機電開発株式会社

Waste heat utilization by using

the heat storage absorbent

Waste heat energy recovery and its off-line transportation

Transportation of heat energy using "HAS-Clay" by container truck

Principle of "HAS-Clay"

➔ Sintered nano-scale compound of

Hydroxy Aluminum Silicate + Amorphous Aluminum Silicate

➔ Phase transition of H_2O (Vaper ⇔ Water) + Chemisorption

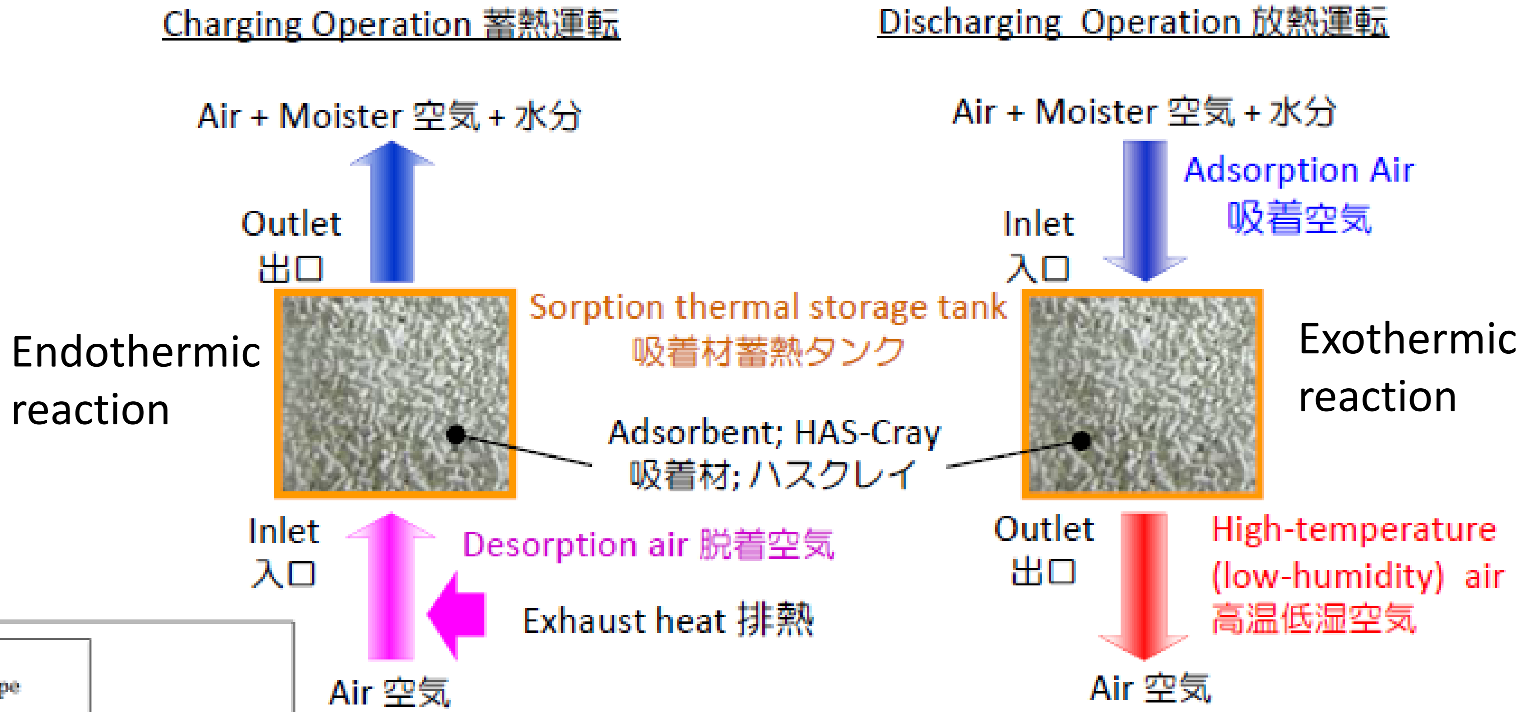
➔ HAS-Clay: "Adsorbent" developed by the National Institute of Advanced Industrial Science and Technology (AIST)

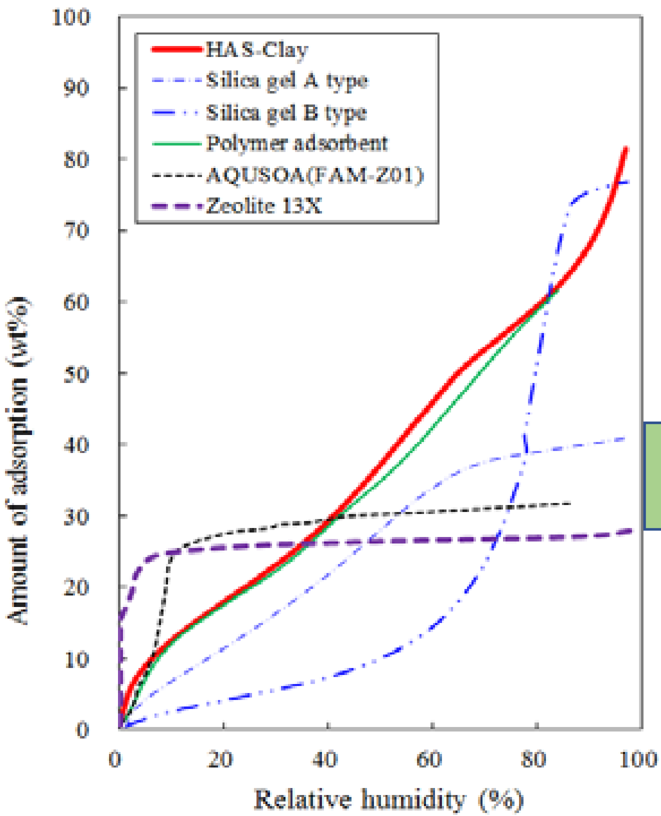
● Specific gravity	1.2
● Adsorbed moisture content	0.37kg/kg
● Volume filling rate	50%
● Heat storage density	580 MJ/m^3

➔ **12 times of energy of natural gas (45 MJ/m^3)**

Energy recovery from waist heat of factory, incineration plant, co-generation, solar and etc.

Heat utilization business: Greenhouse agriculture, wood and biomass drying, heat supply business for community and etc.

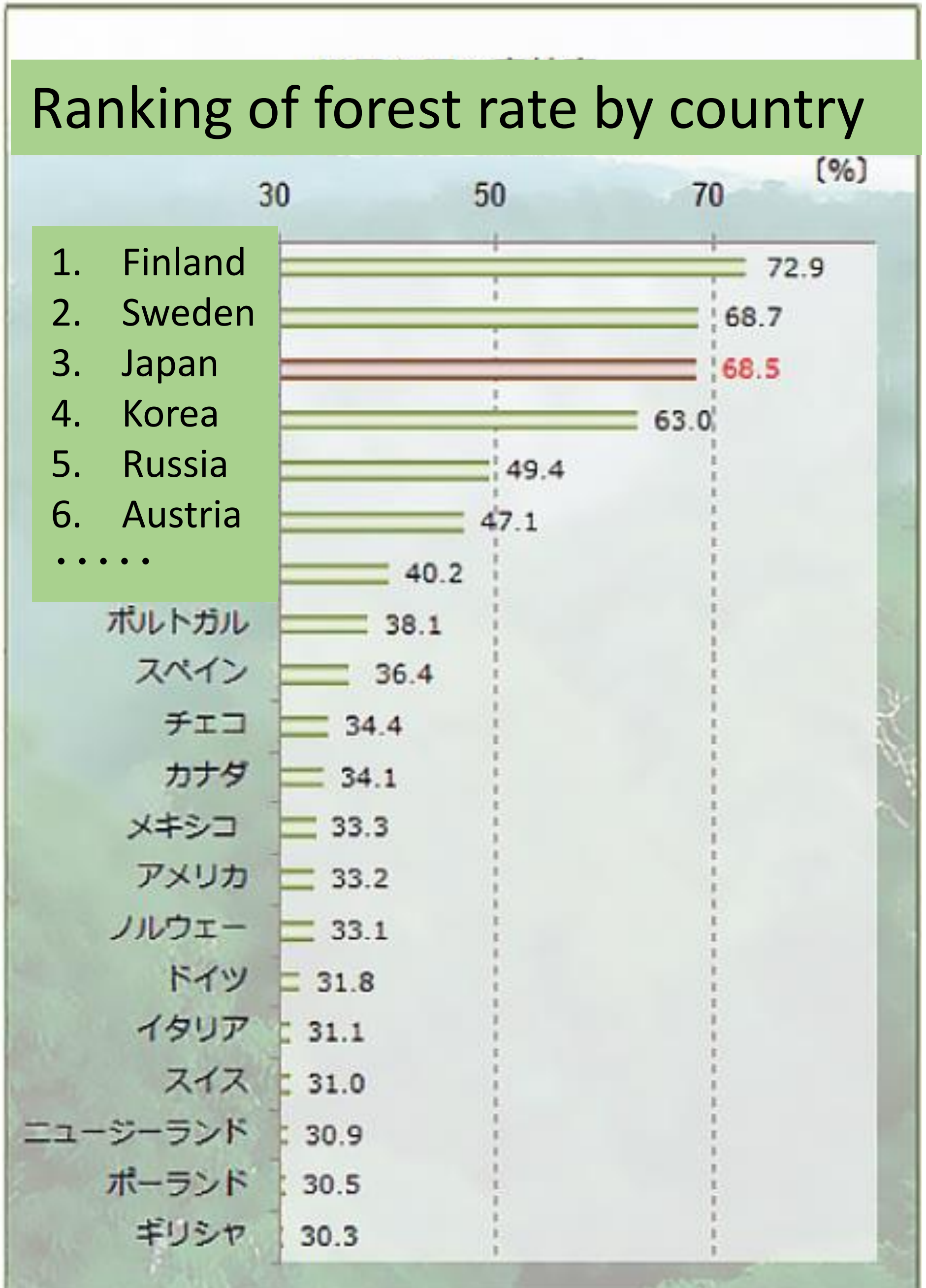




- Amount of moisture adsorption of HAS-Clay increases monotonically as a function of relative humidity in wide humidity range.
- This means that HAS-Clay can be used to recover both low temperature (from ~65° C) and high temperature waste heat.

Make innovations of energy-related industries
by using the ILC as a trigger **in TOHOKU**

By making wide utilization of
unused waste heat **and biomass** for society

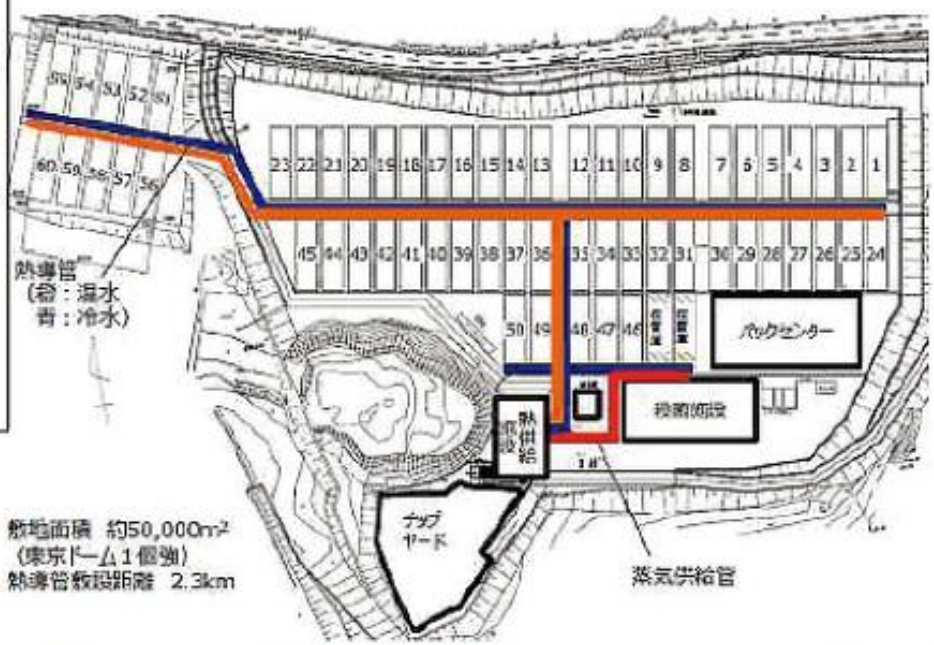


出典：森林・林業学習館

Unused biomass

We have to remind as follows:

- Japan is one of the largest forest nation (proportion of forested land, not the total area)
- Effective utilization of forest resources is in our mission
- The ILC is not exceptional



Example of utilization of unused biomass in Iwate prefecture

Bark of hardwood is smashed and dried (500 MJ/m^3)

Large scale plant of fungal bed cultivation of shiitake mushrooms

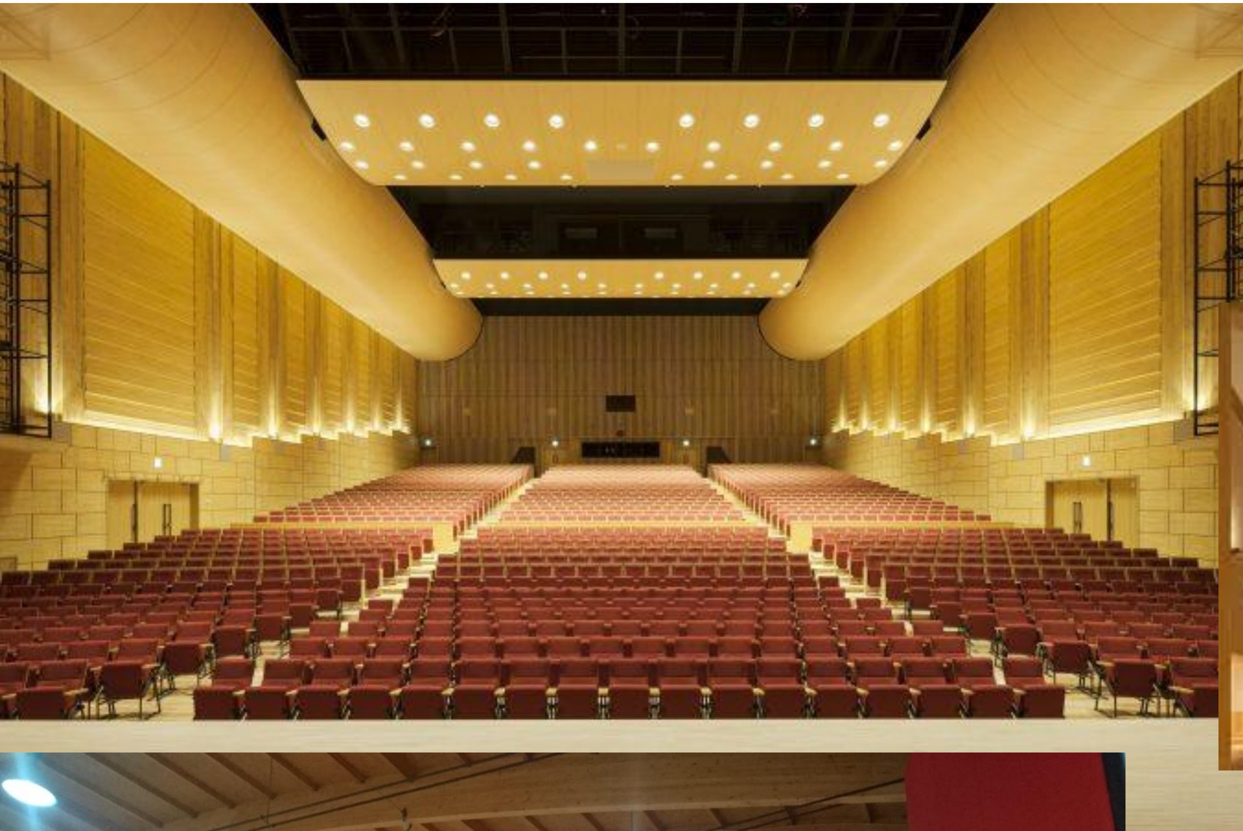
出典：久慈バイオマスエネルギー（KBEC）、東北大学大学院環境科学研究科
第106回コロキウム環境

Firstly, we have to increase the wood demand to increase the biomass unused

ILC-related facility (laboratory buildings, guest houses, and etc.) should be “Wood first” by taking advantage of the characteristics of the Tohoku region

Collaboration
between
Iwate University
and
Shelter Co., Ltd. (Yamagata)

Shelter®
株式会社シェルター

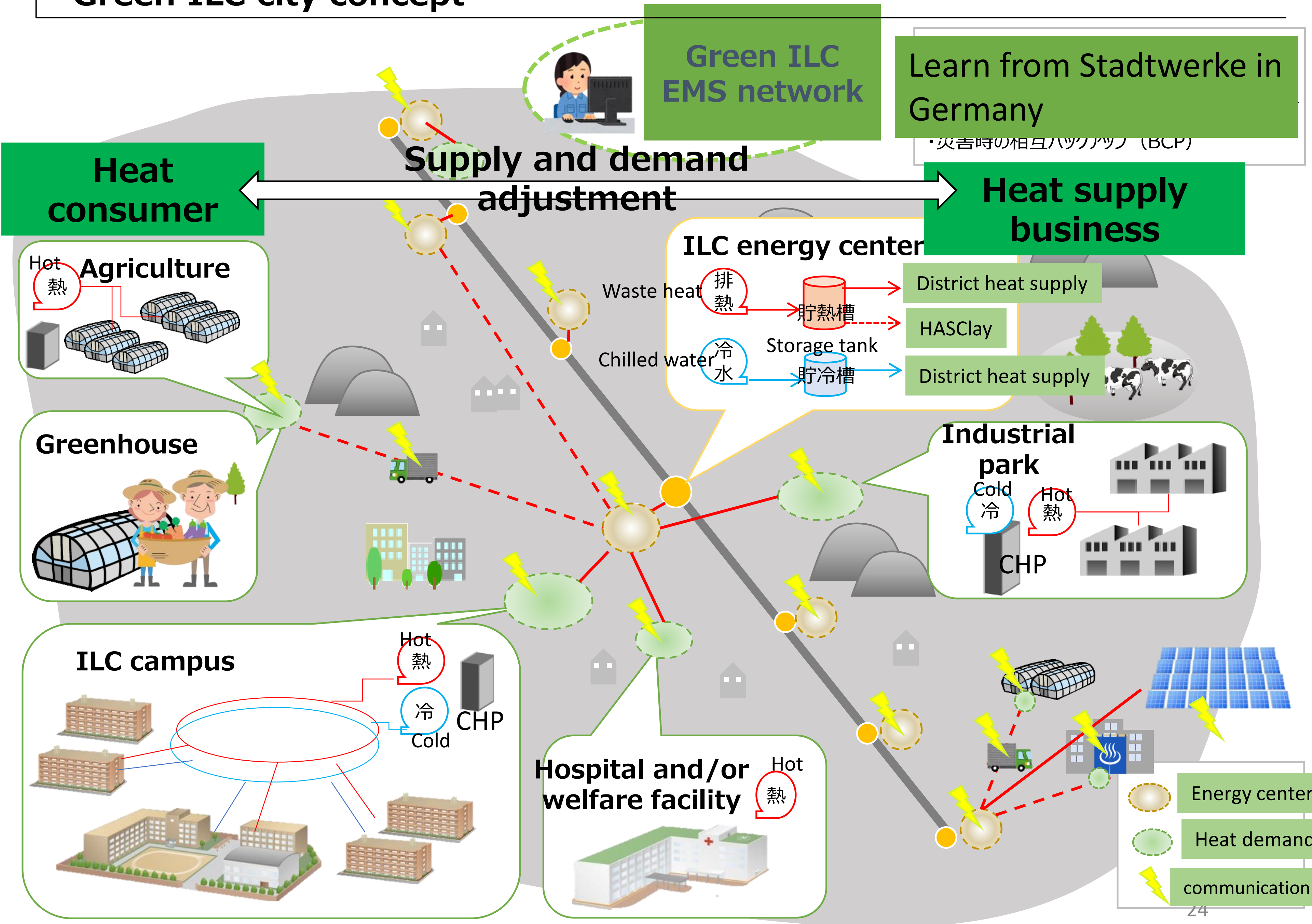


Cultural hall of Nanyo-city,
Yamagata Prefecture
Wooden hall for 1400-seat
by Shelter Co., Ltd.

Swiss Light Source (PSI)

We are making a design of detector assembly hall of ILC based on the hybrid structure of wood, RC and steel frame by this collaboration.

Green ILC city concept



Jomon ruins:
We have a very long history (more than 10000 years) to live in harmony with nature

- Earthenware
- Stoneware
- Lacquerware

石器

Jomon Pochette
5500~4000 years ago

In Japan, we have sufficient sustainable energy

Mt. Iwate

Thank you for your attention

This is a painting by a kid of Ichi-no-seki city to welcome ILC in beautiful Kitakami candidate site.