CPWD CSQ (HQ)
Nirman Bhawan
24 /04/2023

Geothermal Exchange & Net Zero Buildings

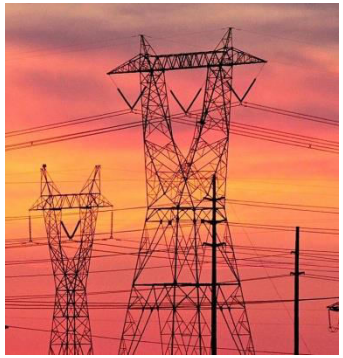
Future Driving force for Low Energy buildings.

- LOW ENERGY CONSUMPTION
- LOW CARBON EMISSION
- LOW REFRIGERANT USAGE

Quantifiable Sustainability.

Grid –Coal- Carbon

Coal (may be $C_{135}H_{96}O_9NS$)



Coal types

Coal	Dry, Carbon content (%)	Dry, volatile content (%)
Anthracite	86-92	3-14
Bituminous **coal**	76-86	14-46
Sub-Bituminous **coal**	70-76	42-53
Lignite	65-70	53-63

70% of the grid is coal

75%+ of the Coal is Carbon

Energy Source and Carbon.

(CEA-www.cea.nic.in)	gms/CO2
Grid Electricity National Grid KWh	724
Petrol (Litre)	2296
Diesel (Litre)	2653
LPG (Litre)	2983
Wood	
IPCC 2014/ IHA 2018	gCO2-eq/KWh
Coal	721.6
Gas	490
Solar PV Utility	48
Solar Roof Top / Off grid	18.5
Hydropower	18.5
Wind Offshore	12
Nuclear	12
Wind On Shore	11

Energy Source

RENEWABLE

- Solar
- Hydro/hydel
- Wind
- Biomass

Infinite

- Geothermal

Finite/Storage

NON RENEWABLE

- Fossil Fuel
- Coal
- Nuclear
- Natural gas

Govt. of India
Central Public Works Department
O/o Chief Engineer (E) CSQ
Room No- 229, 2nd Floor, A-wing
Nirman Bhawan, New Delhi- 110011

No. 9076576/36(11)/NewTech/CE CSQ(E)/2019/570 Dated 22/11/2019

OFFICE MEMORANDUM

Sub:- Adoption of New and Emerging Technologies in respect of E&M Components by CPWD-Reg.

In continuation to the O.M. of even file number 277 dated 21/10/2019, the following additional new and emerging technologies in respect of E&M Services are being notified to be adopted due to energy conservation, energy efficiency and thereby reduction of carbon footprints and other advantages for the upcoming projects across the country subject to technical feasibility and availability of funds:

S. No.	New and Emerging Technologies	Remarks/ Advantages
1.	Geo Thermal Heat Exchange System	To utilize the advantage of difference between ambient temperature and the temperature below ground level in transferring the heat to or from the ground which reduces heating/ cooling load of the building resulting in reduction of energy consumption of HVAC system.
2.	Chilled Beam System for HVAC	This technology uses higher chilled water temperature as compared to conventional chiller plant resulting in substantial reduction in energy consumption of HVAC system.
3.	Inverter type Compressor and Electronically Communicated (EC) Fan based Precision Air-Conditioning	To reduce energy consumption in Precision Air-Conditioning system being employed in Server Rooms etc. where large number of electronic components are housed in an enclosed space.
4.	Smart Intelligent Street	For optimum utilization of Street Lighting System and to reduce

Low carbon technology for CPWD.

will have to adopt for :-

- > Climate Change Mitigation techniques.
- > SDG addressing designs. (SDG -3/7/9/11/13)
- > Decarbonisation of space conditioning.
- > Compliance to Energy Conservation Act 2022.
(Notification CG-DL-E-20122022-241246)
- > NET ZERO Buildings. (Part of Hon PM's Pledge for Net Zero)

Cooling is a Developmental need.

1.2 Cooling is a Developmental Need

The linkages between cooling and Sustainable Development Goals (SDGs) such as Good Health and Wellbeing (SDG 3), Decent Work and Economic Growth (SDG 8), Sustainable Cities and Communities (SDG 11) and Climate Action (SDG 13) are well recognized. The cross-sectoral nature of cooling and its use in important development sectors of economy makes provision for cooling an important developmental necessity, which can have bearing on the environment, the economy and the quality of life of the citizens of the country.

the energetics people
S.A.P. Automation
www.lowenergy.in

In the interest of a cleaner planet.

uLEBs

Ultra Low Energy Building Systems

Performance over certification

UNDERSTANDING GEOTHERMAL

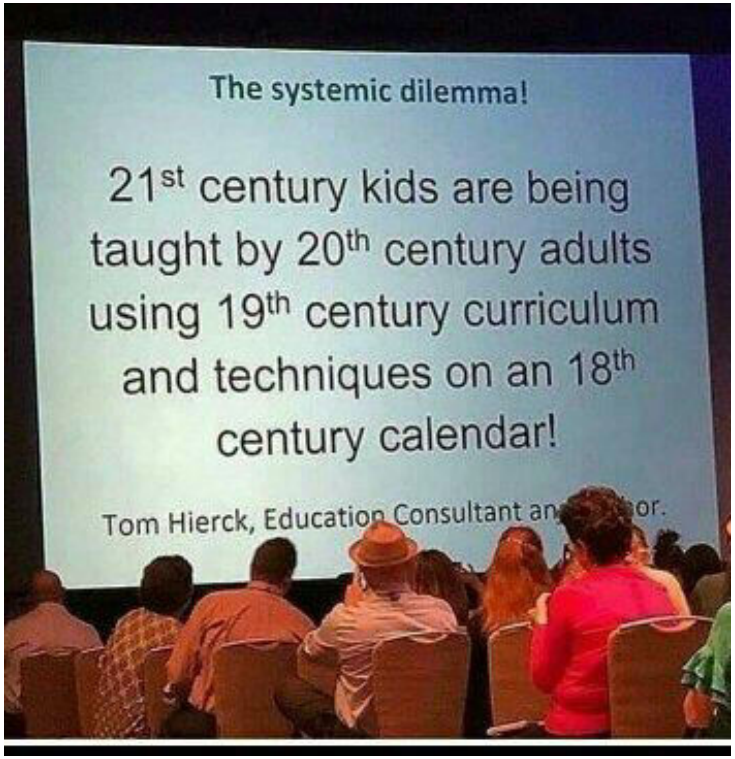
Ground storage based HVAC

GEOTHERMAL
free underground energy

AEROTHERMAL
decarbonized HVAC

Problem Definition.....

- We exchange in the wrong medium.(Air)
- We exchange with the wrong medium.(gas / open loop)
- We exchange with the wrong system (technologies from the last Century)



Geothermal exchange

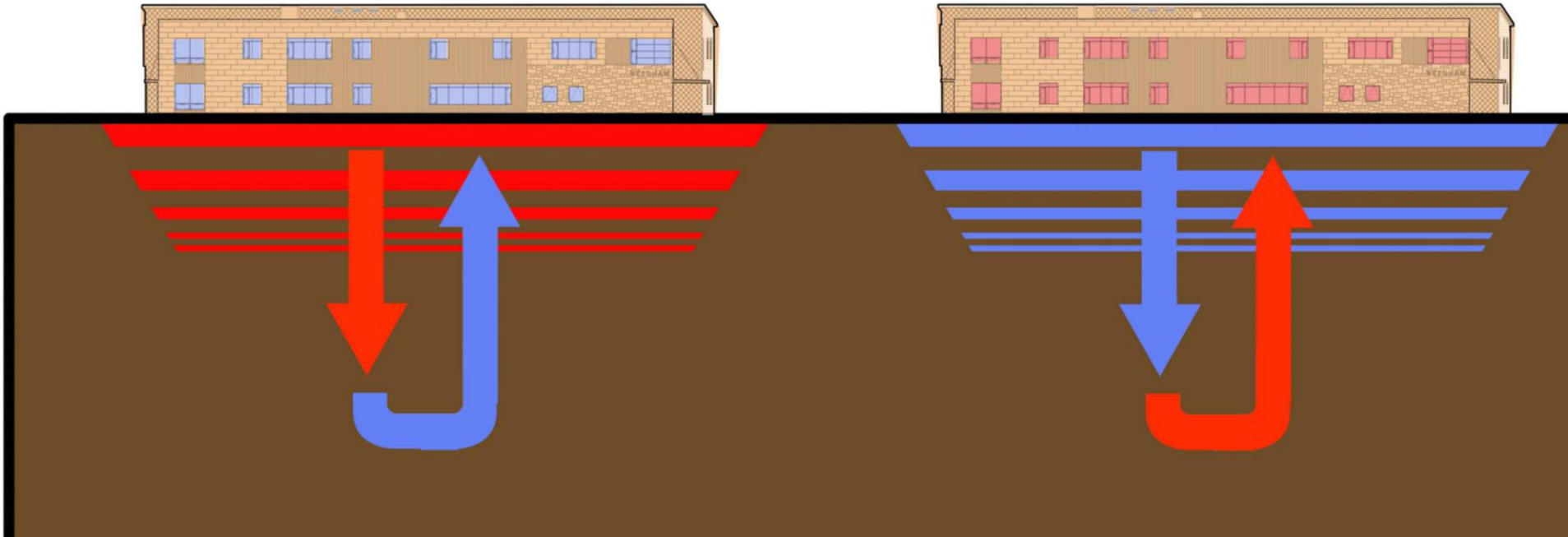
- Is a thermal energy storage system.
- No generation of energy.
- Transfer between earth and building.
- The thermal energy is either sourced or rejected in the ground.
- It's the same energy that is used in different climates.

Geothermal – The Solar energy absorbed in the earth, exchange with the soil temperature gradient,
Advantage stable temperature winter or summer.

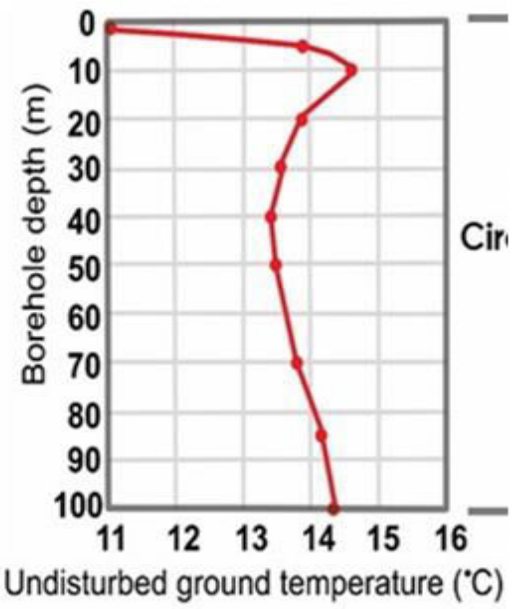
GROUND SOURCE HEATING AND COOLING

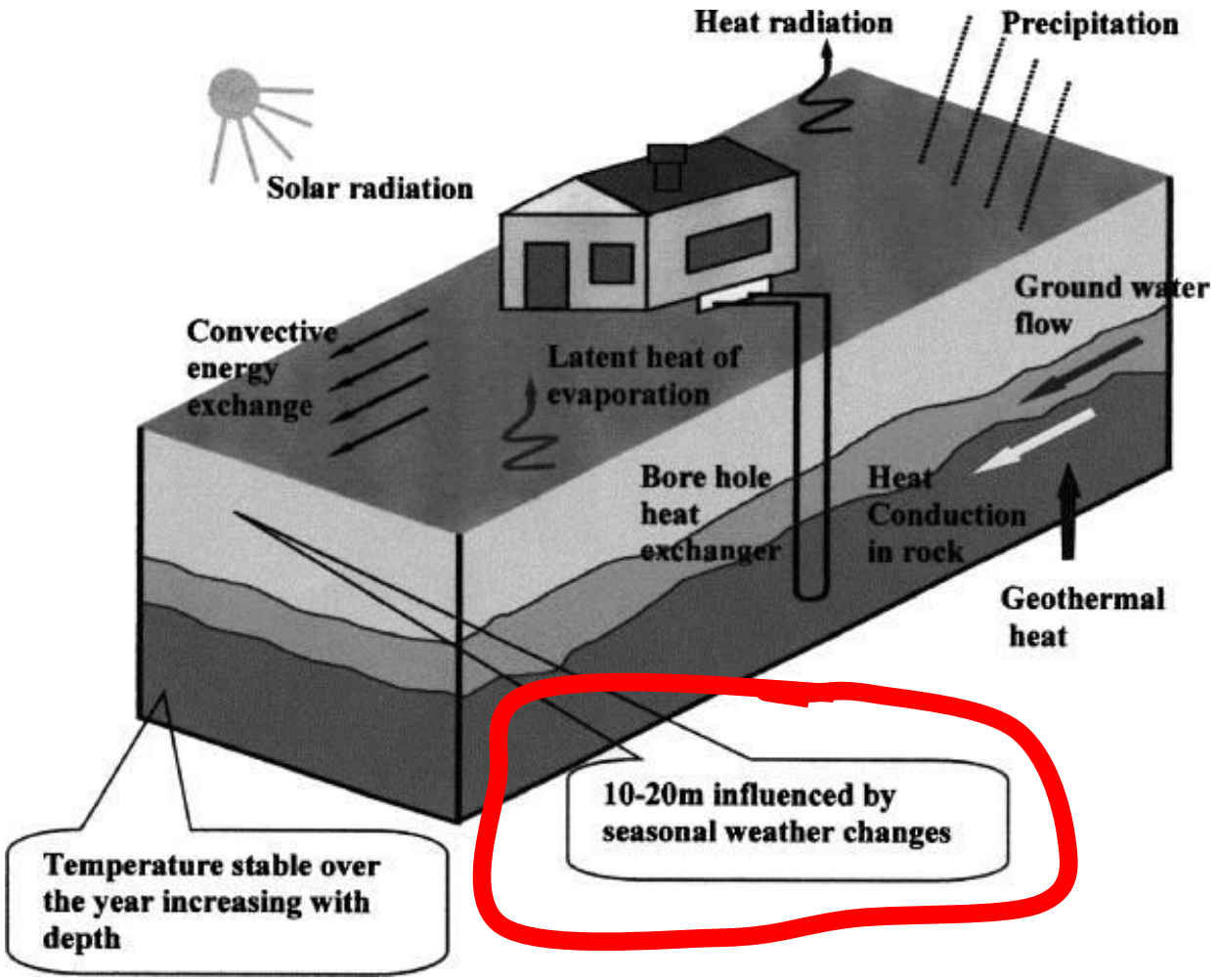
Summer /Cooling Mode

Winter /Heating Mode



Where the stable heat is.....





Delta T (OAT & IAT)

Exchange in Air

	OAT	IAT	Delta T
Winter	-25	20	45
Summer	45	23	22

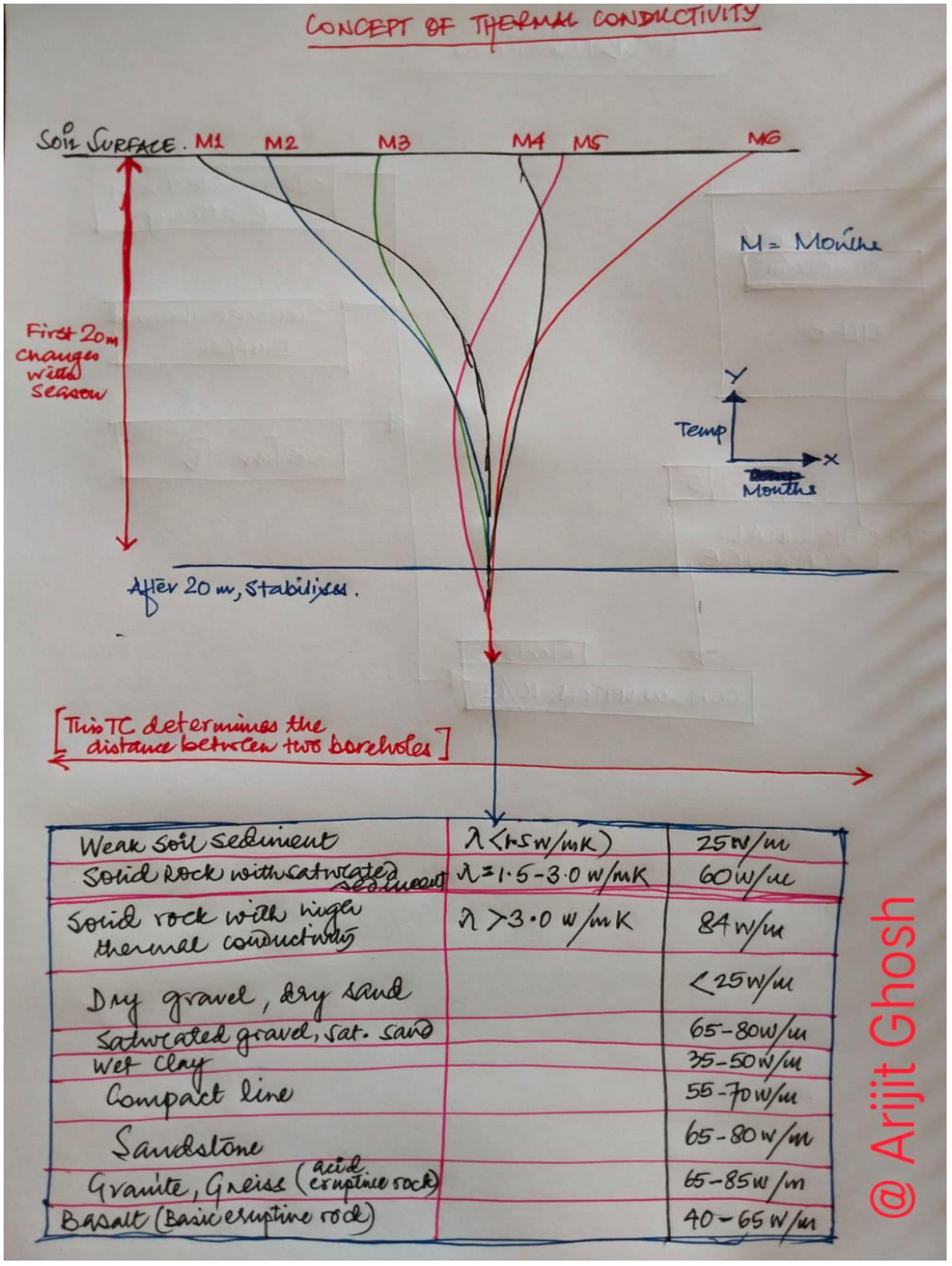
Exchange in Ground

	Soil Temp (approx)	IAT	Delta T
Winter	18	20	2
Summer	18	23	5

Thermal Conductivity

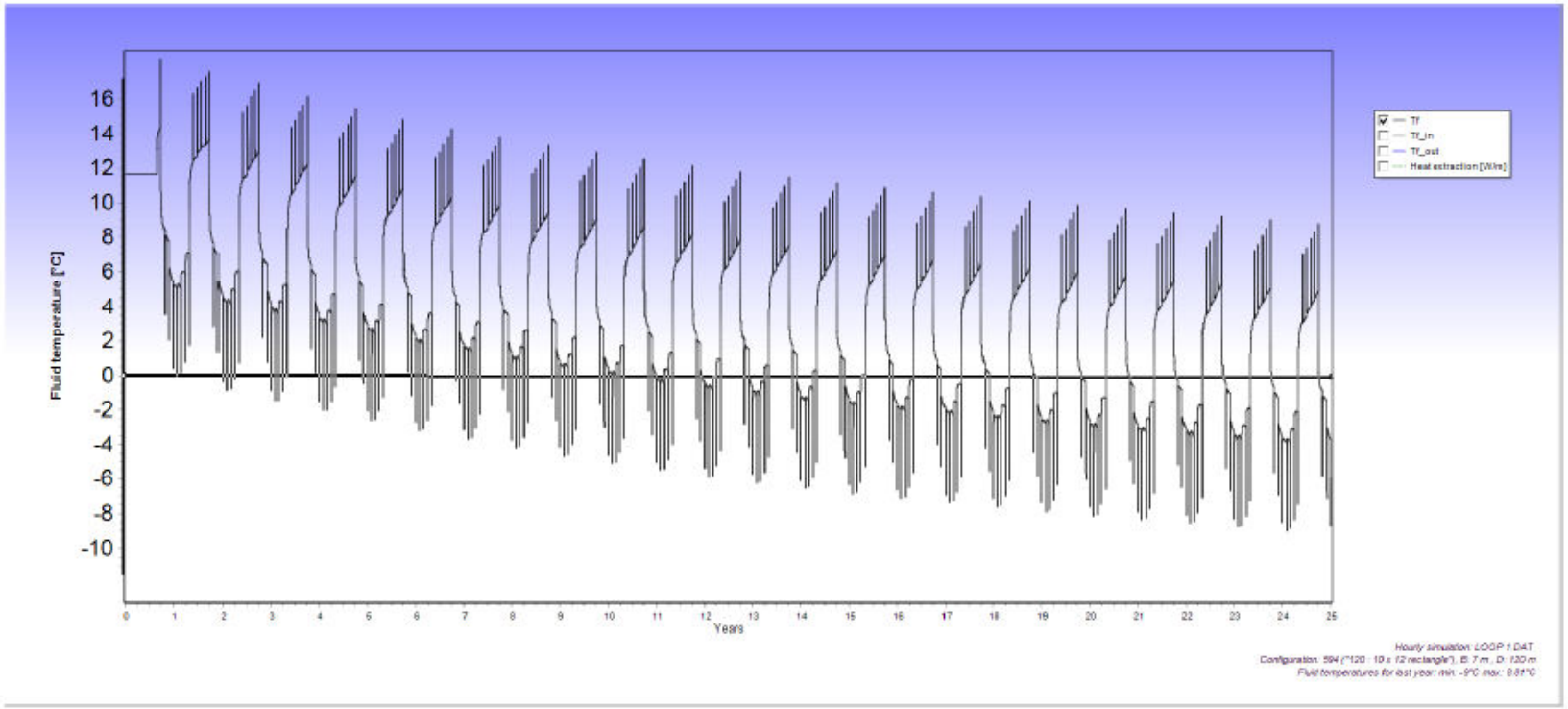
A **Thermal Response Test (TRT)** involves applying a **finite amount** of heat energy into a closed loop borehole over a certain period of time (36-48 hrs), while **monitoring the rate** at which **heat dissipates into the surrounding ground.**

We want stable temperatures .

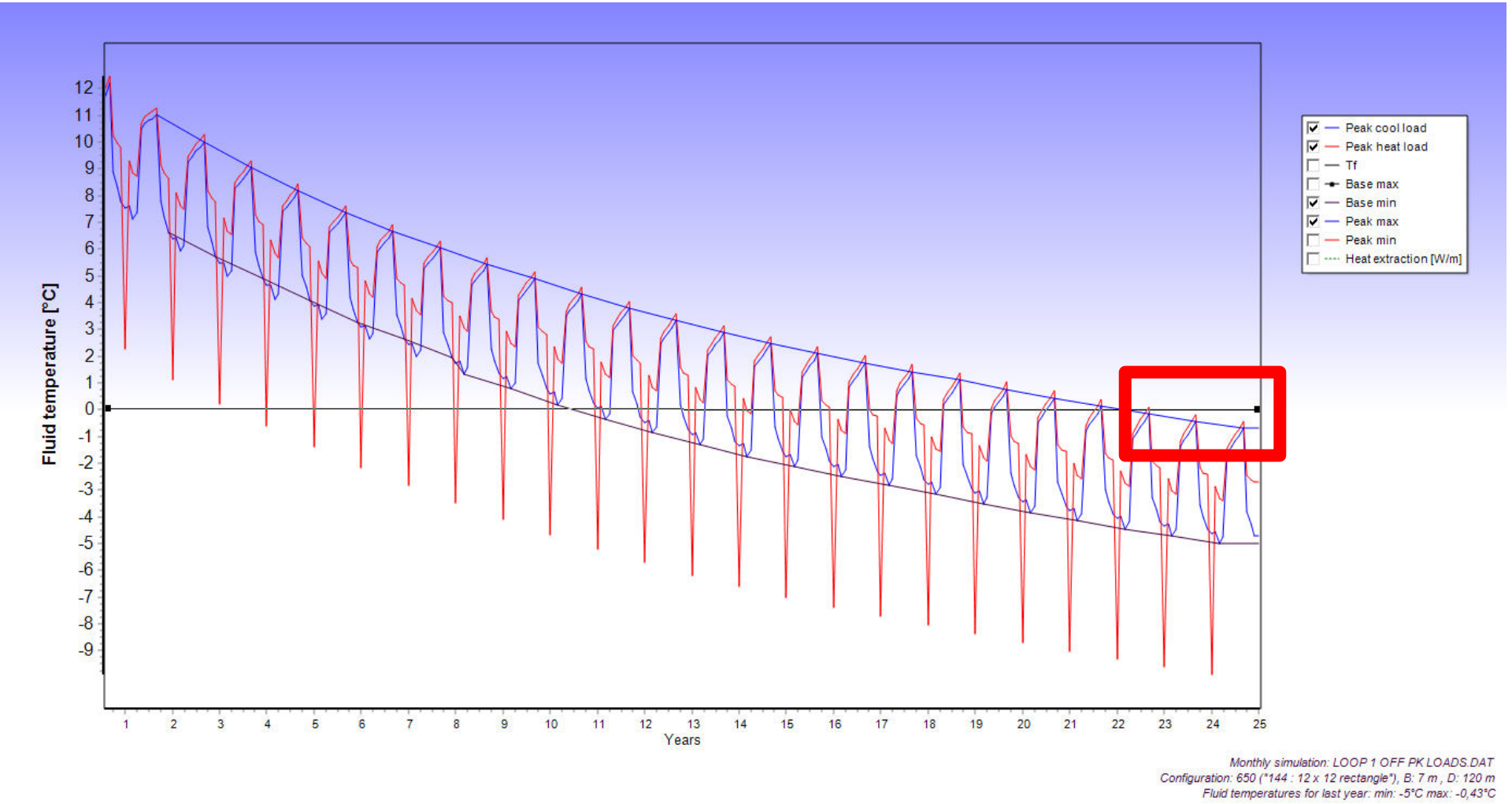


the energetics people
S.A.P. Automation
www.lowenergy.in

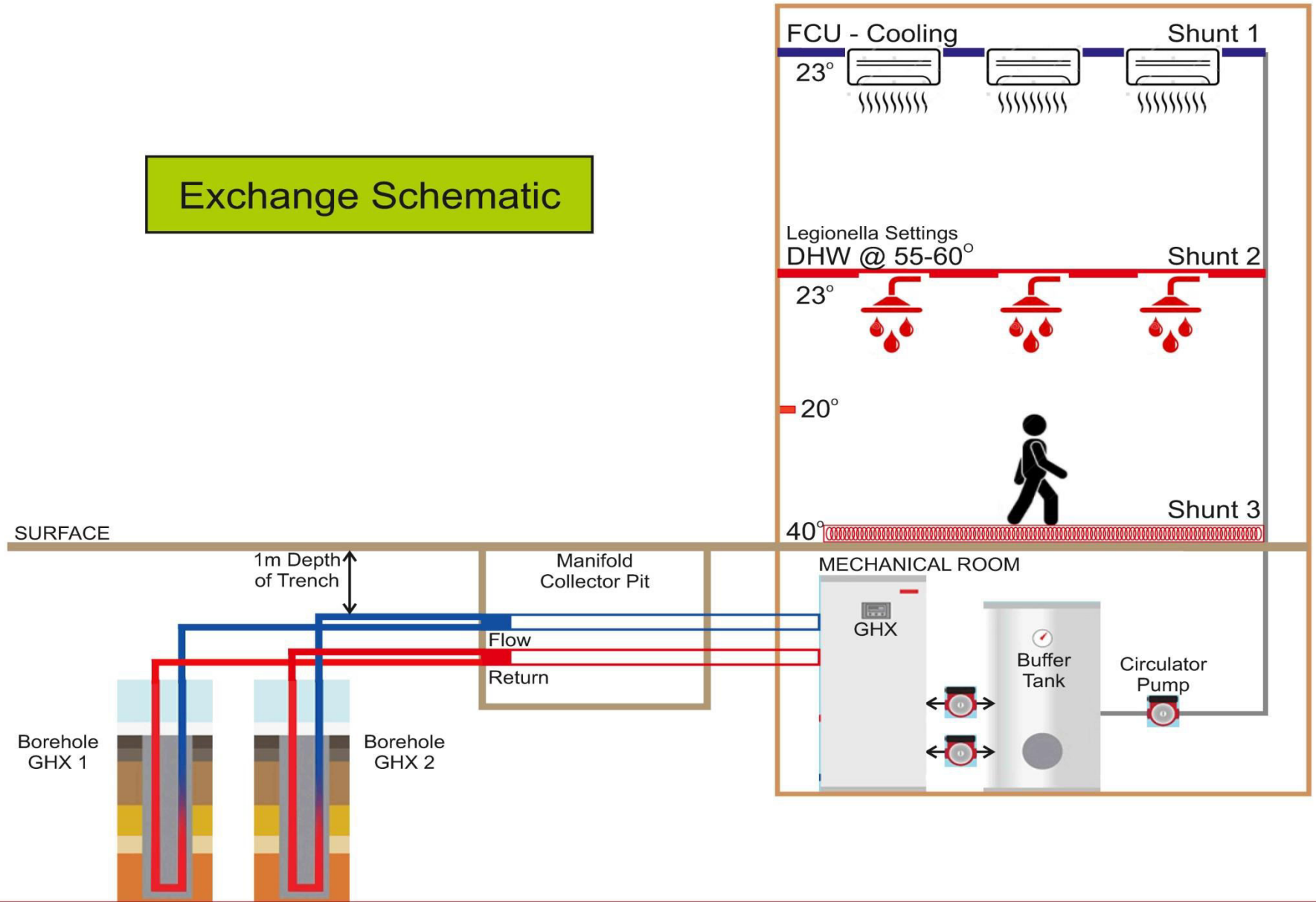
How to design ?
The fluid temperatures in the BHE for 25 years.



Understanding Loop Behaviour (25 years)



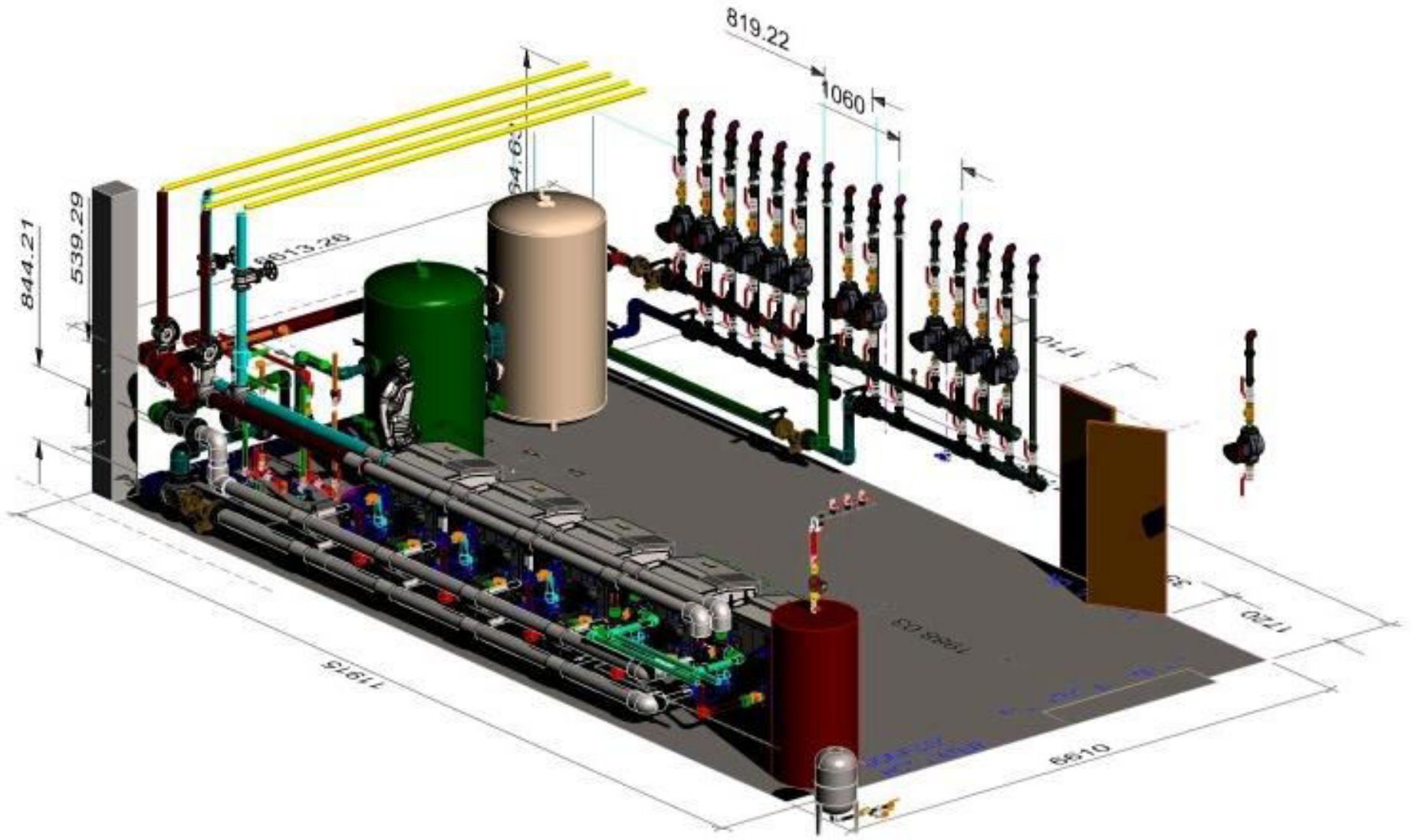
System : Concept



Different Shunt Groups in Distribution : Heating & Cooling

- Heating : With Radiant Underfloor
- Cooling : With Fan Coil Units
- Cooling : With AHU & Ducts
- Domestic Hot Water (DHW)

Machine Room



Energy Storage in Liquid Form

Traditional Design **Decarbonised Design**

Surplus stored energy

$$\Delta Q_{bt} = m_{bt} \cdot Cp_w \cdot \Delta T_{bt}$$

$m_{bt} \approx 500kg$

$Cp_w = 4,18 kJ/kg \cdot °C$

$\Delta T_{bt} = 60°C - 40°C = 20°C$

$$\Delta Q_{bt} = 500 \cdot 4,18 \cdot 20 = 41800\ kJ = 11,61\ kWh$$

Versatility

- Exchanges from ground, hence no relation with outdoor ambient temperature.
- No BMS.
- Ability to produce Heating , Cooling and Hot water from the same system.
- No Scaling.
- Ability to cascade , makes entire system modular , no need for stand by.
- Ability to hybridize with Solar through eManager.

Case Study

Indo US @ Roorkee

Year of Completion 2021

Target : Net Zero

- Building Physics
- Geothermal Exchange
- Solar Hybridization

Drilling :

Drilling :

DTH Rigs have been used to drill 70 m of each borehole. Drilling has been done with mud and water. Total Drilling depth is based on the size of the system and exchange.

Drilling Field : Site actual

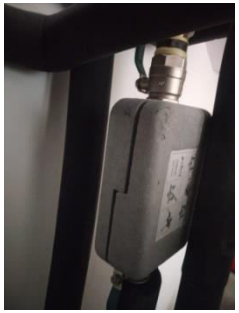
Starting mechanical room

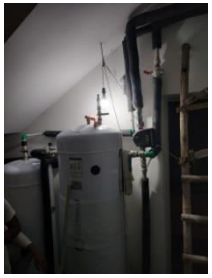


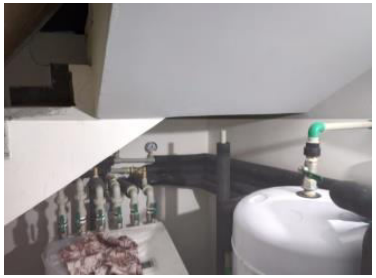






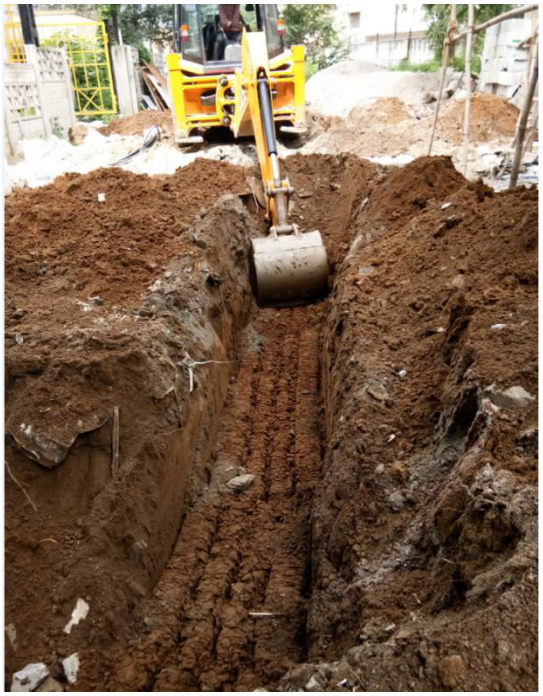








Installing all the hydronic circuit components

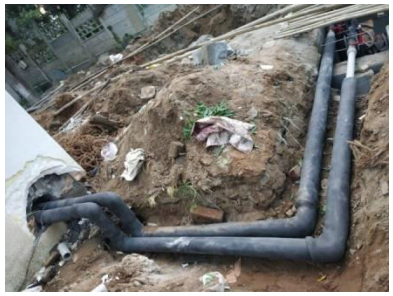


These pipes are now connected from vertical Terminations and brought to the Collector pit Through horizontal travel.

Collector Pit and Header Circuit

All the heat exchanger Horizontal pipes
Must come and terminate in one place.

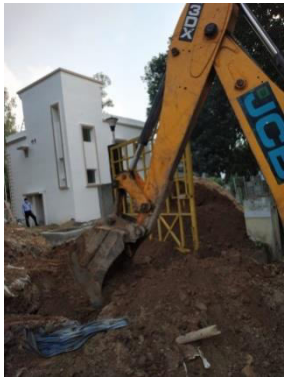
From here only 2 pipes go inside the building.



Fixing the horizontal circuit

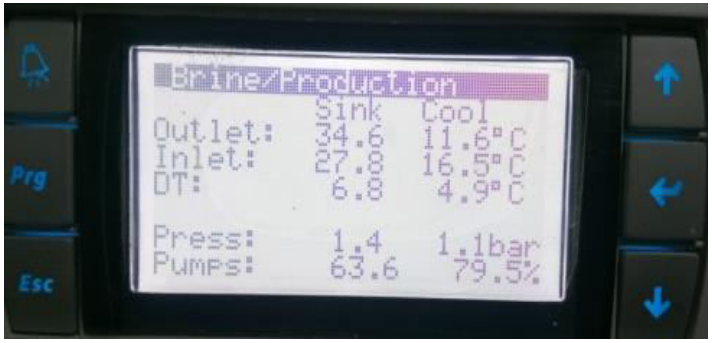
All pipes brought in to the collector pit

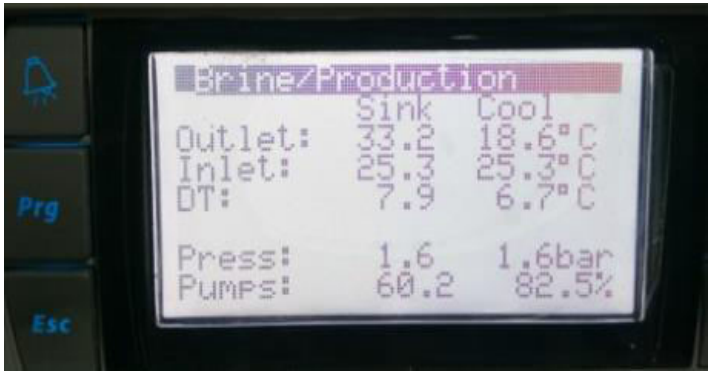
Trench Back filled



All the horizontal digging is filled up again.
Ground levelled.

Sink DT : Brine Production/Exchange (Borehole Efficiency)

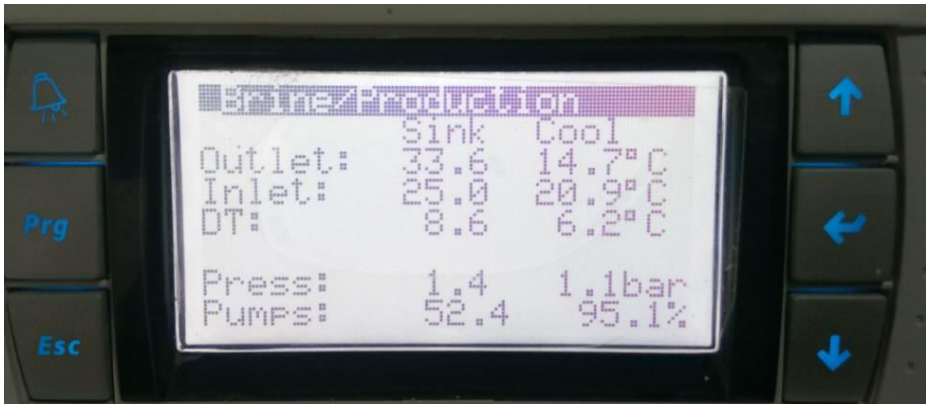


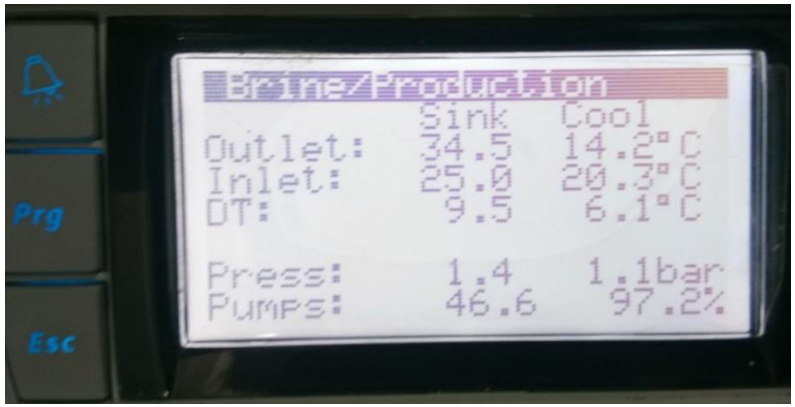


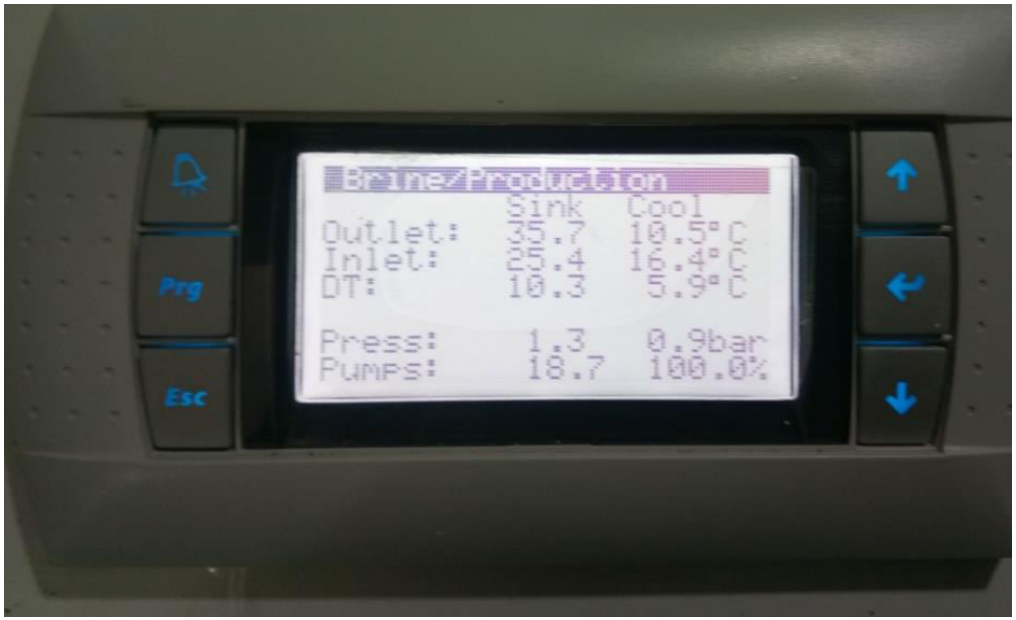
Peak Performance :

This is Renewable Thermal energy

Loop Efficiency - DT



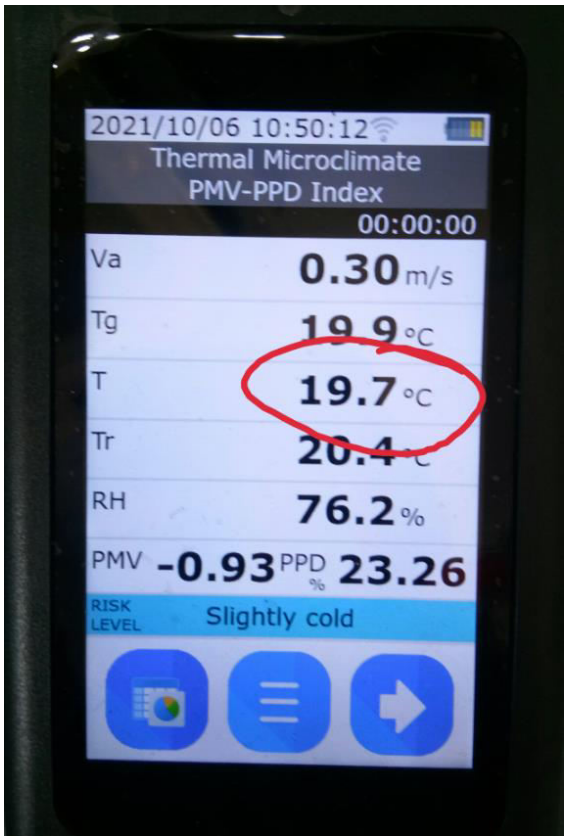




Energy Meter : October 2021

Energy Meter
PF (with Cooling and DHW)

Ability to Cool (Effectiveness)



Solar Surplus : OFFGRID

Leh Airport Design : 20000m2/2500 KW Th/ 439 BHE

No fossil fuel heating/cooling.

Ren Heat + Ren Elec > Hybridization.

Complete Decarbonized HVAC.

BAU on Solar first.

Carbon Neutral HVAC operations.

Green Onsite Energy Resource.

ENGINEERS INDIA LIMITED

(A GOVT. OF INDIA UNDERTAKING)

CONTRACT DOCUMENT
FOR
APPOINTMENT OF GEO-THERMAL ENGG. CONSULTANT
FOR LEH AIRPORT

(BIDDING DOCUMENT NO.: RC/B047-002-SE-TN-4010/2001)

NAME OF CONSULTANT (GEC): M/S S.A.P. AUTOMATIONS (INDIA) PRIVATE LIMITED

Prepared & Issued by

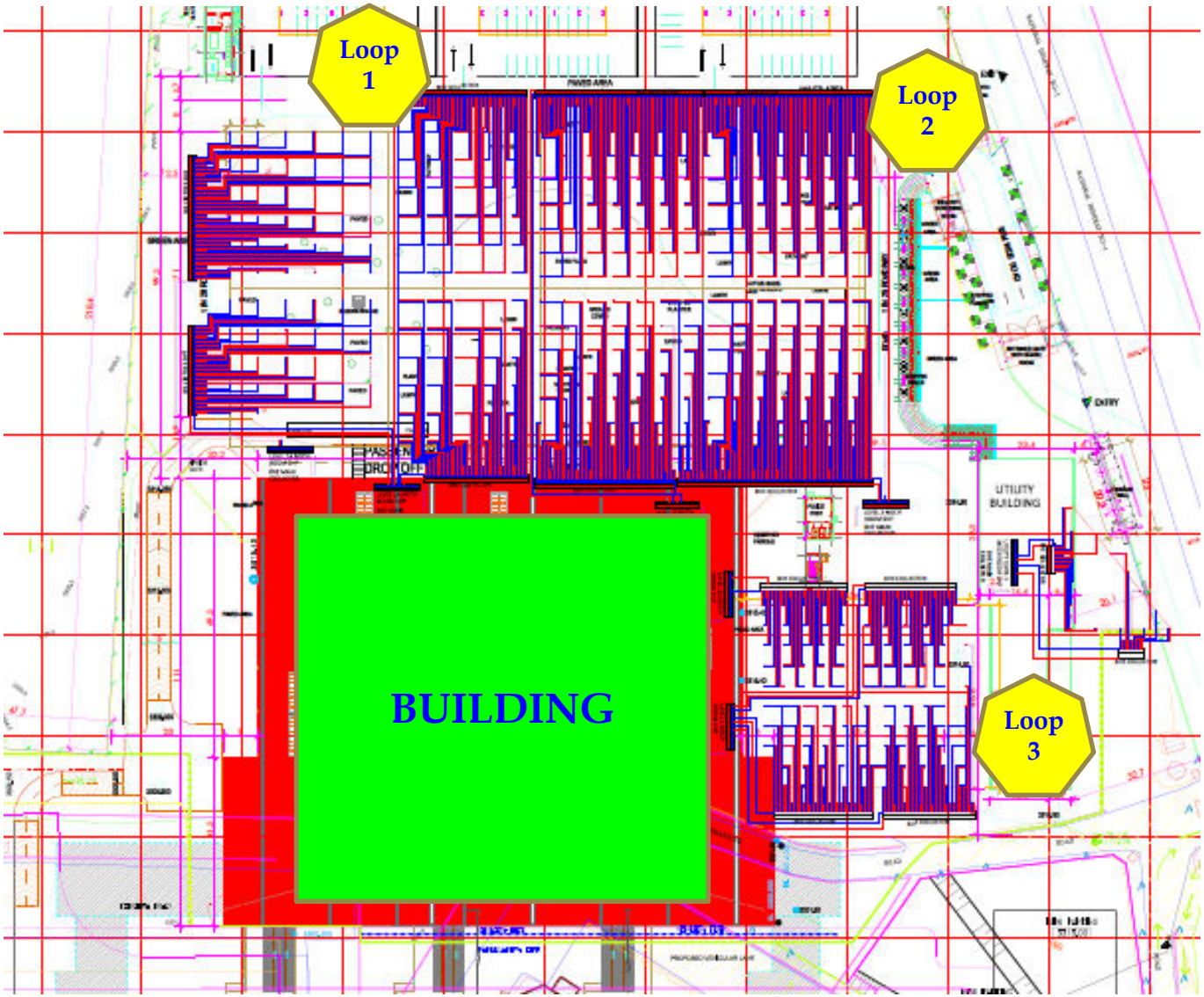
इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

For S.A.P. Automations (India) Pvt. Ltd.

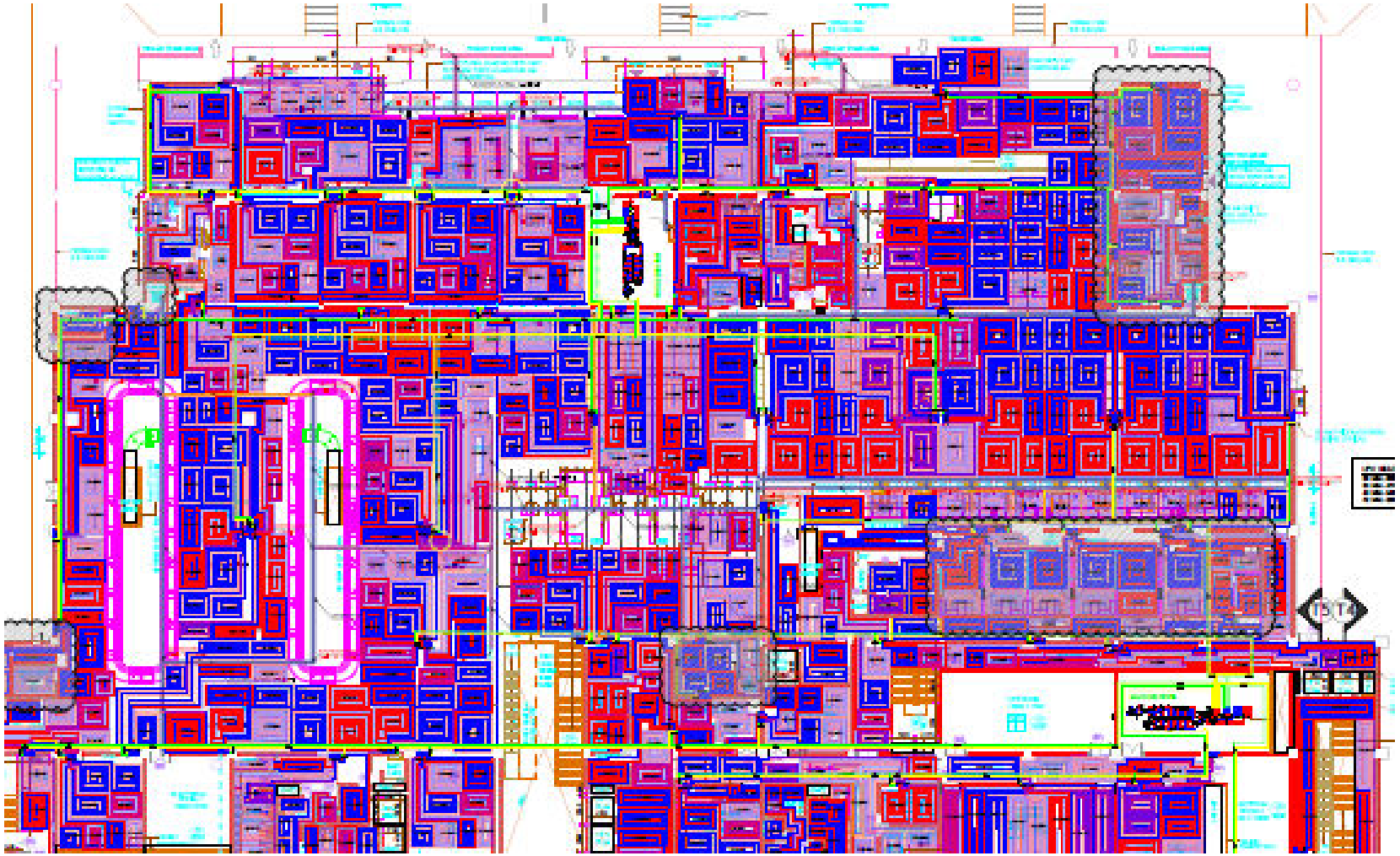
Director

The first Carbon neutral HVAC operations in airports –In India.

Leh Airport Terminal –Design Complete (Loop Arrays based on Thermal Load)



Underfloor Distribution.
Heating Up the Thermal Mass



DSEO Leh

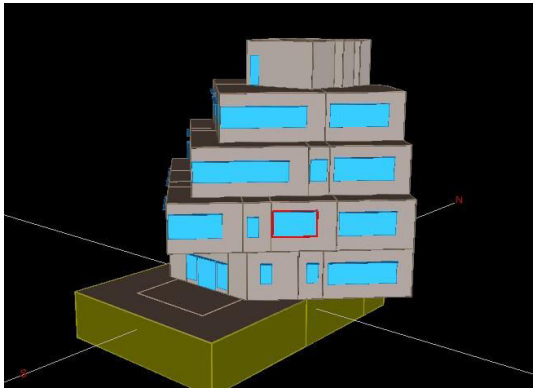
CPWD's Own-The first of its kind.

Attempted : NET ZERO WITHOUT FOSSIL FUEL HEATING.

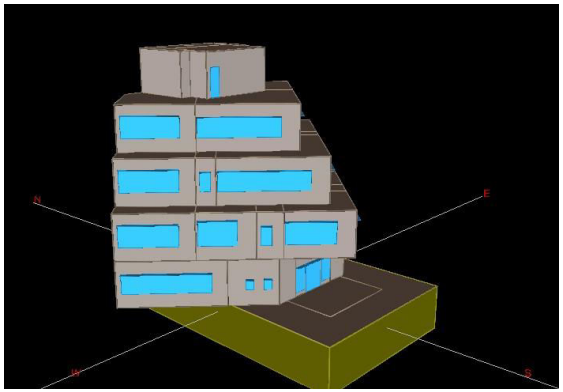
Carbon Neutral Ladakh Design

(Execution : S S Chauhan & Sons / EPC Mode)

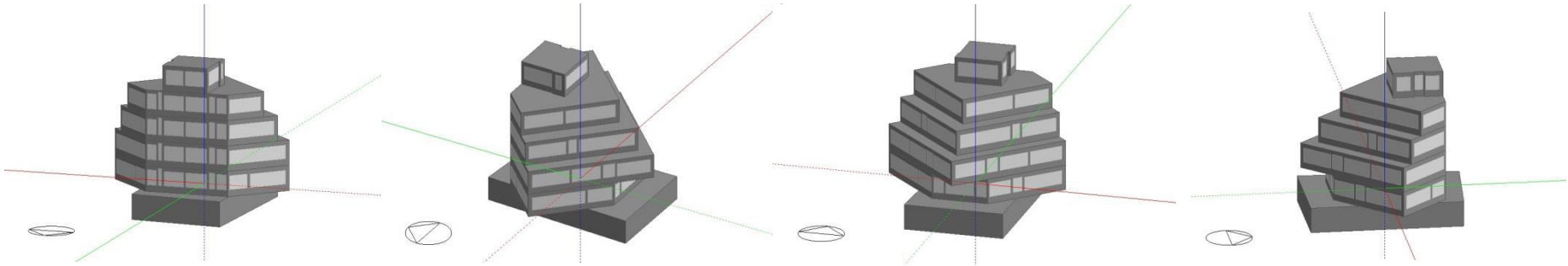
Soft spot – WWR 35%



South East



South West



The *first* CPWD Building
-in line with Carbon Neutral Ladakh

1. Leh's heating demand not be attempted with fossil fuel.

2. Diesel fired Boilers and combination of national grid 32899.16 kgs of emission brought down to Solar Geothermal Hybridization of 1334.44 kgs

3. This also decarbonizes the heating /Cooling/DHW by going almost Off the grid , during BAU hours.

4. The current scenario demands ZNEB actualisation.

5. Complete Hybridization between Renewable Heat and Renewable Electricity.

Final quantification : DSEO (Snapshot)

- EPI > 71.18 Kwh/m2/year
- EUI > 22.18 Kbtu/gsf
- Carbon Emission > 1334.44 kgs or 1.313 (Imperial Tons)
- Carbon Savings from Conventional : 32899.16 - 1334.44 = 31564.72 kgs (savings of Carbon)
- % Reduction of Carbon - 95.94% reduced / avoided.

Greener than the ~~greenest.~~

EUI		EPI	
KBTU	252949.7686	KWh	74135
gsf	11404.09	M2	1041.5
kbtu/gsf/a	22.18	KWh/m2/a	71.18

CPWD DSEO

A building known by its **PERFORMANCE.**

According to ECBC :

EPI =201 as standard for Cold Climates

ECBC will be 21% less =158.79

ECBC Plus 27% less = 146.73

ECBC Super 45% less = 110.55 **ECBC Super**

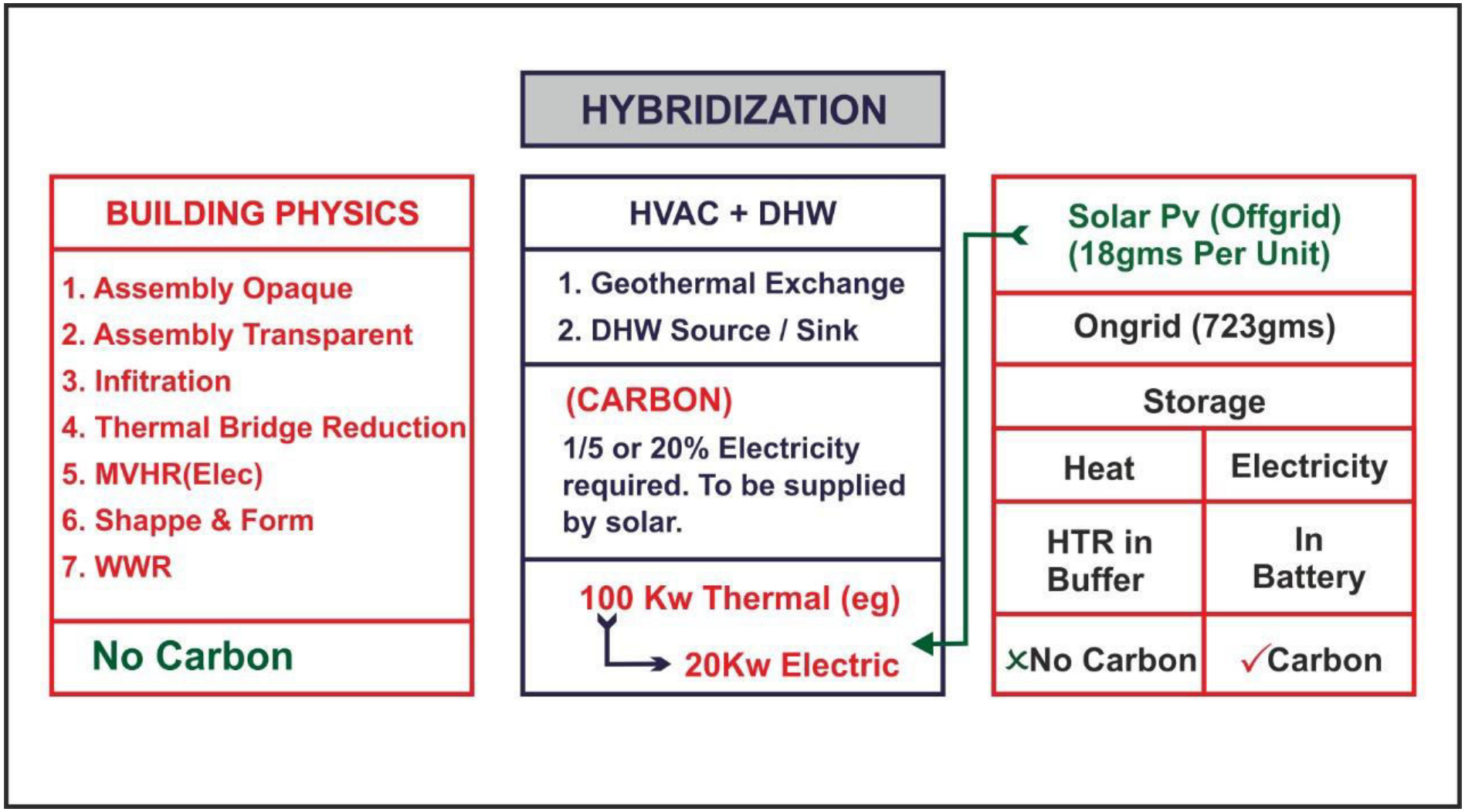
Decouple from climate

HOT	COLD	MODERATE
EPI 100	EPI 100	EPI 100
U value - 0.10 ↑ Assembly - 400 mm Glazing - 0.90-1.30 Infiltration - 3 lit/sec Thermal Bridge -A	U value - 0.10 ↑ Assembly - 400 mm Glazing - 0.90-1.30 Infiltration - 2 lit/sec Thermal Bridge -B	U value - 0.10 ↑ Assembly - 275 mm Glazing - 1.50 Infiltration - 4 lit/sec Thermal Bridge -C
MVHR H_R = 75-80% MVHR Energy = 0.45wh/m^3	MVHR H_R = 75-80% MVHR Energy = 0.45wh/m^3	MVHR H_R = 70% MVHR Energy = 0.75wh/m^3
Thermal Load =125 w/m^2	Thermal Load =120 w/m^2	Thermal Load =110 w/m^2
H+C+DHW SPF - 4.5	H+C+DHW SPF - 4.25	H+C+DHW SPF - 5.0
HTR -✓	HTR -✓	HTR -✓
PV = 100% BAU	PV = 100% BAU	PV = 100% BAU

Hybridization : Ren Electricity + Ren Heat

Not Between National Coal Dominated Grid and Solar

(The only way to make ZNEB)



Hybridization.

Renewable Electricity
Clean from Roof Top Solar
No touching the grid
To address all electrical needs.

Renewable Thermal
Clean from Geothermal
To address all thermal needs.

CARBON FREE ELECTRICITY

CARBON FREE HEAT

India

Threshold Criteria for Certification Levels

Certification Level	Points	Recognition
Certified	50-59	Best Practices
Silver	60-69	Outstanding Performance
Gold	70-79	National Excellence
Platinum	80-100	Global Leadership

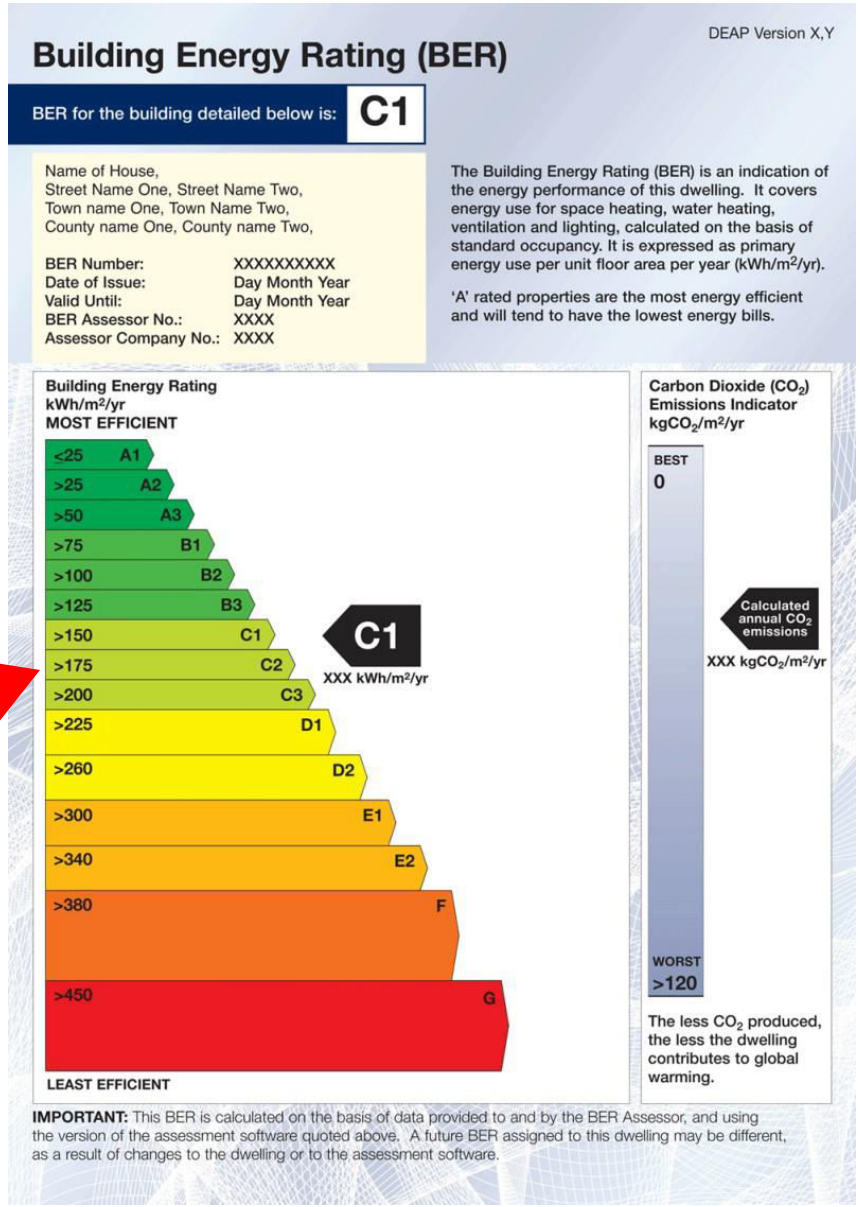
EPI benchmarks for Office Buildings

Climate Zone	Less than 50% AC	More than 50% AC
EPI (kWh/m²/yr)		
Warm & Humid	101	182
Composite	86	179
Hot & Dry	90	173
Moderate	94	179

What is more than 50% ? 51-100%
Benchmark against world standards in EPI.
If its 49% HVAC –EPI 101
If its 51% HVAC –EPI 182

At this EPI is it correlating to Climate Change –Ozone Depletion and CO2 emission ?

World



Chillers and their performance against Geothermal.

CHILLERS			GEOTHERMAL		
(Exchange Temp = 40 Deg C)					
Performance	KW el cons/TR			KW el cons/TR	
Central Plant	0.7		Central Plant	0.48	
Cooling Tower	0.35		Cooling Towers	0	
Fans/FCUs	0.25		Fans/FCUs	0.25	
KW/TR	**1.3**		**KW/TR**	**0.73**	
Energy In	1.3	KW/TR	Energy In	0.73	KW/TR
Energy Out	1 TR = 3.517 KW		Energy Out	1 TR = 3.517 KW	
SPF / COP	3.517/1.30	2.7	**SPF / COP**	3.517/0.73	4.82
Say in 100 KW Scenario					
Load	100		Load	100	
SPF	2.7		SPF	4.82	
Actual Consumption (Elec) KW	37.04		Actual Consumption (Elec) KW	20.76	
			Less Consumption %	**-43.96**	

More refrigerant -more work done - more consumption

BEE - Refrigerant Charge Rate					
				GWP	Same Refrigerant
Category	kgs	KW	total per 100 KW	assumed R410	Emission Kg/CO2
Chillers	0.28	1	28	2087.5	58450
VRF	0.23	1	23	2087.5	48012.5
Packaged DX	0.26	1	26	2087.5	54275
Geothermal/Aerothermal	0.092	1	9.2	2087.5	19205

Buildings will have to adapt for :-

> Climate Change Mitigation techniques.

> SDG addressing designs. (SDG -3/7/9/11/13)

> Decarbonisation of space conditioning.

> Compliance to Energy Conservation Act 2022.
(Notification CG-DL-E-20122022-241246)

> NET ZERO Buildings. (Part of Hon PM's Pledge for Net Zero)

Green Building Documentation.

Result of Huge Documentation

Evolution

Pre 2010 = Prescriptive

2010-2020 = Transition

2020 + = Performance

Final Result

- **IGBC Platinum class buildings can only deliver 15-20 % solar offgrid parameter, the key in making of a ZNEB.**
- **How will the 80- 85% gap of generation be made up to be ZNEB?**

What has the green building been able to achieve ?

Net ZERO

is

QUANTIFICATION.

NET ZERO Defined

- **Autonomous Zero Energy Buildings** all demand are met by site generation, no external network connections.

- **Net-zero site energy** – local generation completely offsets on-site demand, demand and supply are

- **Net-zero source energy** local generation completely offsets primary energy demands, demand and supply are not temporally matched but balance over a year.

- **Lifecycle net-zero energy buildings** local generation completely offsets primary energy demands AND embodied energy, demand and supply are not temporally matched but balance over the lifetime of

- ***NB For a building to be zero carbon (as opposed to just zero energy) then the local generation needs to be carbon free: e.g. PV, solar thermal, biomass, SW.***

What is carbon neutrality ?

- Measure the carbon footprint.
- Then offset or mitigate the same quantum of footprint / from the atmosphere.
- Carbon neutrality is easy to achieve.
- One can emit carbon and then pay for the sins somewhere else.

- **<u>Carbon Neutrality is not going to solve climate crisis.</u>**
- **Climate crisis needs reduction, in emission.**

Carbon neutral and Net Zero.

- Its easy to measure the carbon produce /emit at one place and buy offset somewhere else.
- That is carbon neutral.

- Carbon Credit Certificates = Carbon Trade

- But **Net Zero is different**. In order to be Net zero , need to actually reduce the **emissions by 90-95%** , which is possible by combining **Renewable electricity and Renewable Heat (Hybridization)**

Net Zero Carbon

- To be **Net Zero carbon** ., first have to be **Net Zero energy.**
- Reduction must be in **absolute emissions**. Not related to growth of business.
- **Offset the carbon**.
- **Use of non carbon strategies like Renewable Electricity and Renewable Heat Hybridization.**

How Net Zero is measured in India ?

1.Buildings are measured as EE buildings as in GRIHA and ECBC and the huge shortfall of onsite and local generation is then off set by remote power calculation of grid balance , purchasing of so called green power.

2. That doesn't make the building Net Zero.

IGBC Buildings in India is Net Zero even if……

- IGBC has been classifying buildings as ZNEB /Net Zero energy where as the building may be generating only **20%** of its annual consumption through on site solar and rest **80%** it buys through a **PPA** agreement of Clean Energy Either Solar / Wind or Hydel.

- Most probably the Solar field is hundreds of Kilometres away. Therefore they must be evacuating their yield in the nearest grid connection they could get and definitely not even the town the building is certified in.

Indian Certification Agency : Norms

Temperature	Relative Humidity	**Absolute Humidity/ Humidity ratio**
26 - 2 °C	30%	**5.63 g/kg**
26 + 2 °C	70%	**16.94 g/kg**

End Use	Standard Design	Proposed Design	Measured Data
Cooling	3,64,023	3,50,297	
Heat Rejection	-	5,937	
Pumps	-	1,75,837	
Fans	5,93,662	1,16,274	
Lighting (Interior)	3,98,046	2,53,300	
Equipment	3,15,927	3,15,927	
Lift	66,640	66,640	
Lighting (Exterior)	97,937	18,571	
Total Consumption (kWh)	18,36,235	13,02,783	12,06,410
Unmet Load hours	46	63	-
EPI (kWh/m^2.yr)	106	75	70 (8% Variation) *
EPI Ratio		0.71 (Points: 75)	

*The recorded 8% variation is within the bounds of being less than 20% as defined by technical report, *Methodology for Modelling Building Energy Performance across the Commercial Sector* (NREL/TP-550-41956).

IGBC

4. RESULT : Energy Numbers Details

Total Energy Consumption (Apr 2021- Mar 2022)	kWh	**12,06,410**
Off-site Renewable Energy (from Clean Max India Pvt. Ltd)	kWh	9,60,000
On-Site Renewable Energy from 198 kWp Solar PV (Apr 2021- Mar 2022)	kWh	2,54,635
Total Renewable Energy (Off-site + On-site)	**kWh**	**12,14,635**
Net Positive	**kWh**	**8,226 (0.7%)**
Percentage of total energy consumption met through Offsite - Onsite renewable energy sources	**ratio**	**79:21**
Points		**8**

Summary of energy consumption met through Offsite - Onsite renewable energy sources

79% of the energy comes from outside and the building is Net zero?

How ?

- *if I make building in Arunachal and offset the same consumption in Tuticorin , how may I ask, is the building in Arunachal , Net Zero or Low Energy ?*

- *A world standard that is qualified by less than 2 % of buildings. Here all can be ZNEB*

It starts here .....Source

BEE - STAR RATING PROGRAM -2022

Here for the consideration of EPI , BEE has certain consideration as below.

However, the total electricity would **not include electricity generated from on-site renewable sources** such as solar photovoltaic etc.
Electricity purchased and generated (excl. generated from on-site RE resources)] ÷ [Built Up Area excluding Basement parking, lawn, roads, etc. (in sqm.)]

The most illogical use of Renewable Energy.
The certification agencies take advantage of twisting.

If you twist the law in your favour , how can you evade the law then ?

But not all-(https://living-future.org/lbc/)
Some use logic/science and prudence well

REQUIREMENTS

One hundred percent of the building's energy needs on a net annual basis must be supplied by on-site renewable energy.[1]

No combustion is allowed.

1 There are ZE Certification exceptions, related to the use of off-site renewables and on-site combustion in certain circumstances. These exceptions and others are found in the Zero Energy Handbook, which is available to ILFI members through the Membership Dashboard.

ero Energy (ZE) Certification is a standard eveloped by the International Living Future stitute (ILFI or the Institute) that recognizes he ighest levels of energy performance that can e achieved by built projects. Globally, buildings onsume over 36% of final energy, the majority of hich is still produced by using fossil fuels. This sults in the building sector accounting for over 9% of energy and process-related greenhouse as (GHG) emissions, which in turn have caused n alarming shift in global temperatures that nperil the human and natural worlds.

he Zero Energy Certification program presents new energy paradigm, where built projects atalyze a transition towards a prosperous ture for all with energy infrastructure that is ean, abundant and resilient. This certification the only global third-party verified standard at recognizes built projects with industry- ading energy performance and a balance of enewable energy without the use of combustion. he program utilizes a simple approach to rtification that is based on measured energy erformance rather than predicted outcomes.

THE ZERO ENERGY CERTIFICATION STANDARD REQUIRES THE FOLLOWING:

100% of the building's energy needs on a net annual basis must be supplied by on-site renewable energy.

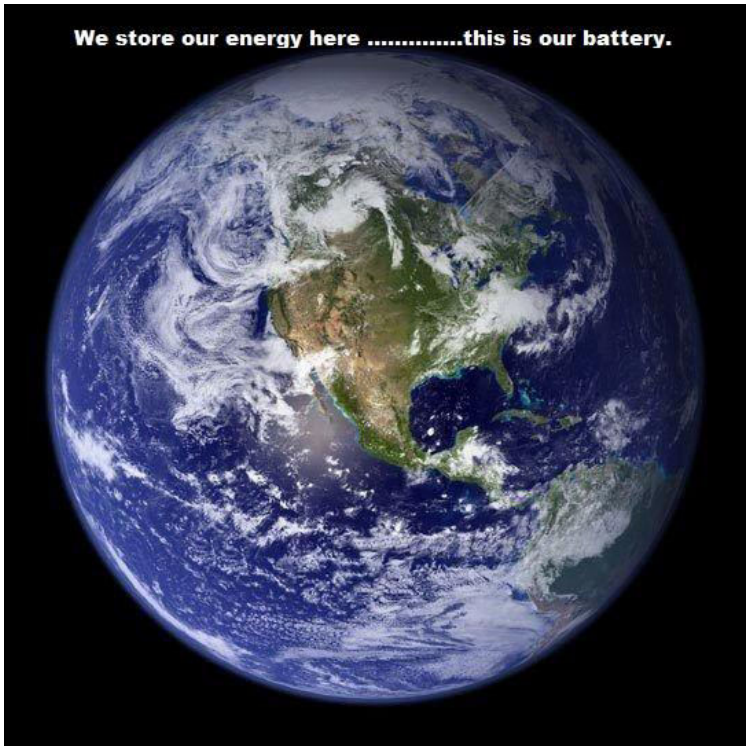
No combustion may be utilized to meet on-site energy demands.

The Zero Energy Certification standard was originally developed by ILFI as the Net Zero Energy Building (NZEB) Certification in 2017, with requirements based on those included in the Living Building Challenge (LBC) version 2.1 Standard. In 2019, the program was renamed to Zero Energy Certification and streamlined to focus its requirements exclusively on the energy balance of a project.

LIVING BUILDING CHALLENGE

Conclusion

- **Reduce Consumption.**
- **Correct technology for exchange.**
- **Supply from nature.**
- **Refrigerant reduction.**
- **Energy consumption reduction.**
- **Low carbon emission.**



Thank You

Disclaimer

- This communication is based on my observations, understanding, knowledge and experience and bears **no** intention to insult ,malign any one or any organisation.
- This effort has been made to improve the performance of buildings and nothing beyond.

The reader at his own understanding may accept or reject the observations.

S.A.P. Automations
S.A.P. Automations (India) Pvt. Ltd.

uLEB
ultra low energy buildings

Arijit Ghosh
Managing Director
+91-9971600708; arijit@sapautomation.in

GEOTHERMAL
free underground energy

AEROTHERMAL
decarbonized HVAC

Reg. Off.: FF-17/367, St. No.- 14, Laxmi Nagar, Delhi-110 092 -INDIA.
Ph. +91-9599 335 359, info@sapautomations.in / www.lowenergy.in