



Bureau of Energy Efficiency



सत्यमेव जयते  
Government of India  
Ministry of Power



**giz** Deutsche Gesellschaft  
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# ANGAN

## Augmenting Nature by Green Affordable New-habitat

A Courtyard for Revolutionary Change in Building Energy Efficiency

An International Conference on Building Energy Efficiency

9<sup>th</sup>-11<sup>th</sup> September, 2019 | Hotel The LaLIT, New Delhi





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THIS PRESENTATION WAS SHARED BY

**Mr. Joerg Gaebler**

Principal Advisor, GIZ, New Delhi

FOR THE SESSION:

*“Integration of Renewable Energy in Buildings  
in India“*

DURING ANGAN 2019

Knowledge Partner

**teri** | THE ENERGY AND  
RESOURCES INSTITUTE  
Creating Innovative Solutions for a Sustainable Future

Event Partner

**TEC INDIA** <sup>TM</sup>  
EVENT & BRAND MANAGEMENT CO.



# ***Integration of Renewable Energy in Buildings in India***

International Conference and Exhibition on 'Augmenting Nature by Green  
Affordable New-Habit – ANGAN – September 9<sup>th</sup> – 11<sup>th</sup>, 2019



## Delhi Model Building by-laws → in favour of Solar (Thermal + PV)

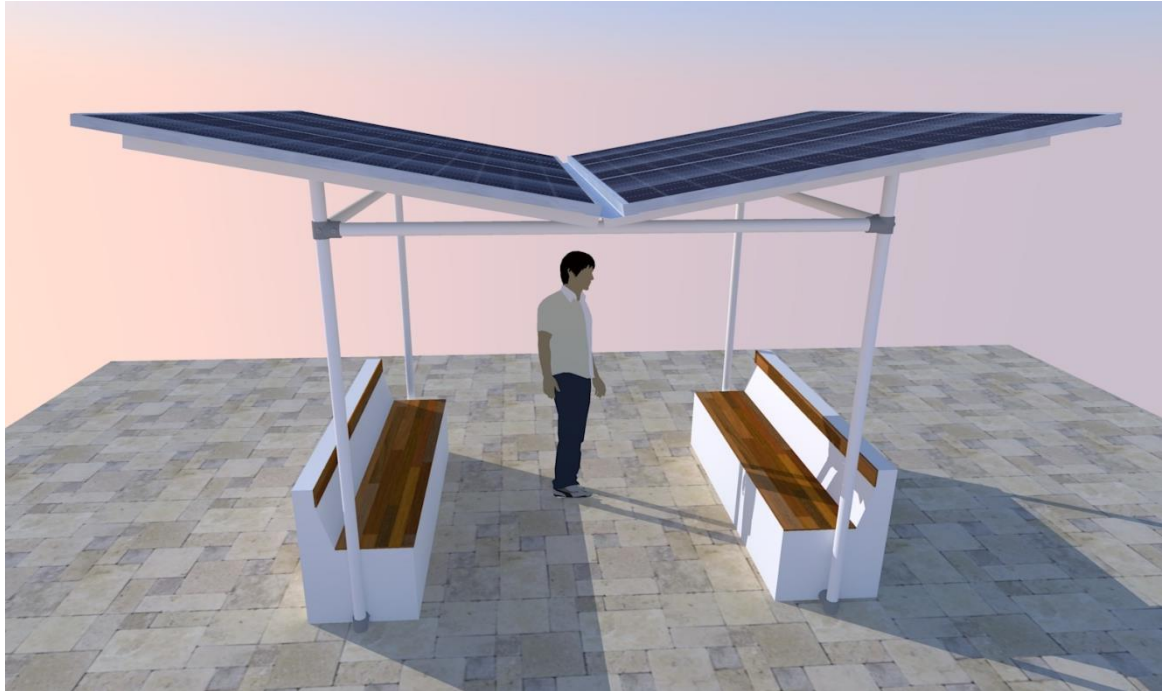
### 13.8 Building bylaws amendment for rooftop solar installations

a) The height of the module structure carrying solar panels shall not be counted towards the total height of the building as permitted by building bylaws, except near airports where building regulations issued by the Airports Authority of India take precedence.

b) *No approval will be required from concerned Municipal Corporation or other Urban Development Bodies like the DDA for putting up solar plants including any additional system for monitoring the performance of solar plant in existing or new buildings.*

c) The support structure on which rooftop solar panels are installed shall be a temporary structure built in accordance with local building codes

<http://delhi.gov.in/wps/wcm/connect/7c342e004e4e1329adcebd0b799661cf/Solar+Policy+English.pdf?MOD=AJPERES&lmod=1190989579&CACHEID=7c342e004e4e1329adcebd0b799661cf>



## **Plug 'n' Play distributed solar with storage for residential applications**

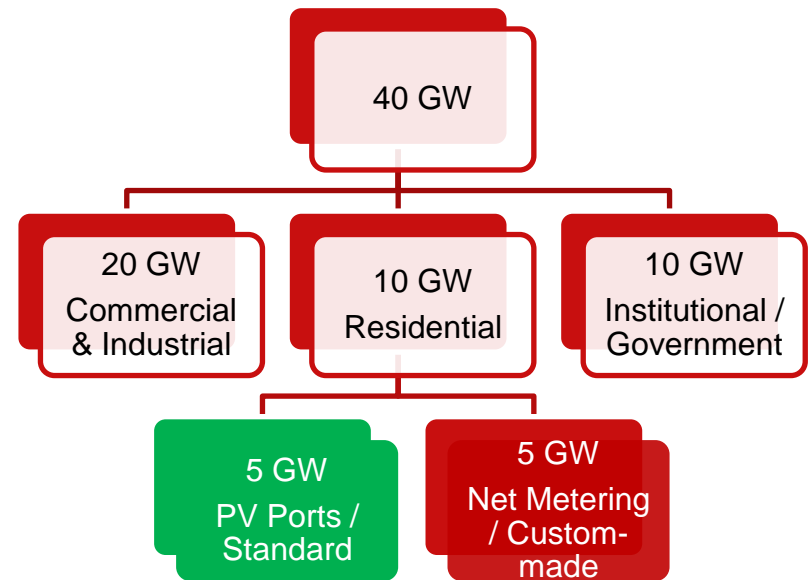
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Concept developed by the Solar team at GIZ India / mandated by MNRE – Ministry of New and Renewable Energy, New Delhi



## DISCOM's in India will become the driver for RTS...

- MNRE has assigned a **14 GW** target for residential segment by 2022, only **5%** capacity is achieved as 03/19.
- Total SRISTI scheme budget is 11,000 Crore
- End-User Subsidy
  - Upto 40% subsidy for upto 3 kW
  - 20% for 3-10 kW systems
  - 20% for upto 150 kW systems
- Demand Aggregation eligible in any state & city of India



Target Audience for Plug 'n'  
Play Concept with Battery  
Storage



## PV Port + Store...

...concept addresses RESIDENCES & DISCOM needs:

- The peak(s)?
- Power Outages?
- Consistent Solar Quality?
- Increased Awareness to go Solar?
- Aggregated Solar / Supplied through DISCOM
- Quick, easy and portable installations
- Virtual or Group Net Metering possible



Erects in 2-3 hours

Meets 2x the annual  
electricity demand of  
an Indian Home

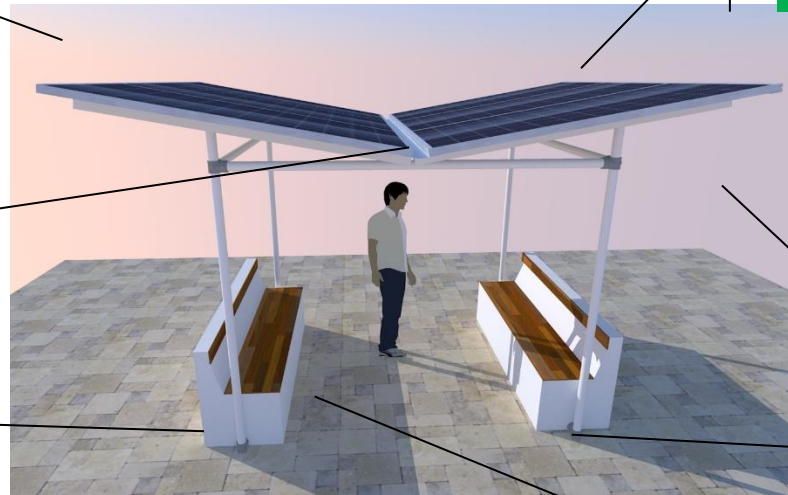
Sprinkler mechanism  
for cleaning

UV Stabilized  
Benches housing  
batteries / inverters /  
control mechanism



Plugs in regular  
power socket

Six glass-glass modules  
(300-350 Wp)



Light weight portable  
structure

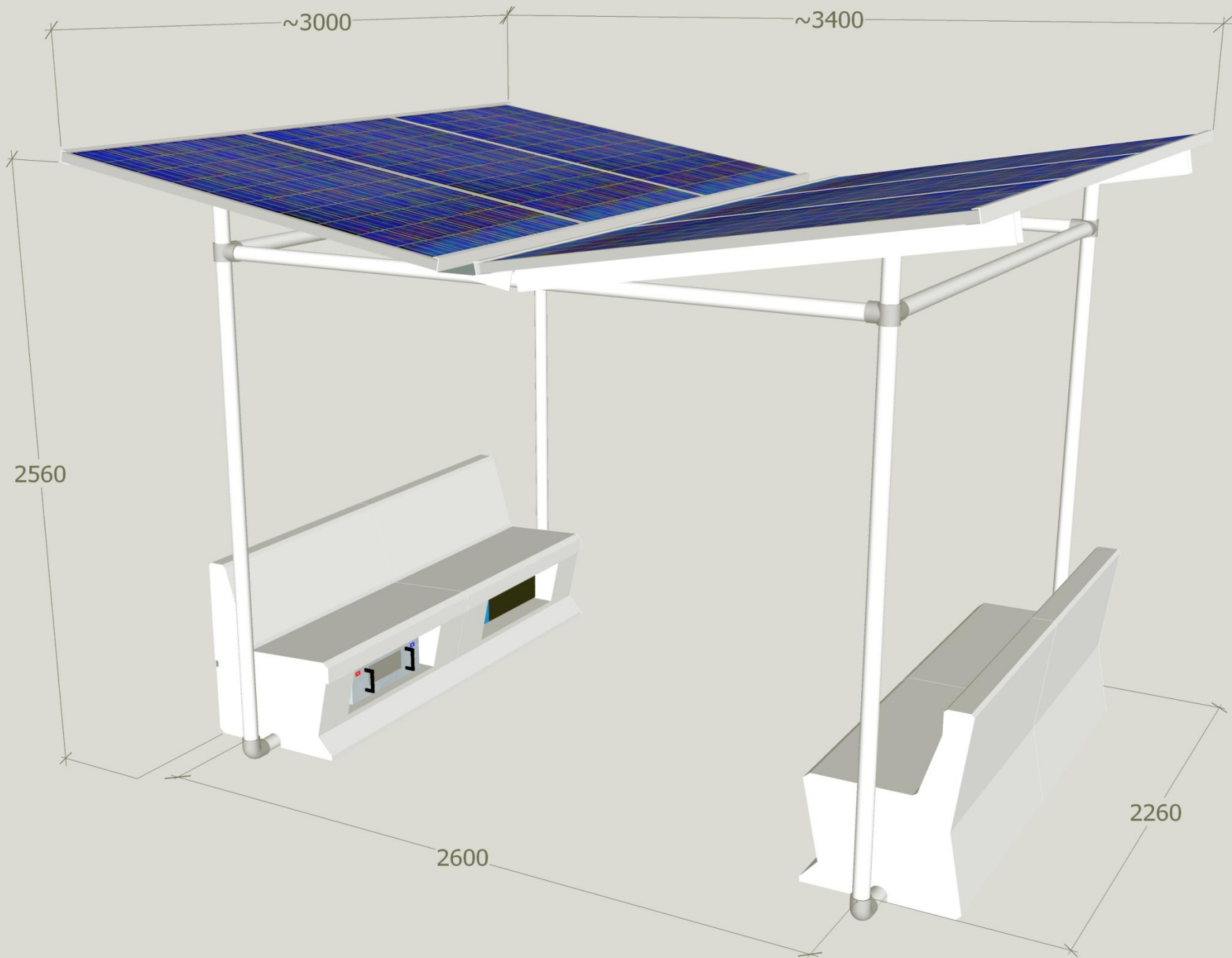
Puncture less foundation

No Grid Connection –  
only grid interactive



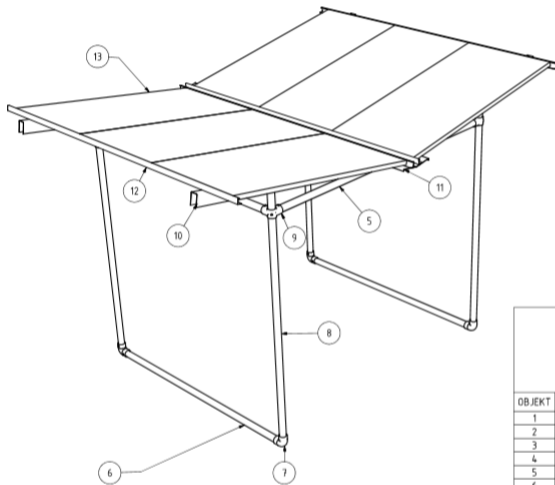
# Mechanical & Electrical concept







Structure can withstand 180km/hr wind speeds without needing any fixation to the roof



TEILELISTE

OBJEKT	ANZAHL	Länge (mm)	BAUTEILNUMMER	MASSE	Gesamtmasse	VOLUMEN	Gesamtvol
1	2	2200	Galvanized Tube 60.3 x 3.25 x 2200	10,1 kg	20,1 kg	1,3 l	2,6 l
2	2		90deg ELBOW Tubeclamps 125	1,2 kg	2,4 kg	0,2 l	0,3 l
3	2	2400	Galvanized Tube 60.3 x 3.25 x 2400	11,0 kg	21,9 kg	1,4 l	2,8 l
4	2		SIDE OUTLET TEE Tubeclamps 116	1,2 kg	2,4 kg	0,2 l	0,3 l
5	2	2550	Galvanized Tube 60 x 3.25	11,6 kg	23,3 kg	1,5 l	3,0 l
6	2	2200	Galvanized Tube 60.3 x 3.25 x 2200	10,1 kg	20,1 kg	1,3 l	2,6 l
7	2		90deg ELBOW Tubeclamps 125	1,2 kg	2,4 kg	0,2 l	0,3 l
8	2	2400	Galvanized Tube 60.3 x 3.25 x 2400	11,0 kg	21,9 kg	1,4 l	2,8 l
9	2		SIDE OUTLET TEE Tubeclamps 116	1,2 kg	2,4 kg	0,2 l	0,3 l
10	4	2000	U-crossbar 3 mm	13,0 kg	52,0 kg	1,7 l	6,6 l
11	1	3000	Rain duct 15 mm	21,4 kg	21,4 kg	2,7 l	2,7 l
12	4	3000	PV Module rail 3 mm	5,5 kg	21,9 kg	0,7 l	2,8 l
13	3	2000 x 1000 max	325 Wp PV Module	20,0 kg	60,0 kg	16,1 l	48,4 l
14	3	2000 x 1000 max	325 Wp PV Module	20,0 kg	60,0 kg	16,1 l	48,4 l
15	8		Screw M12 x 80	0,1 kg	1,5 lb	0,0 l	0,1 l
16	8		Screw M12 x 30	0,0 kg	0,6 lb	0,0 l	0,0 l

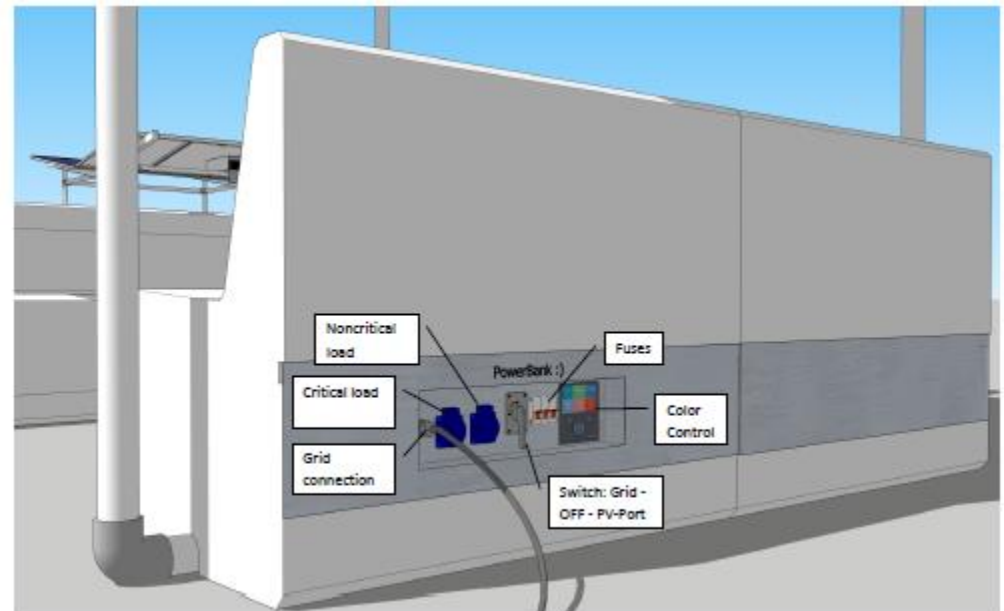
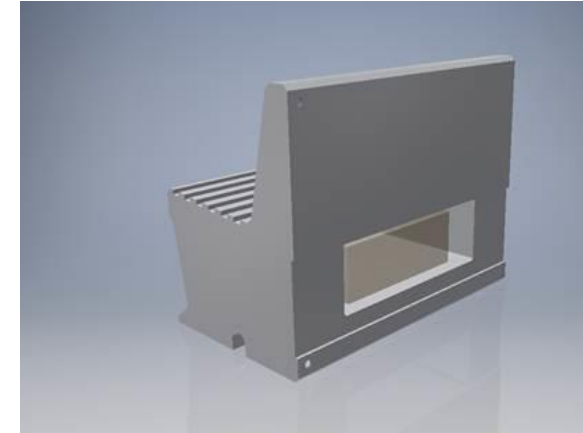
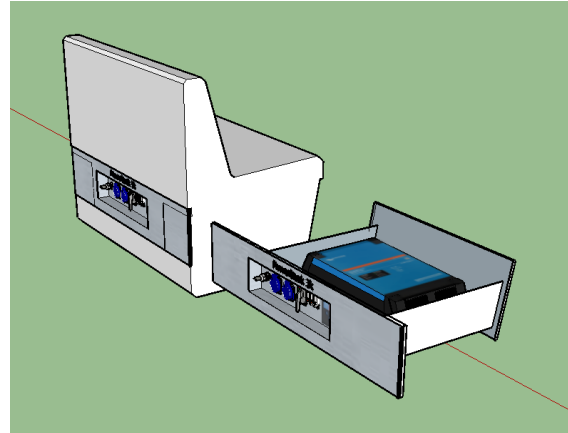


DATE	22.10.2018	BY	PP-115-R-115
ISSUED FOR		PROJECT	Simply Solar PV-Port Design
ISSUED BY		NO.	PV_Port3
ISSUED TO		REV.	1

STAAD REPORT: R1824-01  
REF NO: SOL3110/07



- Rotomoulded benches, UV stabilized plastics
- Inverter, battery and electronics is surrounded by water – which improves efficiency by keeping the temperature low
- Water filled bench act as dead weight





## Important Functionalities

**In parallel to the grid:** All loads are supplied by PV. If loads > PV, grid is used

**During power outage:** PV + batteries supply the critical load (similar to conventional UPS)

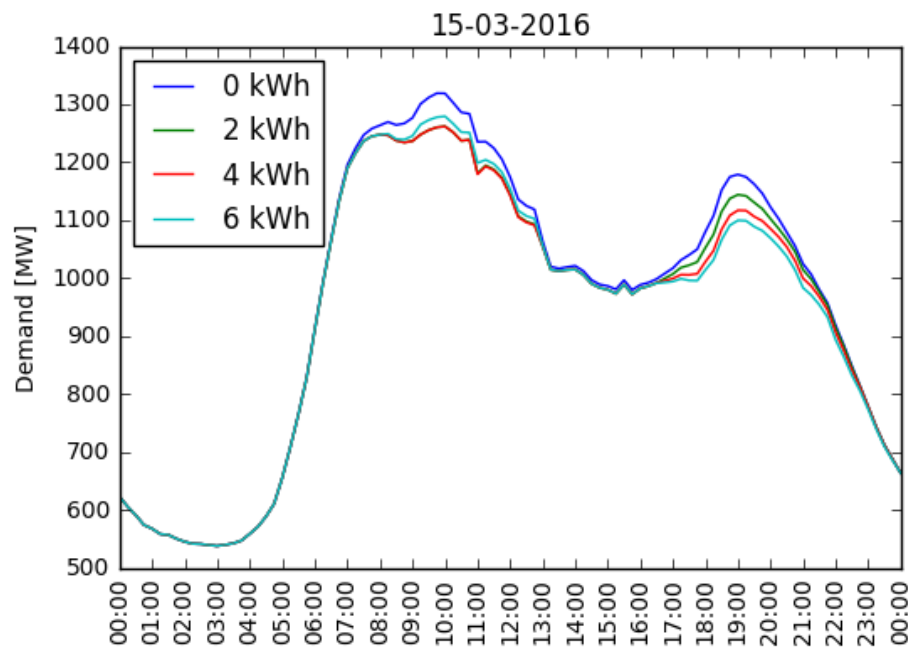
**No export to the Grid:** At all times, there is no export to the grid after the Discom meter

**Peak shaving:** The batteries can discharge during peak load / TOD benefit

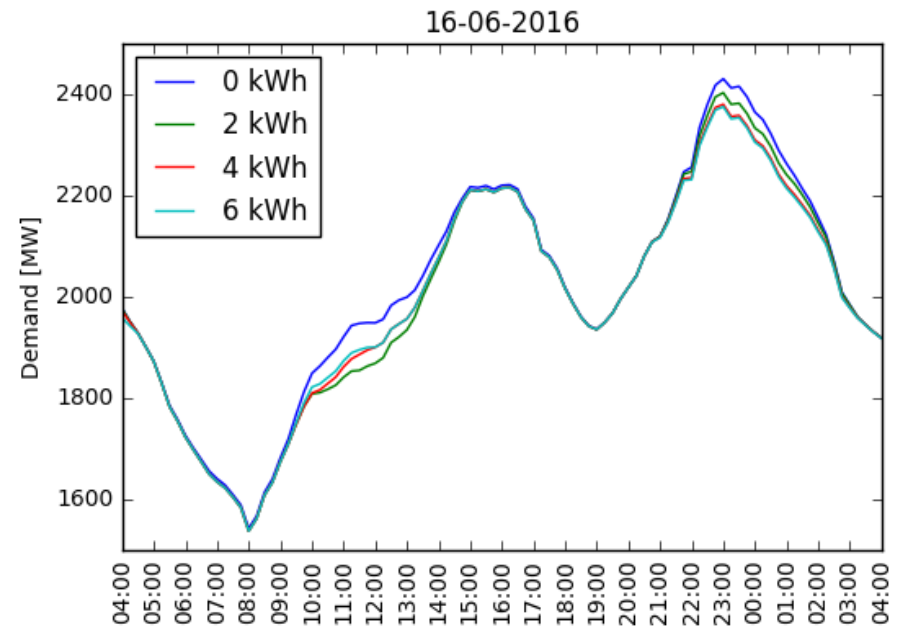


## Peak Shaving

Analysis of a discom's power demand with 50,000 PV Ports = 100 MW



0 kWh = no PV-Port



0 kWh = no PV-Port



## PROSUMER

- Buying and installing PV will become as **simple as to a consumer durable product** (e.g. Buying and installing an air conditioner)
- **Mass-scale procurement** could lead to **substantial cost reduction** (e.g. LED by EESL)
- UPS and PV system are **merged in a single product**
- **Subsidies** if any could be **integrated in advance**
- Storage will allow consumers to save more money considering **Time of Day tariff scheme** introduced by DERC
- **Quality assurance and reliability** could be ensured through embedding checks and balances in mass procurement
- **Easy financing** (e.g. Zero interest EMI financing) may be encouraged with Banks
- **Lead time** for installation may be **reduced** from several weeks/months to few days

## DISCOM

- **Reduction in peak demand**
- **Increased life** of stressed assets
- **Reliability of the network elements** shall be improved due to reduced stress on the equipment
- Promotion of rooftop in residential market will **reduce the need of cross-subsidy**
- PV ports shall **reduce** the requirement of **purchase of expensive electricity** through exchange market by using firm capacity of storage
  - In several instances Discoms purchase electricity @ more than 5 Rs/kWh
- Reduction in expensive power procurement / backing down expensive power plant will **reduce the overall power purchase cost**

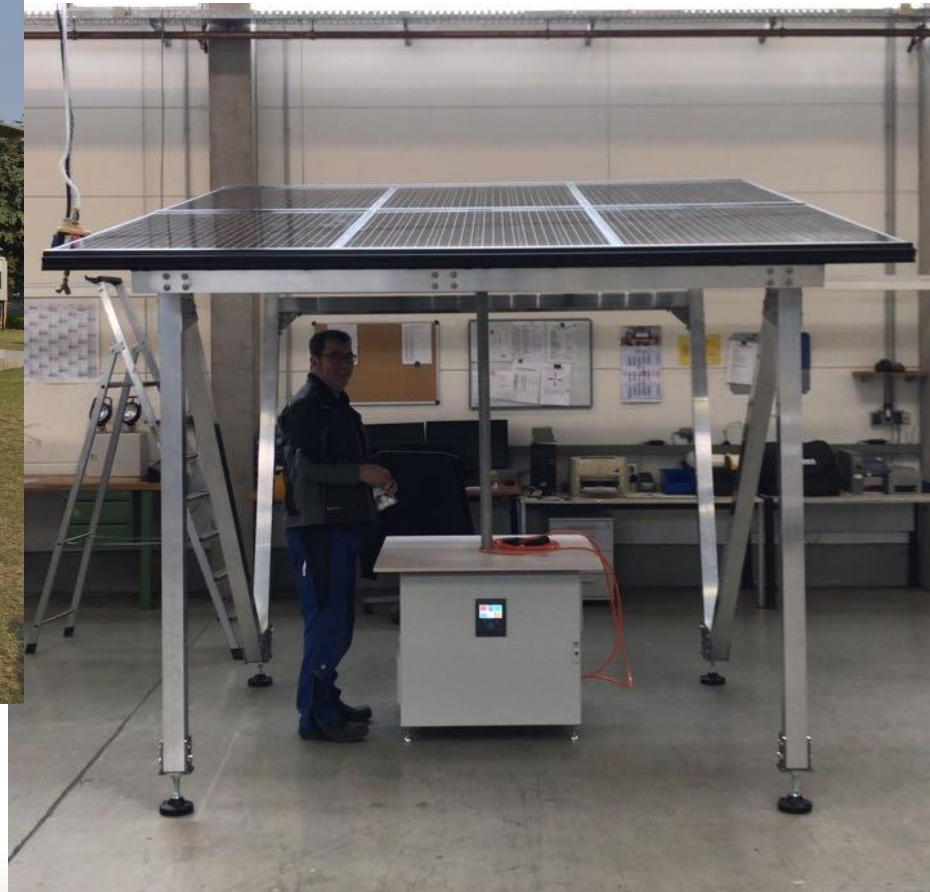


# Prototype 1.0 & 2.0 development and further activities





## Prototype – 1 (made in Germany)



**System handed over to MNRE /  
NISE / ISA**

# PV Port exhibited at RE-INVEST 2018

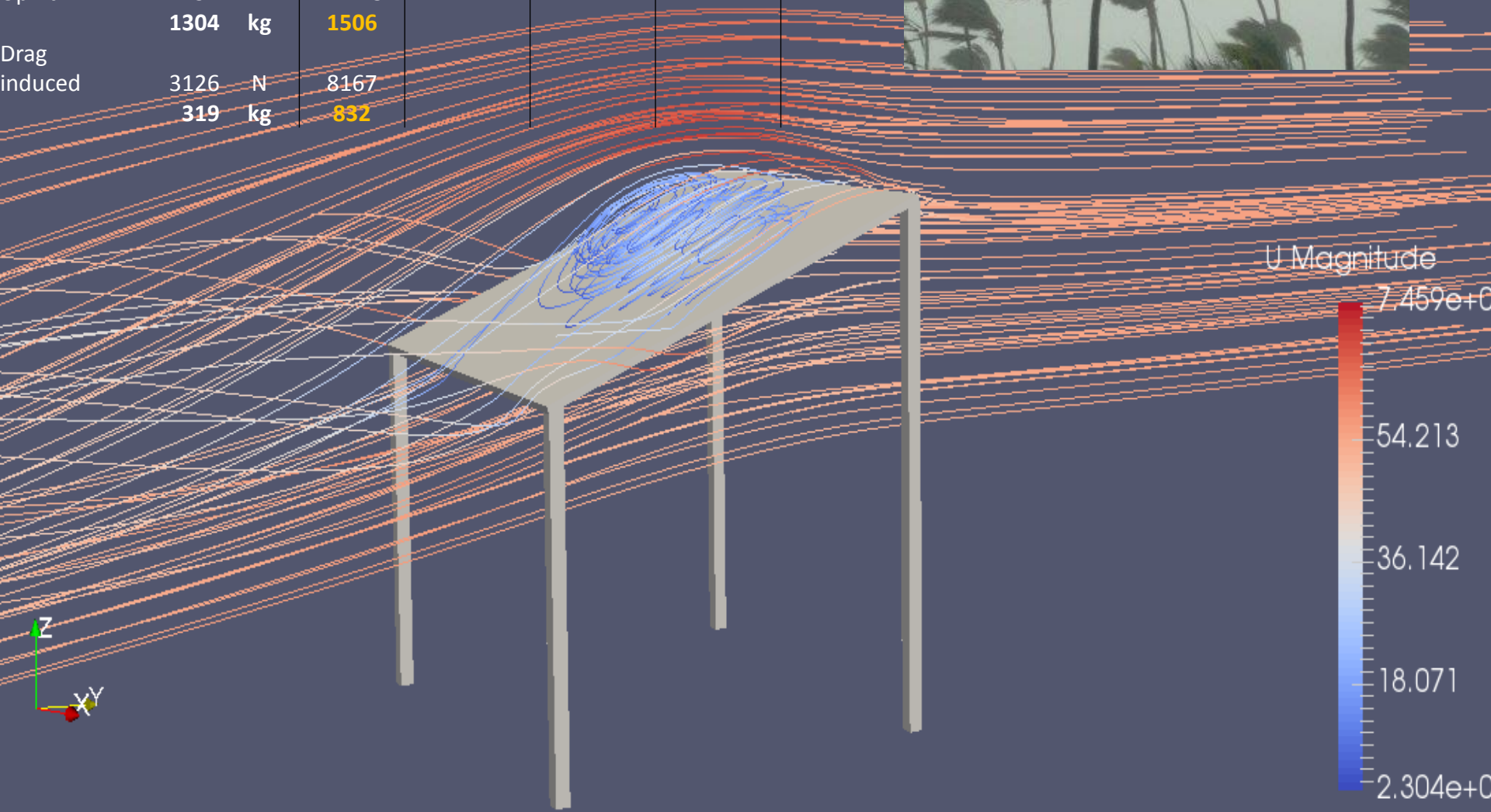




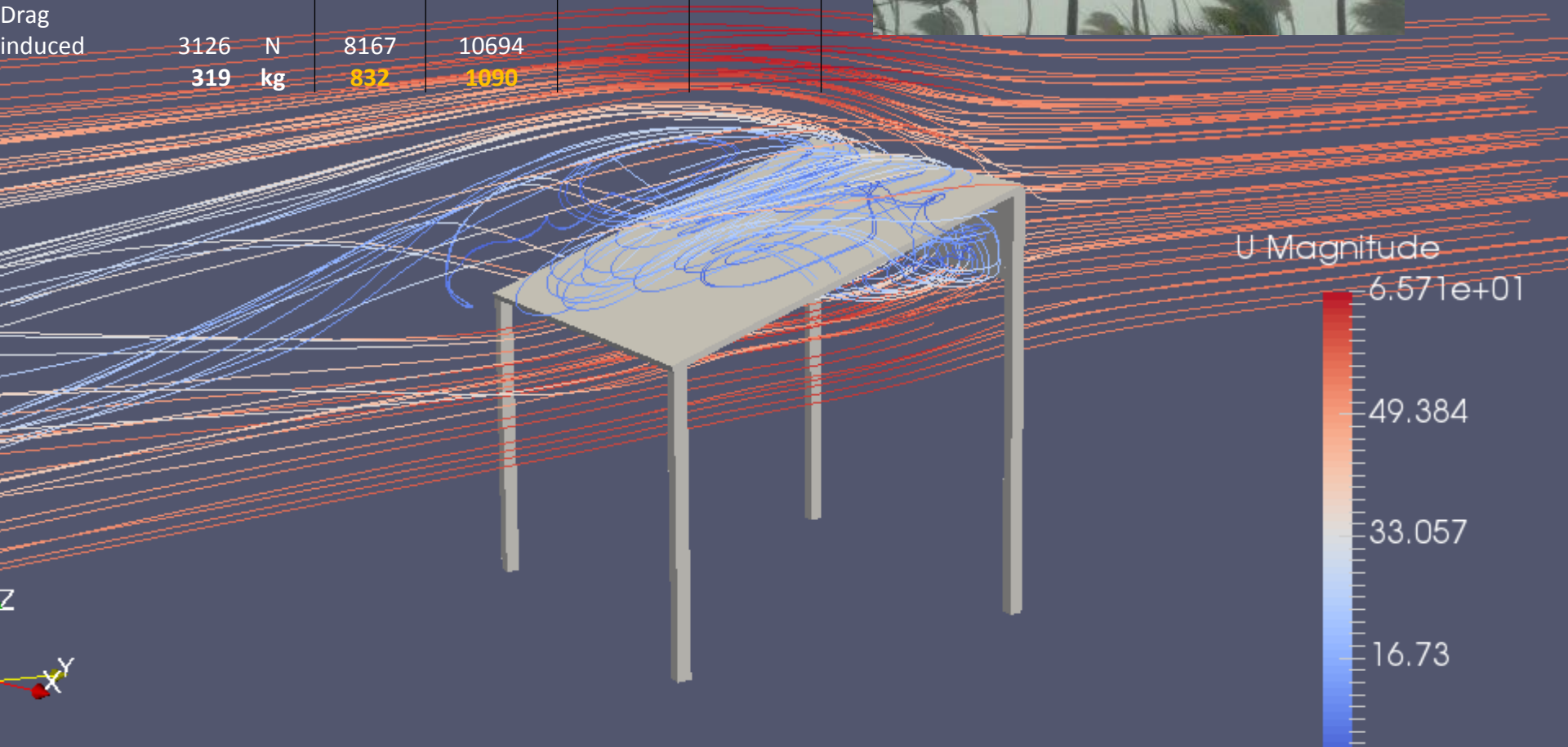
## PV Port 2.0 - Improved design (again – design Simply Solar, Germany)



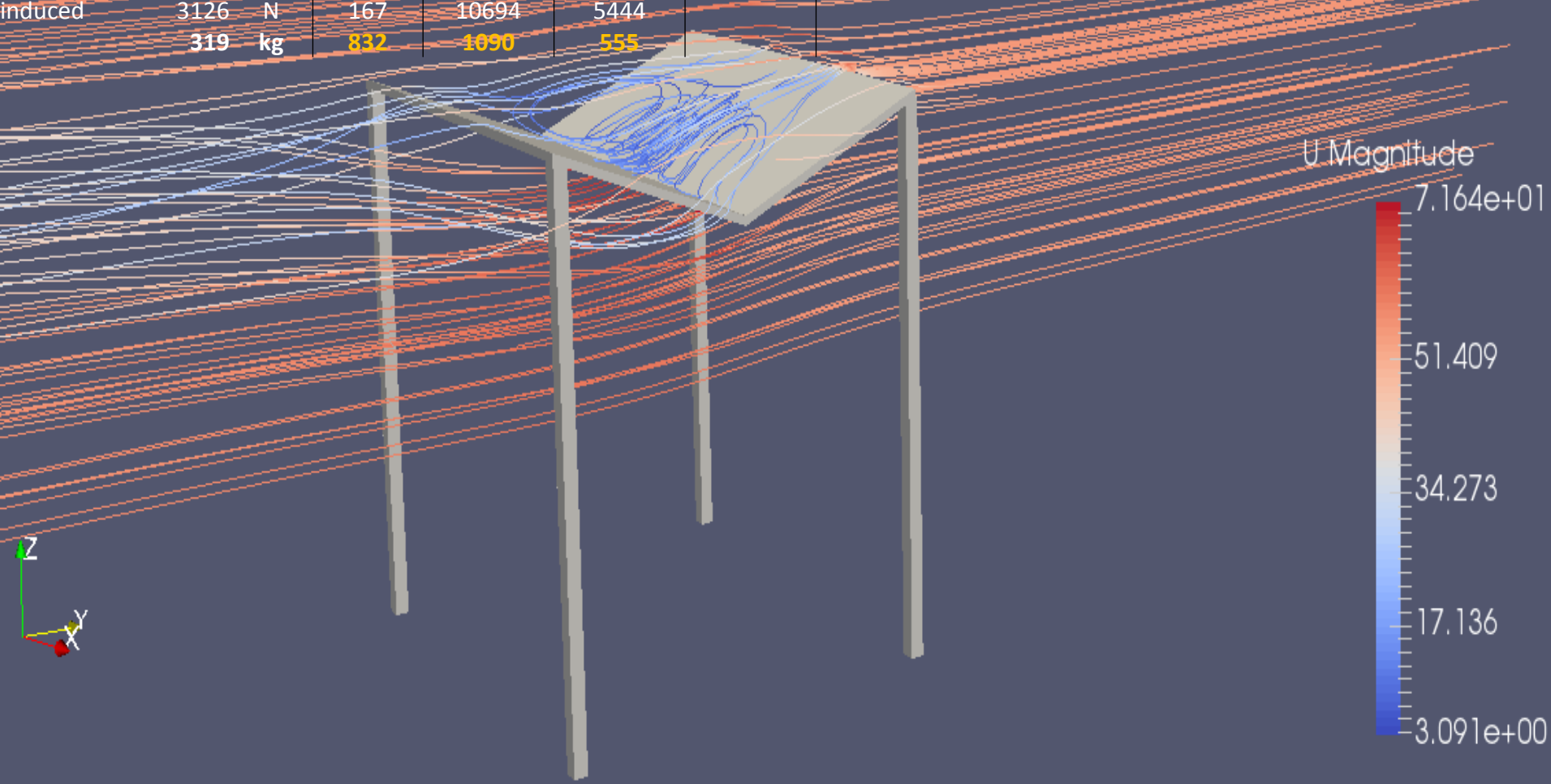
	Theory		Simple roof	
Width	3	m	3	
Length	3,5	m	3,5	
Inclination	20	deg	20	
Vwind	200	km/h		
cL	0,658	-	0,76	
cDinduced	0,161	-	0,42	
Uplift	12794	N	14778	
	<b>1304</b>	<b>kg</b>	<b>1506</b>	
Drag induced	3126	N	8167	
	<b>319</b>	<b>kg</b>	<b>832</b>	



	Theory		Simple roof	Top wall
Width	3	m	3	3
Length	3,5	m	3,5	3,5
Inclination	20	deg	20	20
Vwind	200	km/h		
cL	0,658	-	0,76	0,23
cDinduced	0,161	-	0,42	0,55
Uplift	12794	N	14778	4472
	<b>1304</b>	<b>kg</b>	<b>1506</b>	<b>456</b>
Drag induced	3126	N	8167	10694
	<b>319</b>	<b>kg</b>	<b>832</b>	<b>1090</b>



	Theory		Simple roof	Top wall	East-west
Width	3	m	3	3	3
Length	3,5	m	3,5	3,5	3,5
Inclination	20	deg	20	20	20
Vwind	200 km/h				
cL	0,658	-	0,76	0,23	-0,08
cDinduced	0,161	-	0,42	0,55	0,28
Uplift	12794	N	14778	4472	-1556
	<b>1304</b>	<b>kg</b>	<b>1506</b>	<b>456</b>	<b>-159</b>
Drag induced	3126	N	167	10694	5444
	<b>319</b>	<b>kg</b>	<b>832</b>	<b>1690</b>	<b>555</b>



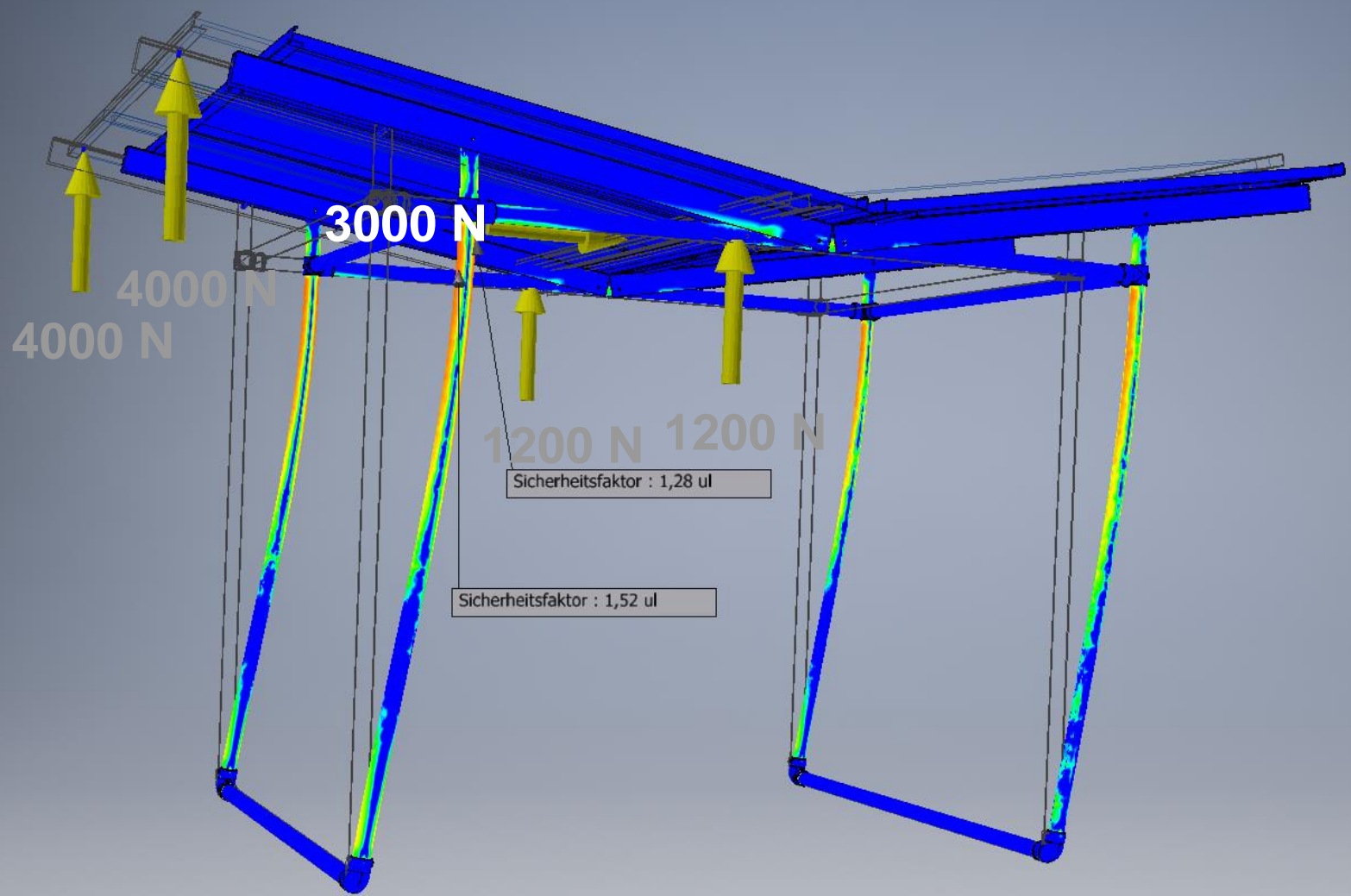


**Max. bending load 1,63 kNm**

**Max. tensile load 12,49 kNm**



Typ: Sicherheitsfaktor  
Einheit: ul  
23.12.2018, 15:29:38



**SOLCON CONSULTANTS**  
STRUCTURAL & CIVIL ENGINEERS

ISO 9001:2015 CERTIFIED | EUROGLOBAL CERTIFICATIONS (UK) LIMITED

A handwritten signature in blue ink, appearing to read 'B. Müller'.





**Water filled benches as dead load, 250 kg each**



## Concept of Electronics and Battery Integration





## Easy Accessibility of Electronics for Repair







# “Hybrid Solar rooftop system”

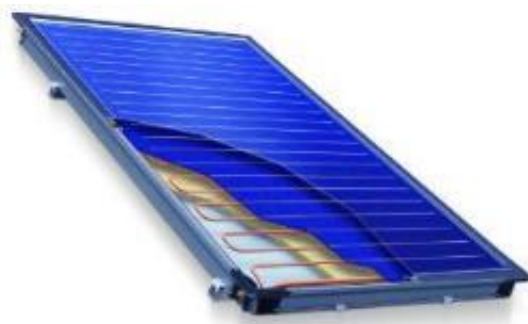
Under Photovoltaic Rooftop Project  
Indo-German Energy Programme, GIZ  
In cooperation with Ministry of New and Renewable Energy,  
Government of India



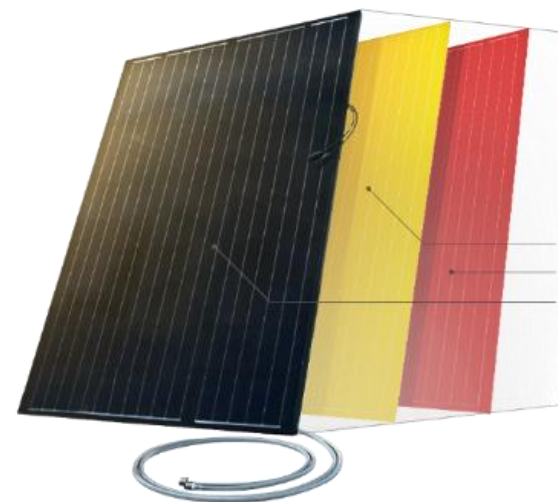
## What is a photovoltaic thermal module?



**Photovoltaic Panel  
(PV)**

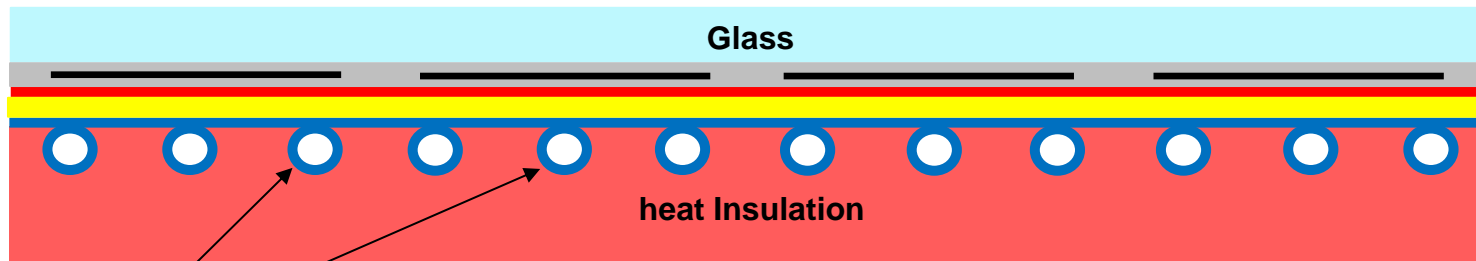


**Solar thermal heat  
exchanger**



**Photovoltaic/thermal  
(PVT)**

**Power  
Heat  
1 Module**



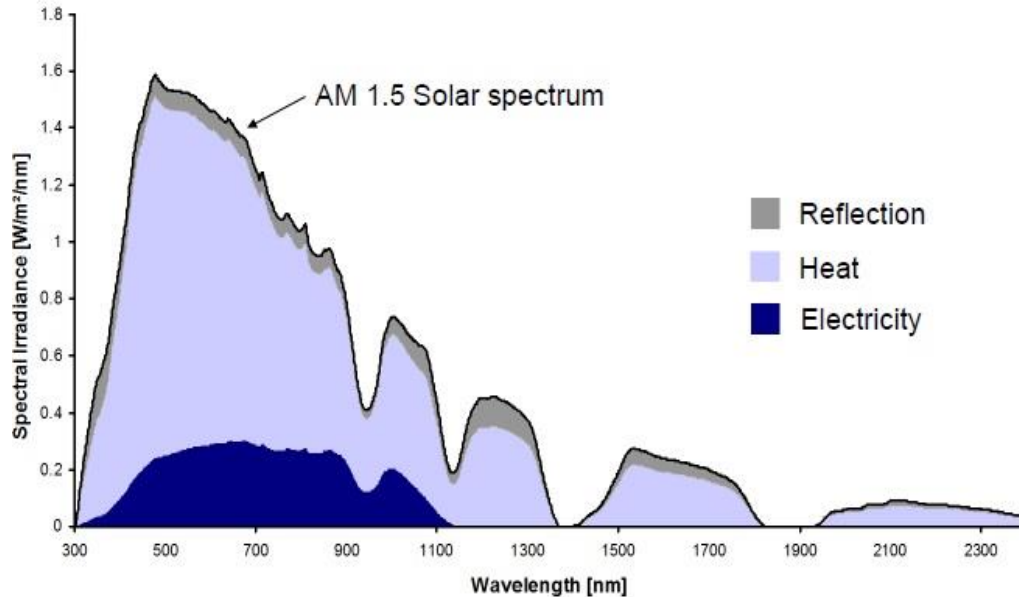
**Liquid-cooled uncovered PVT flat-plate collectors**

**fluid channels**

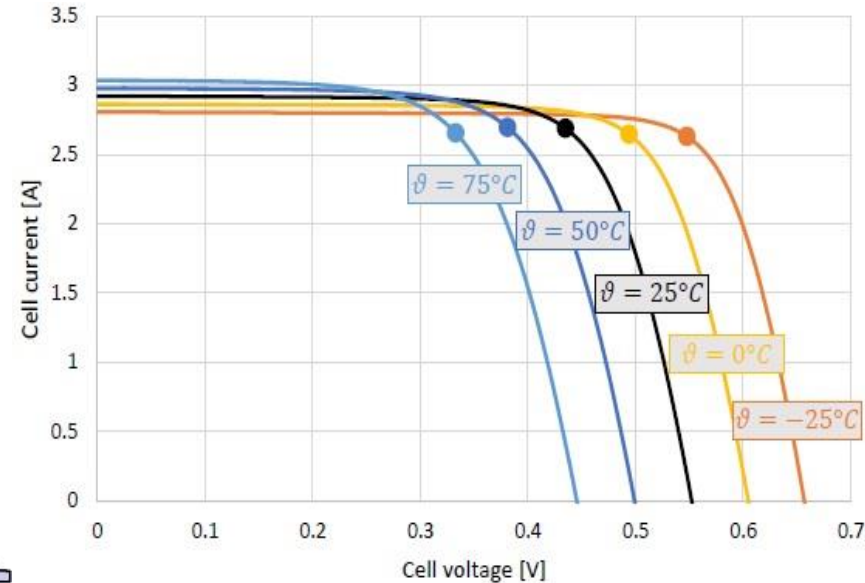




## Motivation for PVT Solar Collectors



Spectral properties of a crystalline silicon photovoltaic cell. Source: P. Dupeyrat [1].



**Characteristic curves of a crystalline silicon solar cell at different cell temperatures and constant irradiation of 1 000 W/m<sup>2</sup>**

Motivation

Heat generated in PV Cells is made useful  
 Extraction of heat increases the electrical efficiency of PV cells

Benefit

Production of solar electricity and heat from the same surface  
 High surface-specific efficiency



## Why PVT and its solution hypothesis

Mean operating temperature of PV panel in India is ~ 45 °C

### Approach

- Assess techno-economic performance of PVT technology in India through demonstration projects
- Establish joint venture; technology license for local manufacturing

#### Nation

- Ⓢ Reduction in conventional hot water Generation
- Reduce requirements of land for addition of capacities
- Tap solar potential, cleaner sources and as alternate technology option

#### Consumer

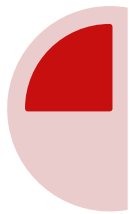
- Ⓢ Reduce dependency on electric/gas/wood,
- Long term reliable energy source with two-fold benefits
- The ease of connectivity with the consumer premises

#### Make in India

- Ⓢ Self-replication potential is promising for rooftop projects
- Commercialisation of PV/T manufacturing in India
- Manage electrical & thermal demand (low & Medium heat application)



## Based on the study results- setting up demonstration projects is envisaged with broad tasks



### Phase I

**Task 1:** Preliminary assessment of the potential of PVT technologies in India – a comparative analysis through simulating collector performance by Fraunhofer ISE **(Completed)**

**Task 2:** Establish demonstration project(s) **(Completed)**

**Task 3:** Performance monitoring for one year



### Phase II

**Task 4:** Identify promising sectors/applications **(Completed)**

**Task 5:** Support preparation of policy/scheme for promoting PVT

**Task 6:** In case an international technology is found to be promising, licensing of technology shall be evaluated for supporting “**Make in India**”

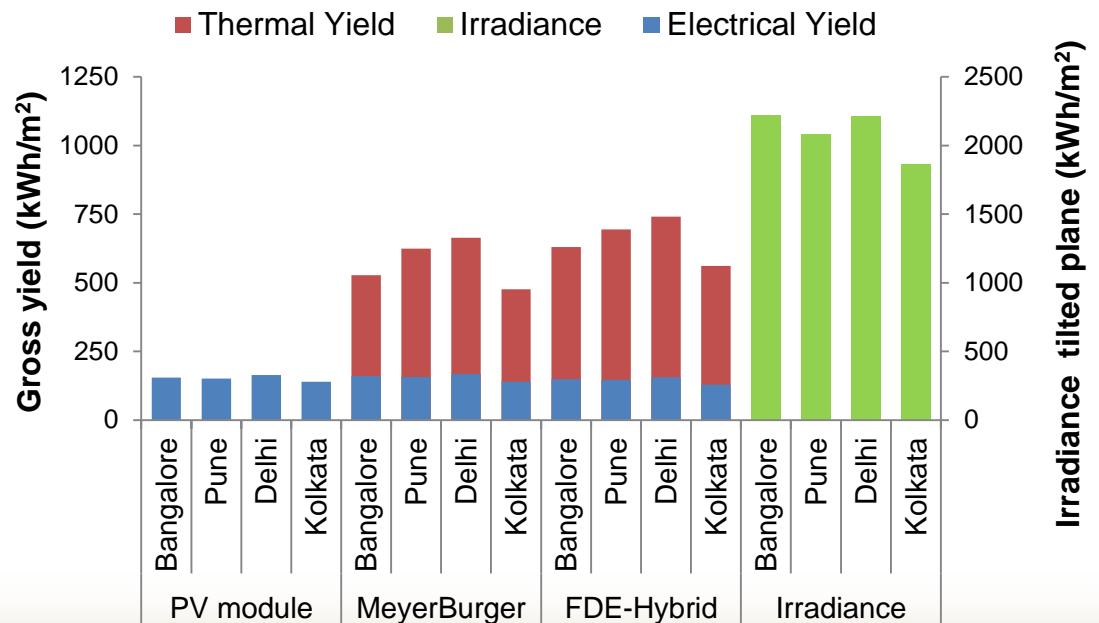


## Simulation results proves PV/T technology promising for India – Fraunhofer ISE study

- Assessment of gross energy yields of unglazed PVT collectors in Indian climate – 4 regional cities
- Key findings
  - High yields in all regions across country
  - Low temp suitable for unglazed technology

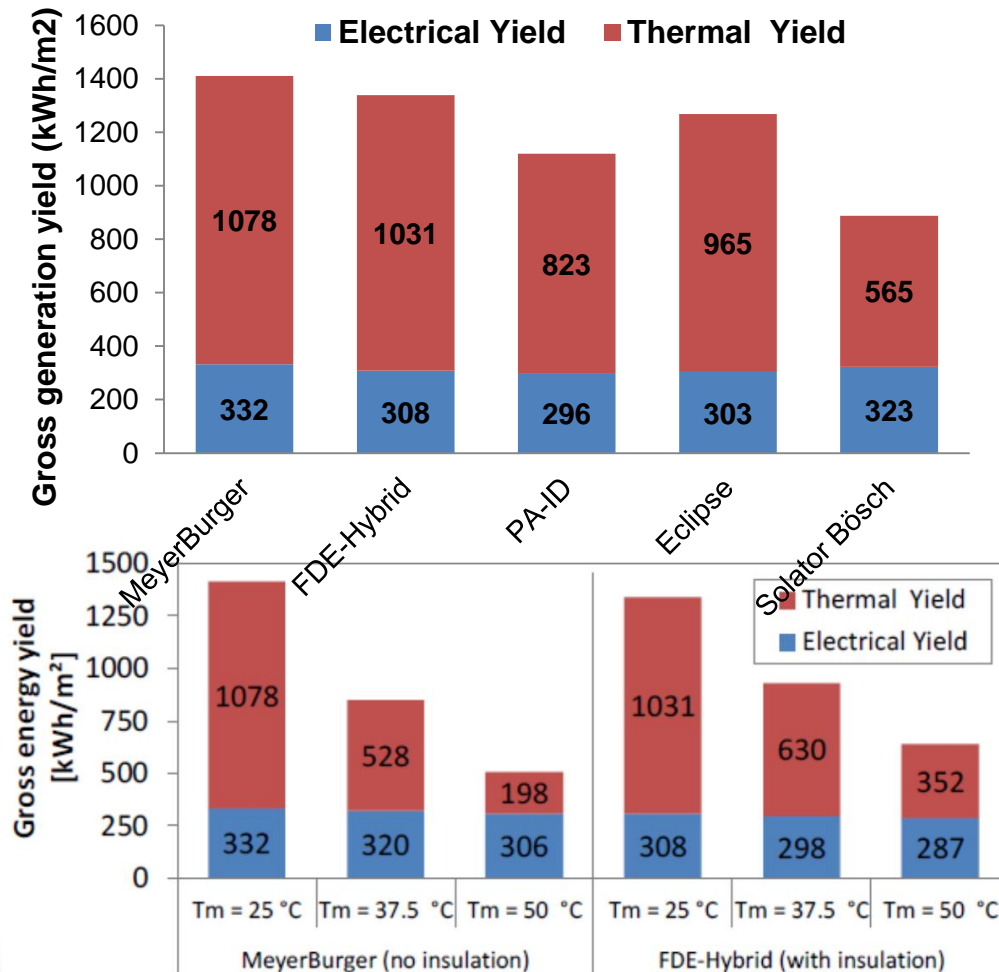
### High yields at all locations

**Electrical+78%,  
thermal+450% compared to  
Germany**





## Roughly 3X thermal energy generation (1/2)



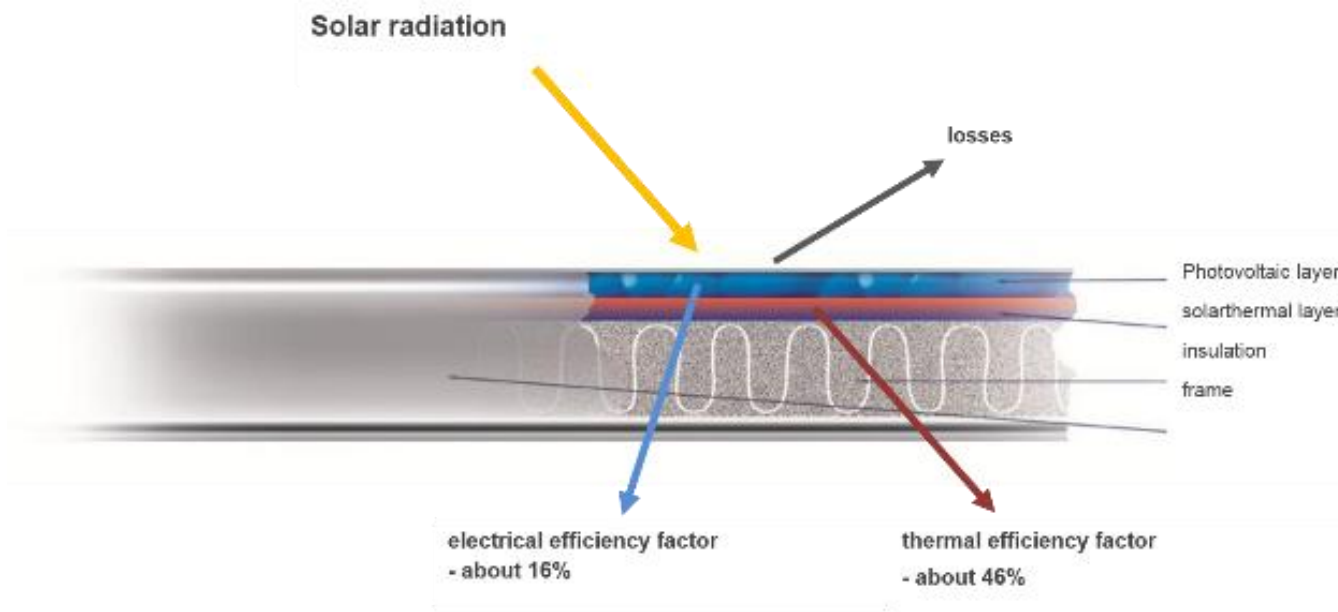
- Differences between PVT collectors mainly due to
  - ✓ Thermal insulation at backside
  - ✓ Thermal coupling between cell and fluid ( $C_{\text{bond}}$ )

Mean fluid temperature  $T_m$  has a significant impact on yields

Lower fluid temp → higher elec. & thermal yields



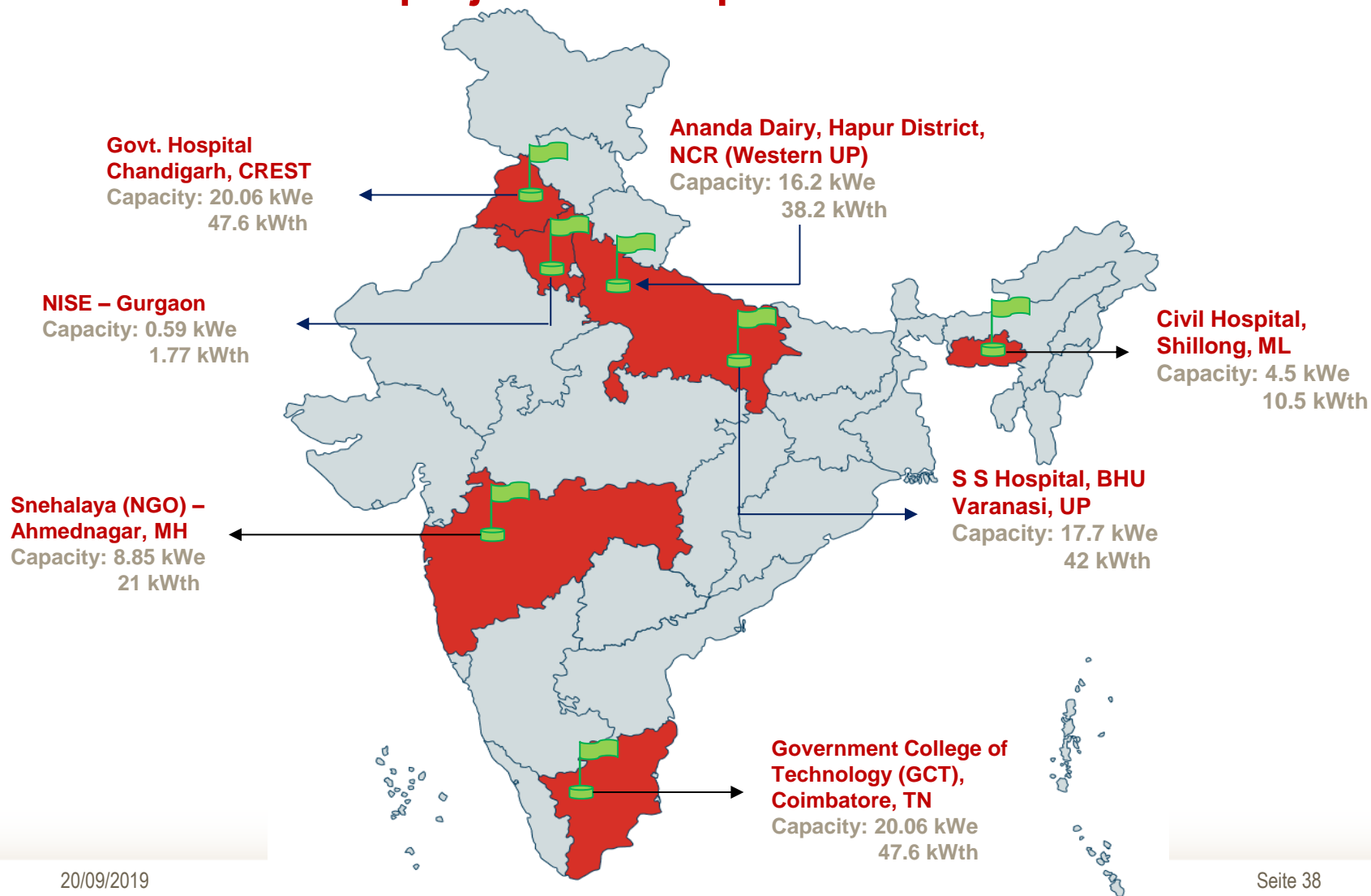
## Selected technology for demonstration- unglazed PVT from PA-ID Germany



**One 2 Power Module – 295 Wp electrical and 719Wth thermal  
energy (50 litres of hot water per day per collector )**



## PV/T demonstration project landscape





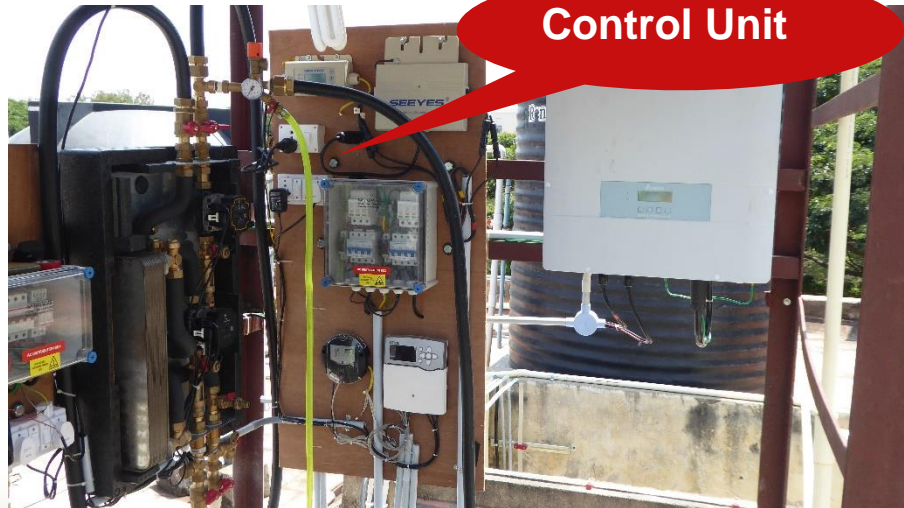
## Actual system photographs – Coimbatore



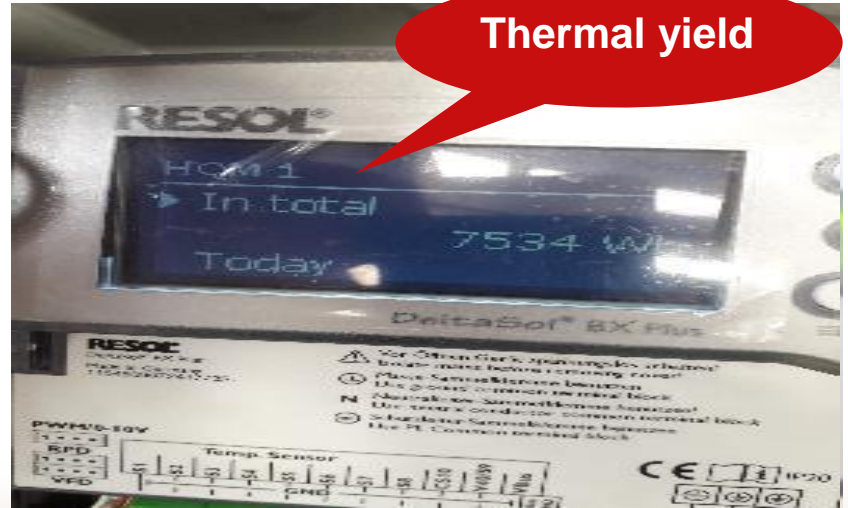
Solar Field



Storage tank



Control Unit

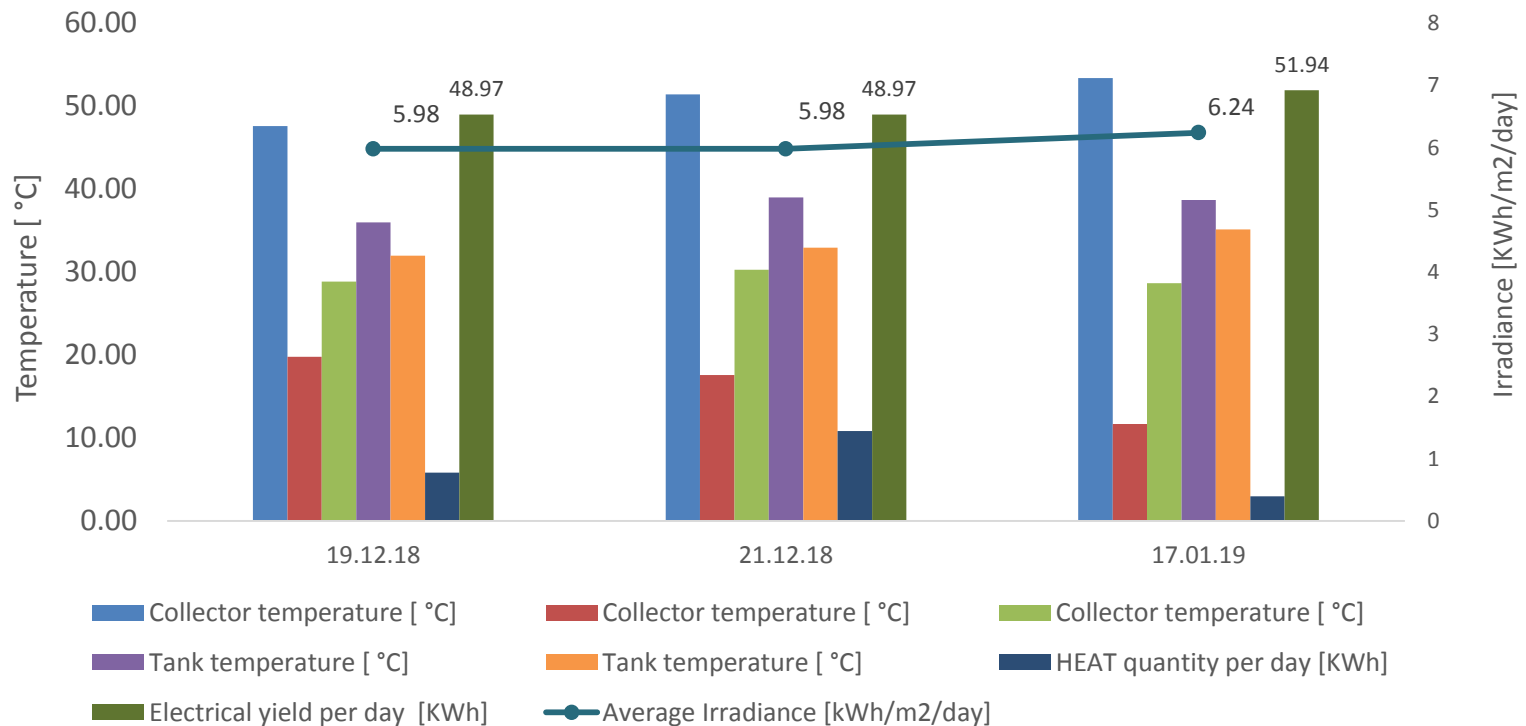


Thermal yield



## Analysis of PVT with PV at Coimbatore – practical data

Coimbatore Girls Hostel (Temperatures for different days)



<https://www.vbus.net/#visualization/diagram/show/16437>



# Rooftop Photovoltaic project under Indo German Energy Programme

**Responsible**  
Joerg Gaebler

**Project Manager**  
Abhinav Jain

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Deutsche Gesellschaft für  
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