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الـدولي السادس للـبـيـئـة
Ajman 6th International
Environment Conference

Emerging and Innovative Energy Technologies to Support and Foster Energy Transition

Chaouki Ghenai, PhD

Sustainable and Renewable Energy Engineering Department, College of Engineering

Coordinator - Renewable Energy and Energy Efficiency Research Group
Sustainable Energy and Power System Research Center, RISE

Leader – Energy and Climate Change: Sustainability Office

University of Sharjah, Sharjah, United Arab Emirates

TOWARDS >>> 2071 SHAPING THE FUTURE FOR ENVIORMENTAL SUSTAINABILITY

March 28-29, 2022

Outline

Energy Transition

1. Decarbonization
2. Digitalization
3. Decentralization

Emerging and Innovative Energy Technologies to Support Energy Transition

1. Bifacial Solar PV Integrated with Cool Roof Technology
2. Solar PV Electric Vehicle Charging Station
3. Artificial Intelligence for Energy and Power Systems Forecasting (Supply and Demand)
4. Power-to-X Technology (Electro Fuels or E-Fuels)
5. Supercritical CO_2 Power Plants

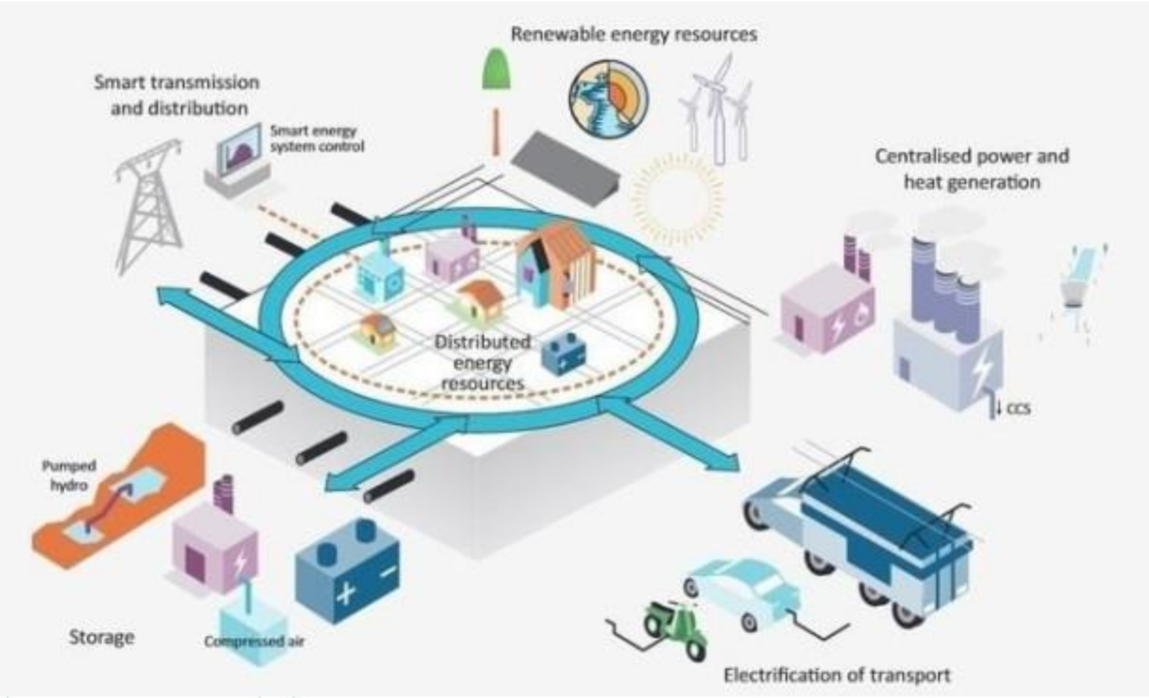
Energy Transition

Pathway Toward Transformation of the Global Energy Sector

Transition from centralized and fossil fuel-based energy system (coal, oil, natural gas) to Future Decentralized Energy Systems (Cleaner, Sustainable, Intelligent, Efficient, Affordable, and Reliable) using renewables (solar, wind, biomass, geothermal, hydro, ocean, tide, wave), energy efficiency, energy management and Conservation,and advanced energy storage.

Decarbonization

Decentralization



Digitalization

De-regularization

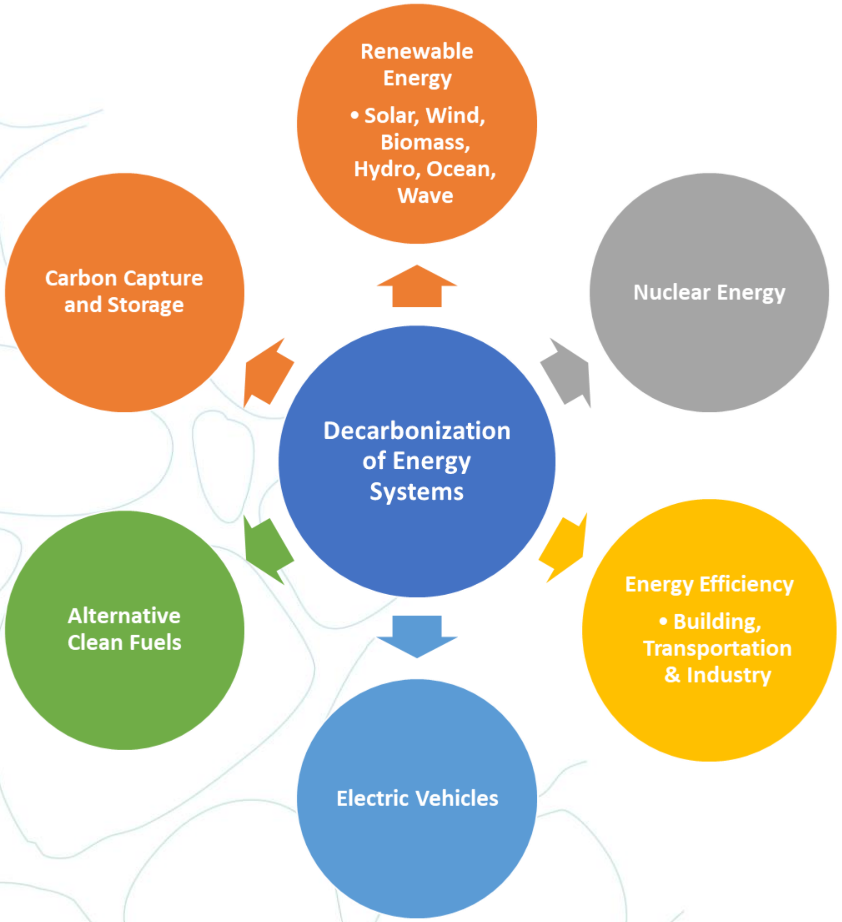
Energy Transition – Transform Energy Systems Changes to Foster Energy Transition

- Adoption of **large-scale affordable PV-systems**
- Development of **large-scale wind farms**
- **Electrification of Transport** - heavy-duty transport – trucking, shipping and aviation
- Development & Modification of Grid Network
  - Grid modifications - facilitate decentralization of the energy systems (**Micro Grid Power Systems**)
  - Transformation of distribution networks to smart grids - intelligent matching of local demand and supply
  - Expand transmission networks - connect large-scale wind farms and solar plants
- Development of large-scale **energy storage**
- Development of **green alternative fuels** (low and zero carbon fuels)
- Development of more efficient energy systems (**Energy Efficiency**) and **Carbon Capture Utilization and Storage** (CCUS)

Energy Transition
Innovation – Accelerate Energy Transition

- **Technological Innovation**: Development of new or improved product to reduce carbon emissions in the energy sector.
- **Foster Innovation** - put the proper **policy incentives** in place, based on a long-term perspective.
- **Power-system integration**: Development of large-scale power systems and reduce cost of renewable power.
- **Integrate Variable Renewable Energy** (VRE) sources (solar, wind, biomass into existing power grids).
- Innovation for the **Electrification** of transport, buildings and other end users.
- **Innovation in R& D**
- **Innovative policy frameworks**, **new business models**, suitable **financing mechanisms** and a range of **social measures** to promote Renewable Energy and Energy Efficiency.

3 Ds Energy Model – Decarbonization



- Key Factor for the Energy Transition
- Decarbonization - critical
- Energy sector - move away from fossil fuels toward renewable energy sources
- Challenges – address this transition in transformative ways.
- Emerging and Innovative Energy Technologies

3 DS Energy Model -Digitalization

Digitization: key factor for power generation (more efficient, grid more secure and resilient), building (reduce energy consumption), aviation industry (more sustainable), and industrial application (reduce waste).

Buildings

Transport

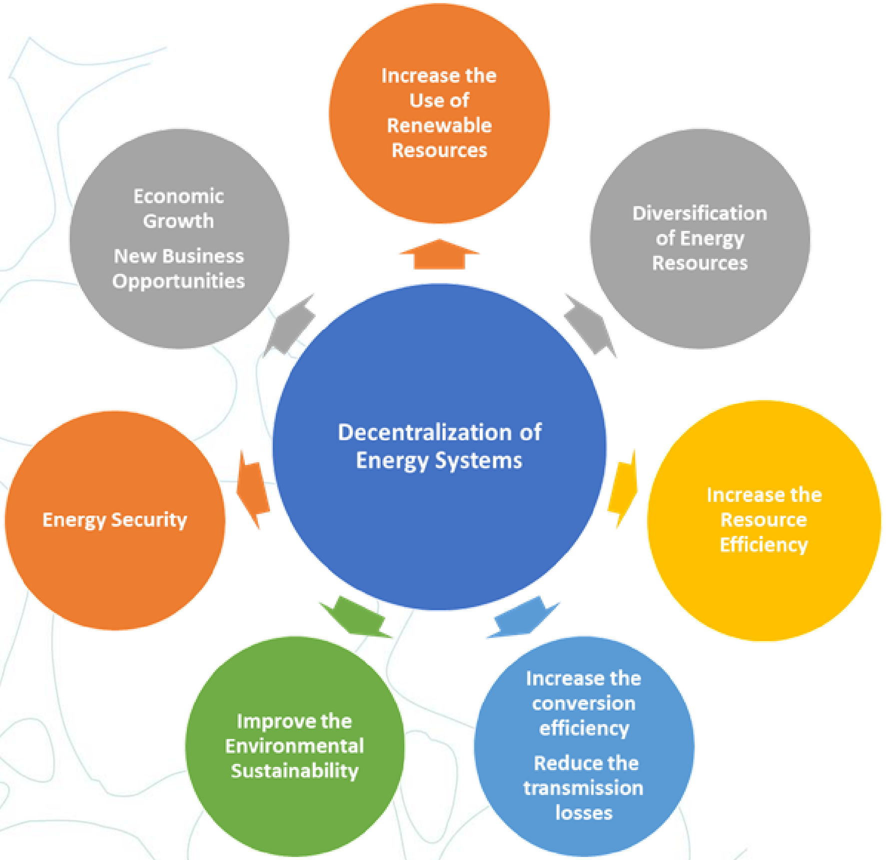
Industry

Oil & gas

Coal

Power

3 Ds Energy Model: Decentralization



Increased conversion efficiency (capture and use of heat generated, reduced transmission losses)

Increased use of renewable, carbon-neutral and low-carbon sources of fuel

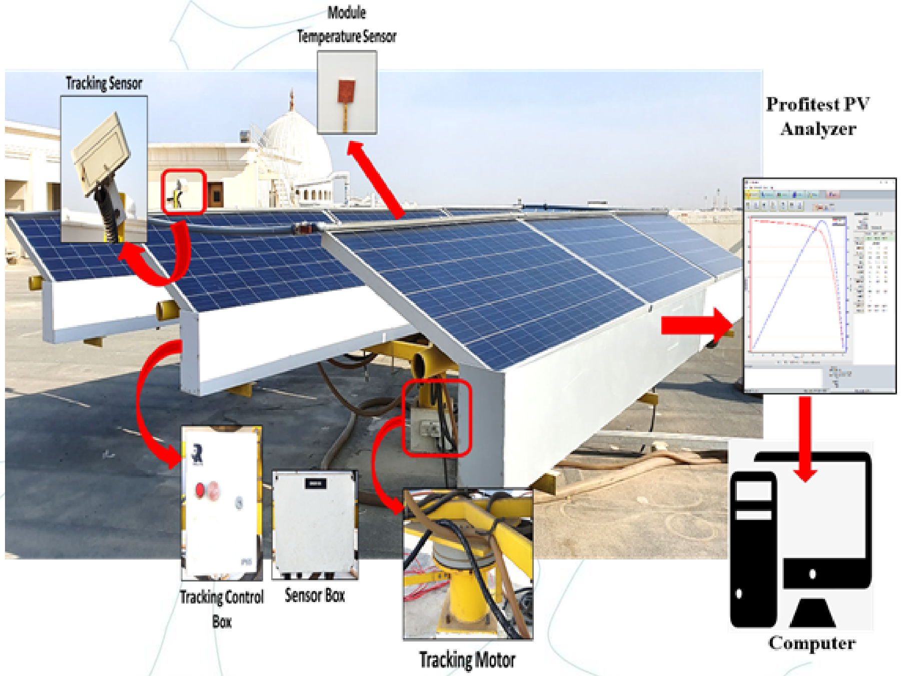
More flexibility for generation to match local demand patterns for electricity and heat

Greater energy security for businesses that control their own generation

Greater awareness of energy issues through community-based energy systems, driving a change in social attitudes and more efficient use of our energy resources

Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

Challenges: Dust, Temperature, Solar position



3KW PV/T system installed on the roof of W-12
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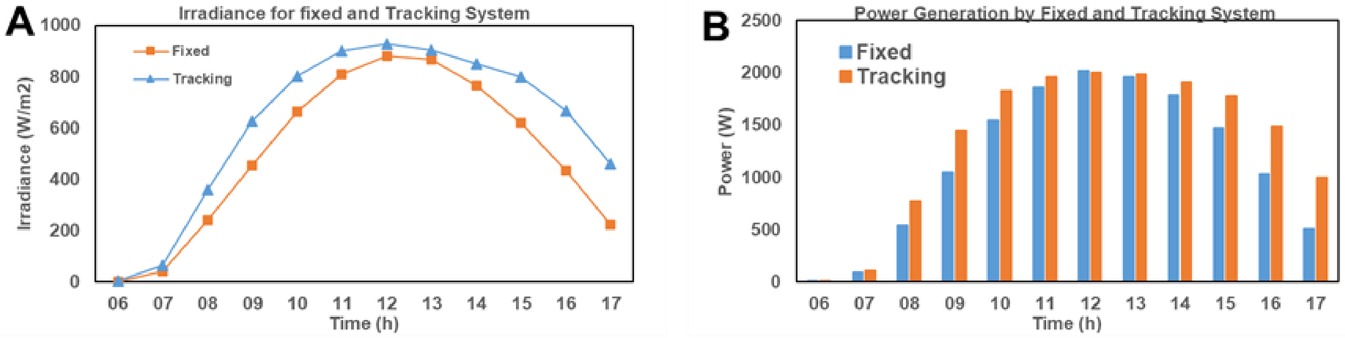
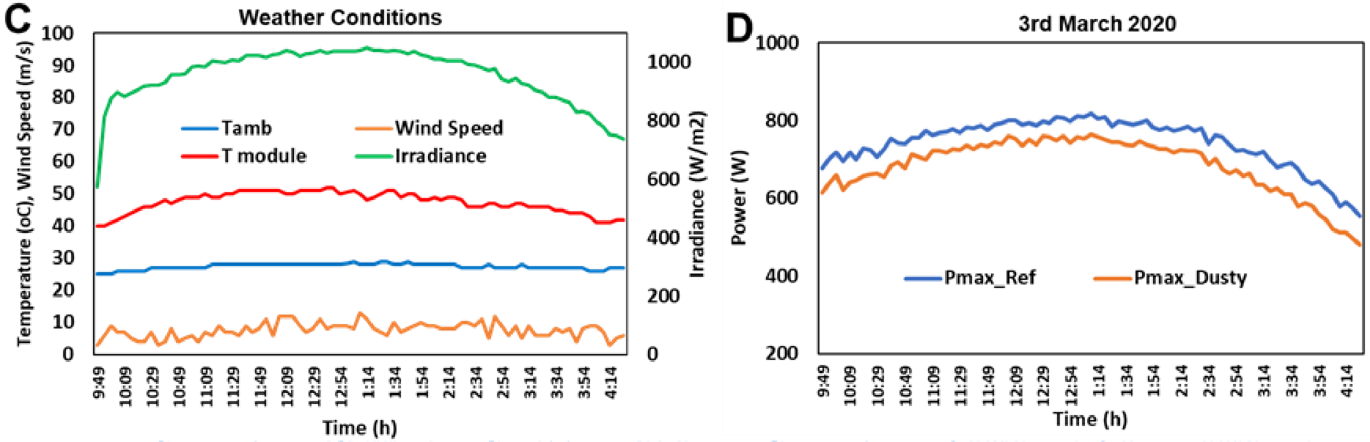


Comparison: (A) Irradiance on the Plane of Solar PV Panel, (B) Power Generation



Comparison: (C) Weather Conditions, (D) Power Generation: ref. PV Panel & Dusty PV Panel

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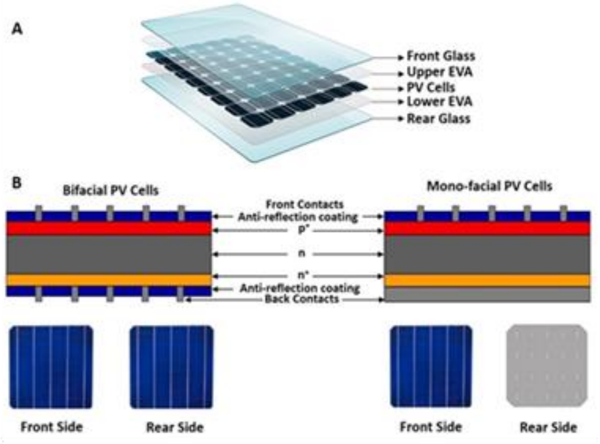
Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

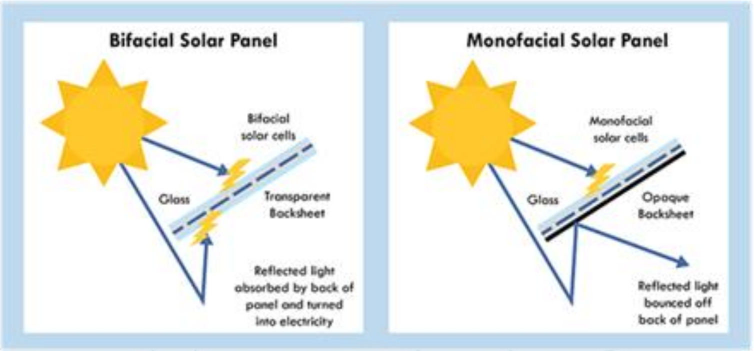


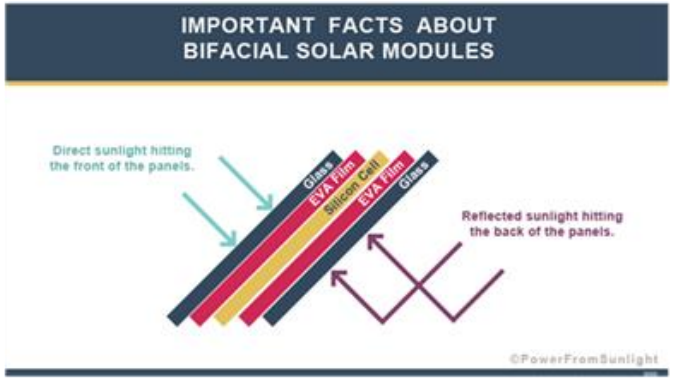
Cool Roof Technology: Cool Coatings Materials

- High reflectance of daytime solar energy - reflect solar radiation in **the visible, infrared and ultraviolet spectra.**
- **Reduce the transmission of heat** inside the coated building (Cool Roof) or structure (Coll Pavement).

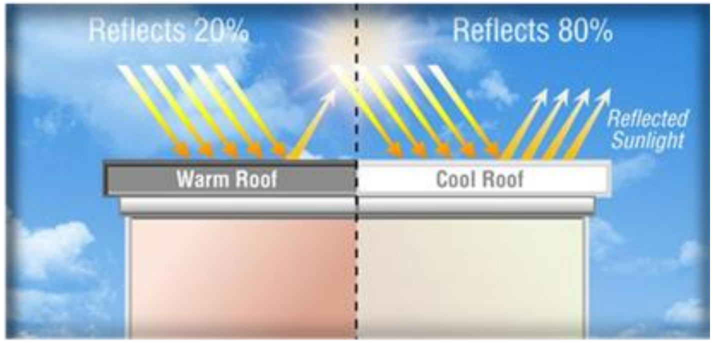
Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

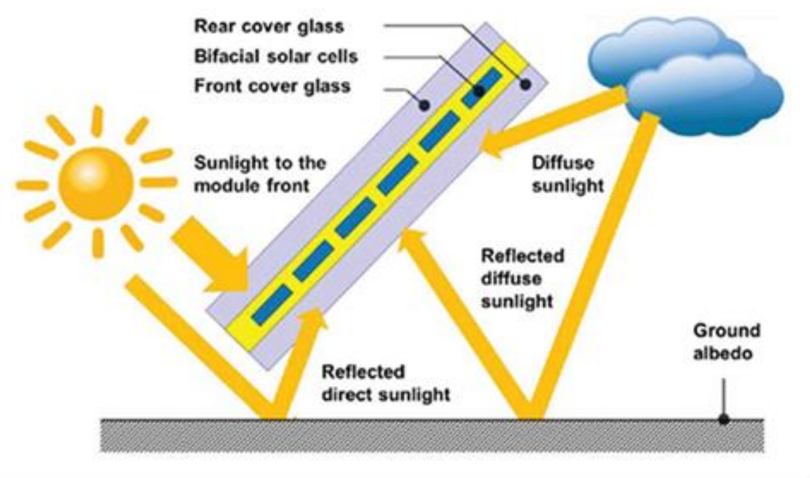
Bi-Facial Solar PV





Cool Roof Technology





The many advantages of Bifacial solar panels

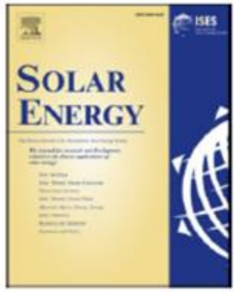
- Capture sunlight from both sides
- Generate up to 30% more solar power
- Better aesthetics with transparent sheets or glass
- More efficient cell structure than traditional panels
- Increased durability and longevity
- Reduced Balance of System (BOS) costs
- Installation in any direction – vertically or horizontally

Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

Sensitivity analysis of design parameters and power gain correlations of bi-facial solar PV system using response surface methodology

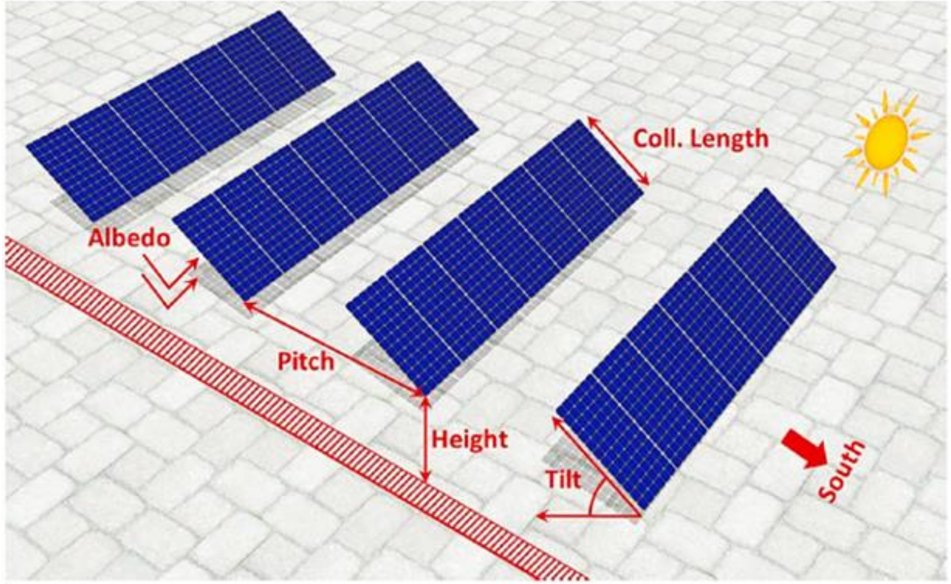
Chaouki Ghenai [a,b,*], Fahad Faraz Ahmad [b], Oussama Rejeb [b], Abdul Kadir Hamid [c]

[a] *Sustainable and Renewable Energy Engineering Department, College of Engineering, University of Sharjah, Sharjah, United Arab Emirates*
[b] *Sustainable Energy and Power System Research Centre, Research Institute for Science and Engineering, University of Sharjah, Sharjah, United Arab Emirates*
[c] *Electrical Engineering Department, College of Engineering, University of Sharjah, Sharjah, United Arab Emirates*



Specifications of bifacial solar panel.

Description	Value	Unit
Solar system capacity	10.5	*kW*
Solar panel: SEAB72T-375	375	*W*
Quantity	28	*unit*
Array orientation	4 × 7	*row × column*
Type	Bifacial	
No. of cells	72	*unit*
Dimension	1972 × 992	*mm*
V_{oc}	48.16	*V*
I_{sc}	9.94	*A*
V_{mpp}	39.60	*V*
I_{mpp}	9.47	*A*
Temp for Pmpp	−0.397	%/°C
Temp for Isc	0.028	%/°C
Temp for Voc	−0.281	%/°C
Efficiency	19.18	%
Bifaciality Factor	70	%
Dimension	1972 × 992	*mm*

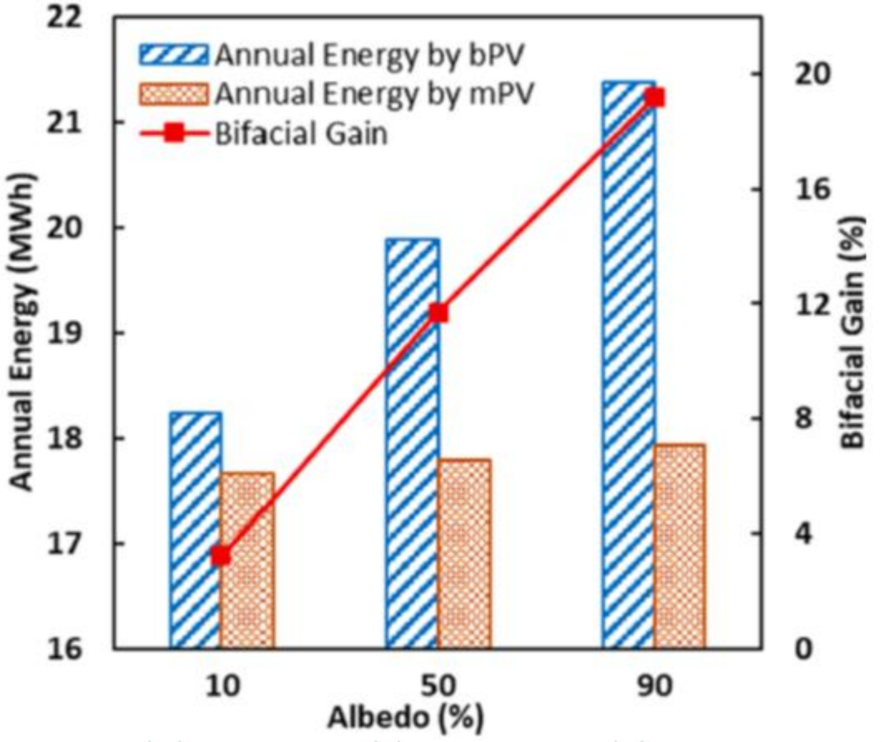


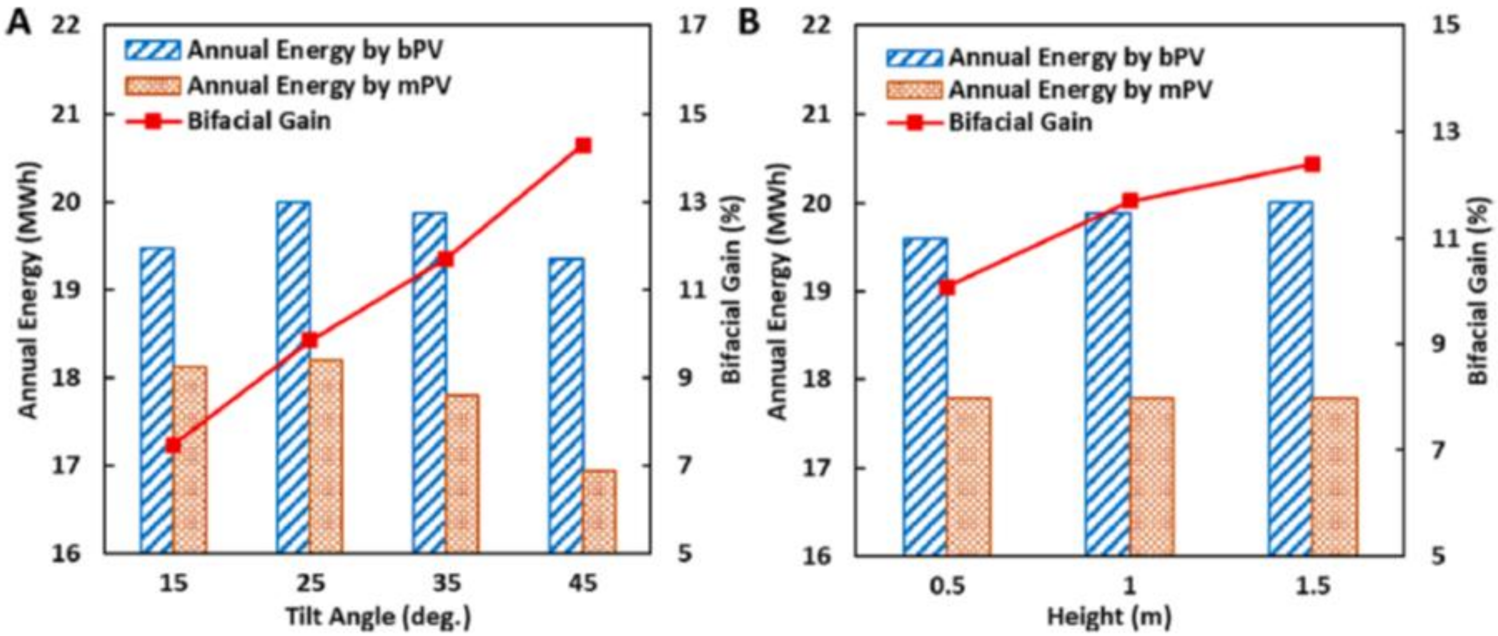
Row spacing: (1.07, 1.79, and 2.36 m) based on the tilt angle (15°, 25°, 35°).

The row spacing was varied in this study to avoid the problem of shading

Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

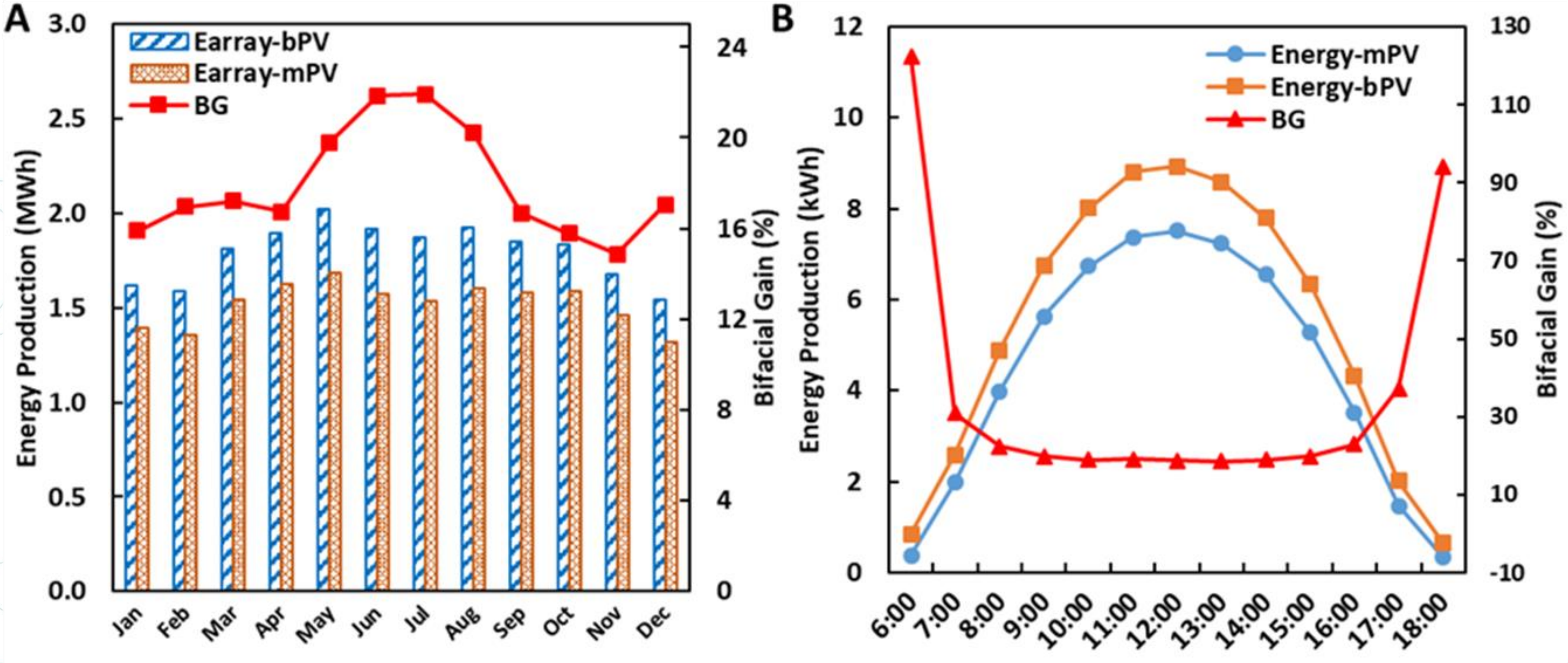
Performance Analysis: Effect of Albedo, Tilt angle, and Height





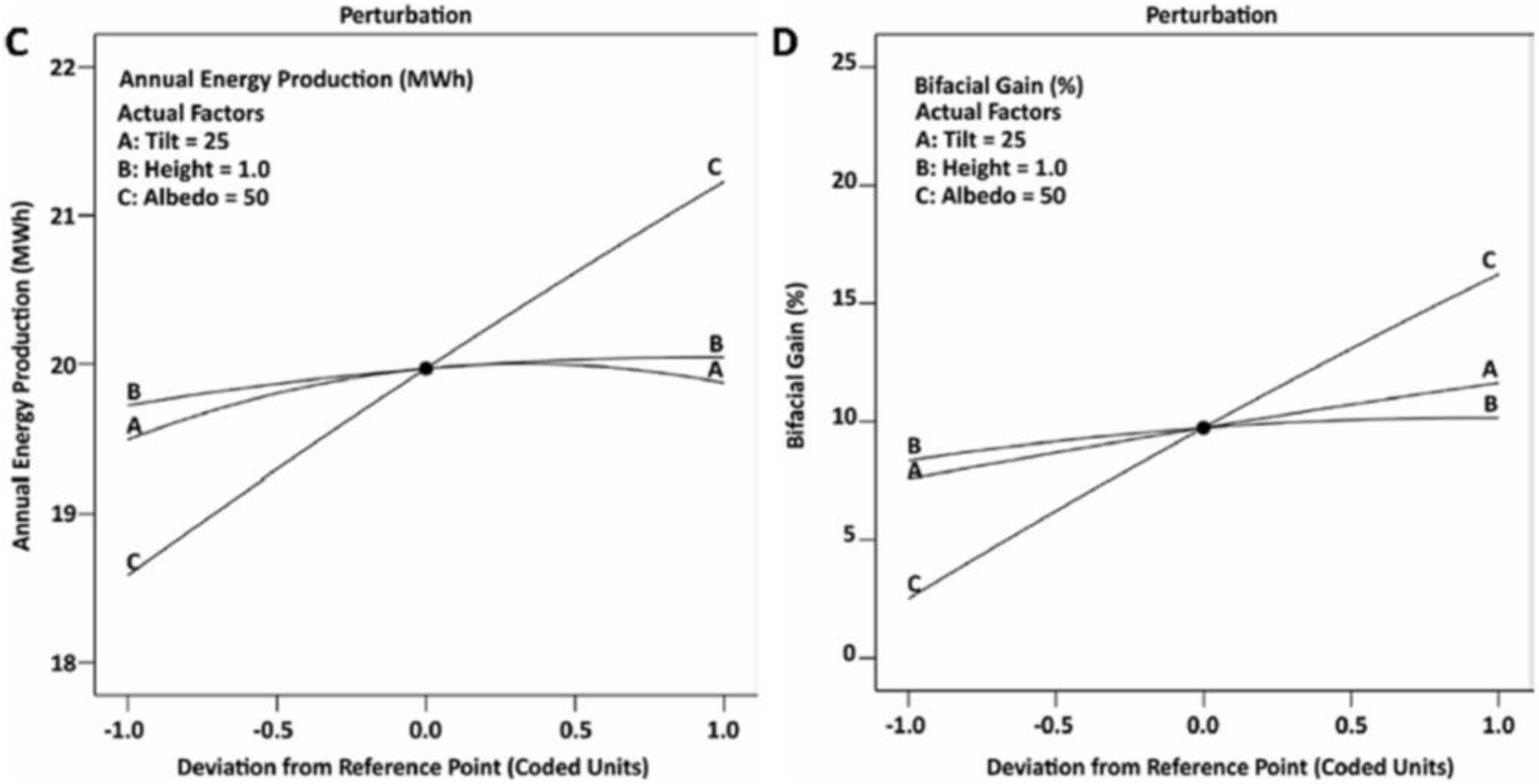
Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

Performance Analysis: Monthly and Daily Profiles



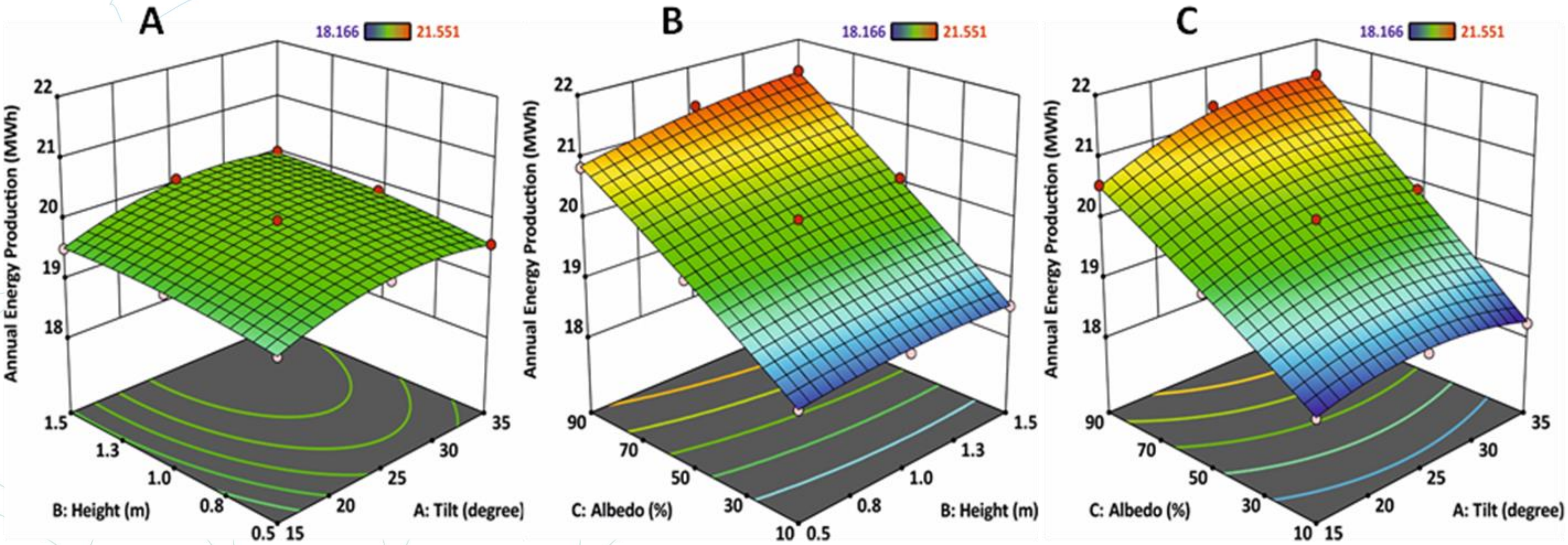
Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

Annual Energy Production & Bifacial Gain: Perturbation Curve



Decarbonization: Bifacial Solar PV Integrated with Cool Roof Technology

3D Surface Plots: Annual Energy Production



Decarbonization – Digitalization – Decentralization
Solar PV EV Charging Station

Decarbonization, Digitalization and Decentralization
Off-Grid Solar PV Electric Vehicle Charging Station

Off-Grid Solar PV system

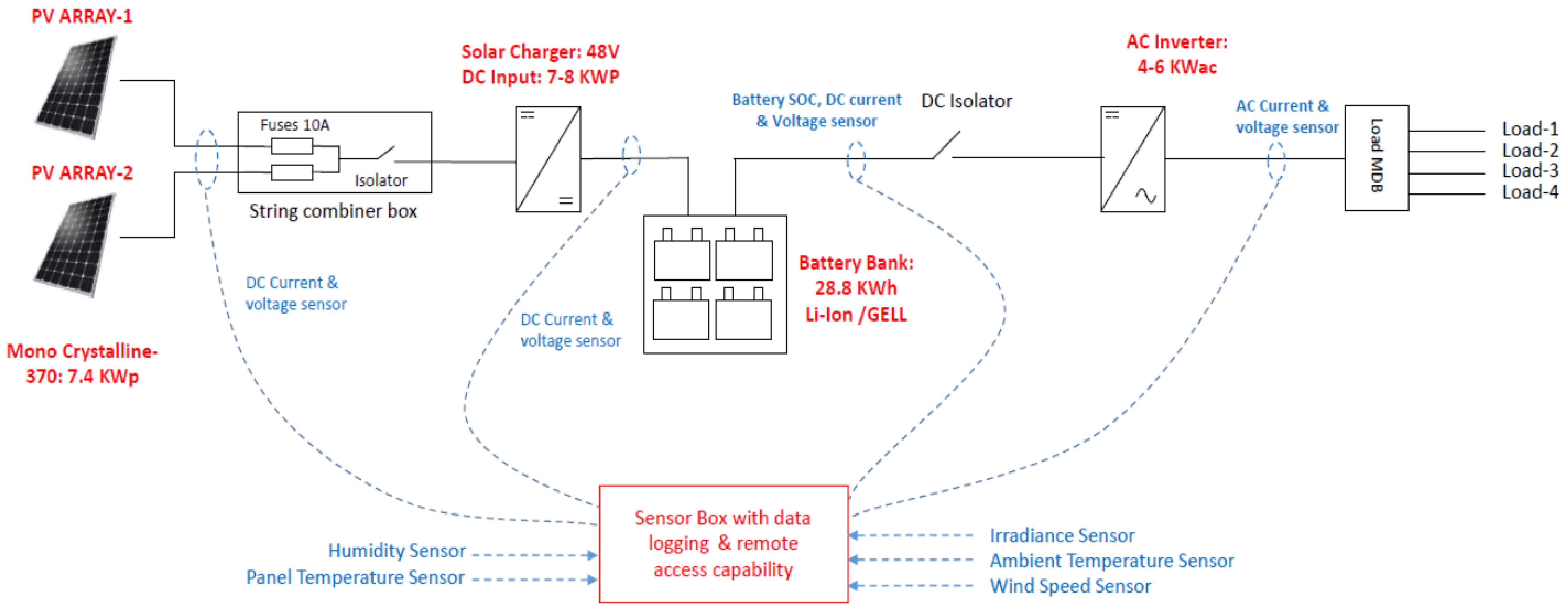
Weather Station

Energy Storage & Inverters

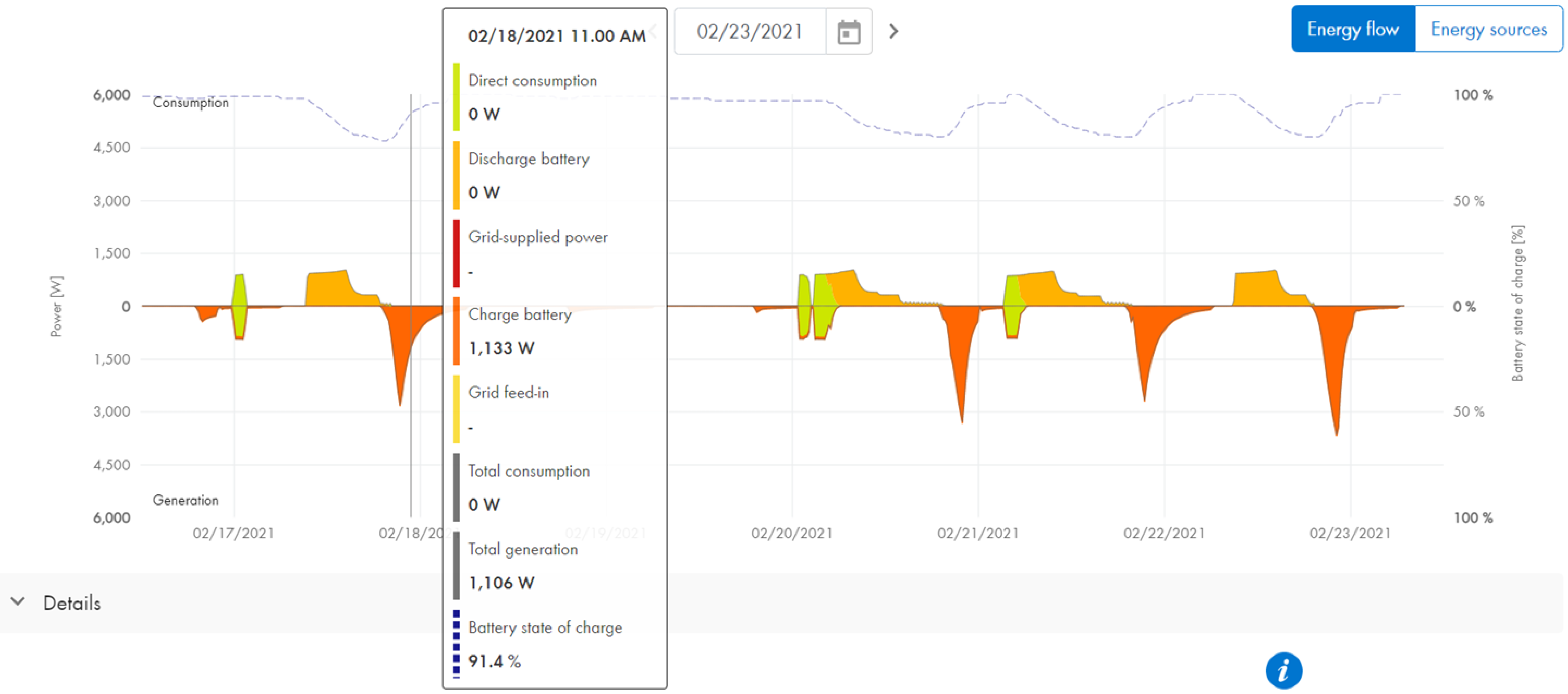
Data Acquisition System

Golf Cart

Decarbonization – Digitalization – Decentralization
Solar PV EV Charging Station



Decarbonization – Digitalization – Decentralization
Solar PV EV Charging Station



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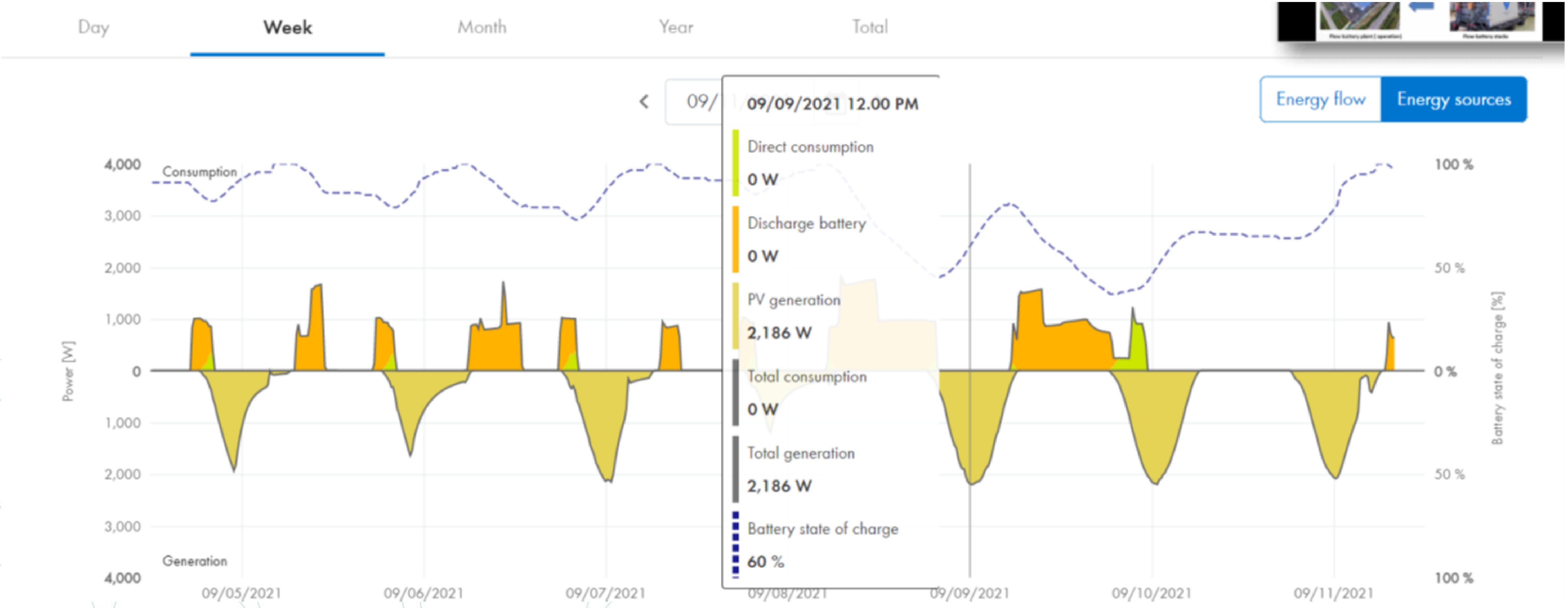

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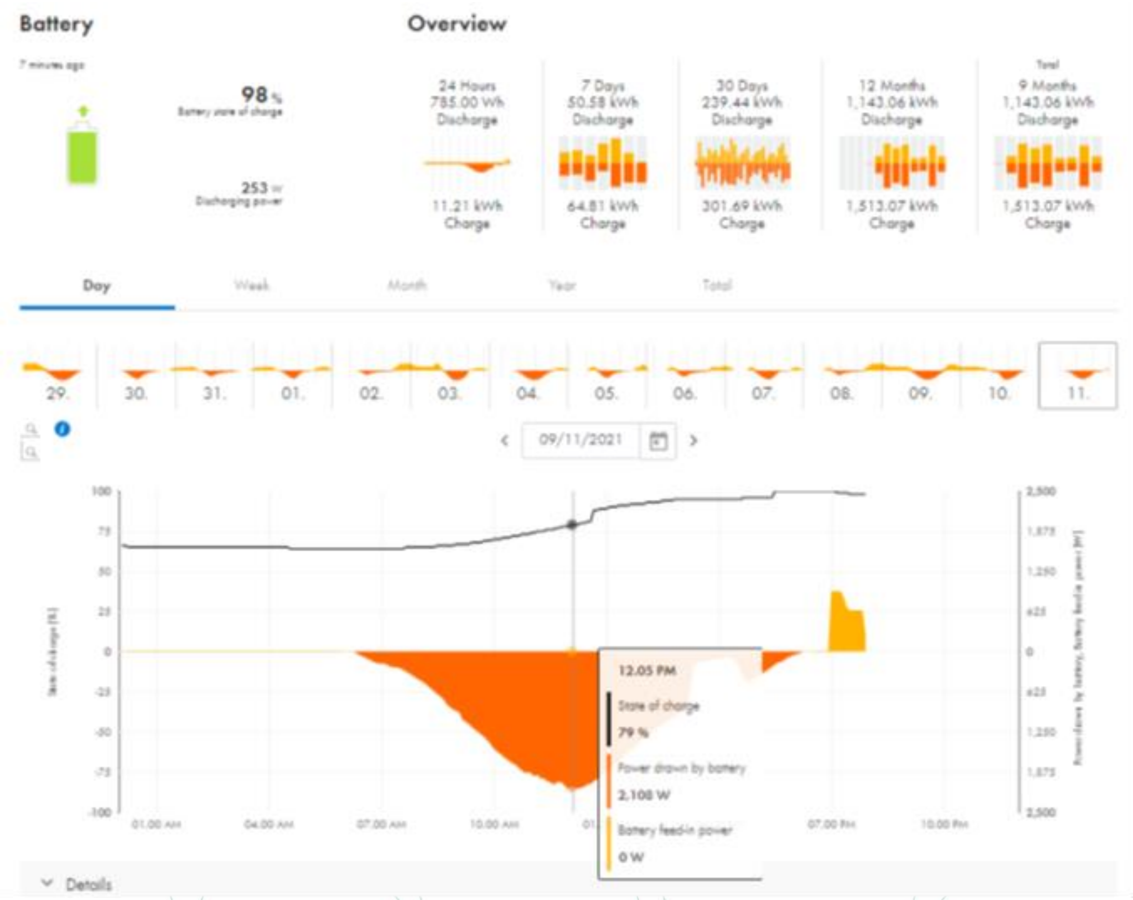
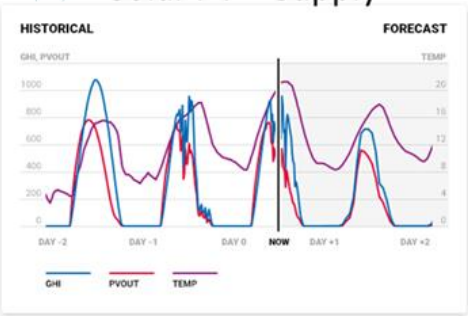
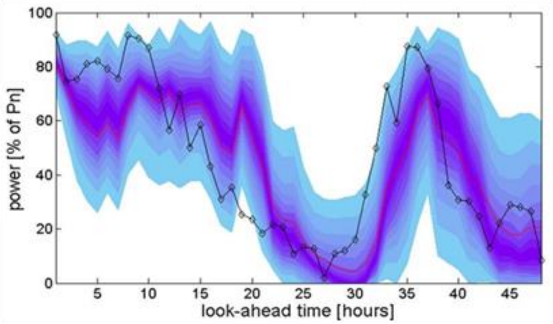


Digitalization
Artificial Intelligence for Energy Forecasting
RE Power (Supply) & Electricity Consumption (Demand)

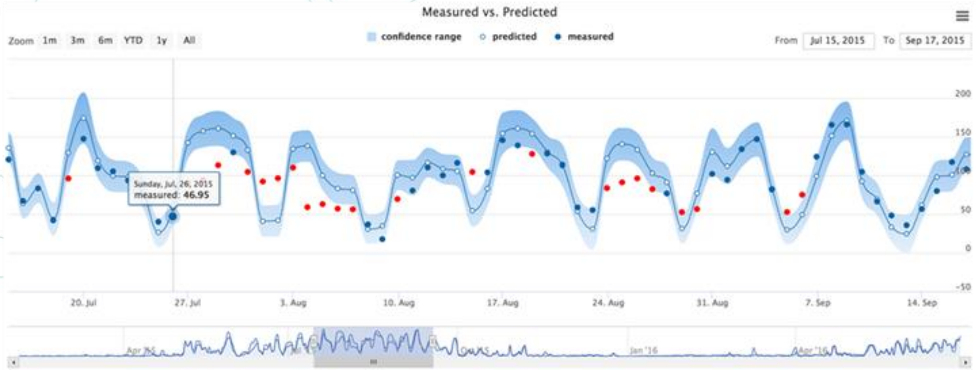
Solar PV – Supply



Wind Turbine – Supply



Building – Demand



Forecasting Horizons: Short (hrs), Medium (days), long term horizons (weeks – month)

Input data: Weather conditions (solar irradiance, temperature, wind, humidity, cloud, aerosol) & historical data

AI & ML Algorithms: Artificial Neural Network (ANN), Adaptive-network-based fuzzy inference system (ANFIS), …

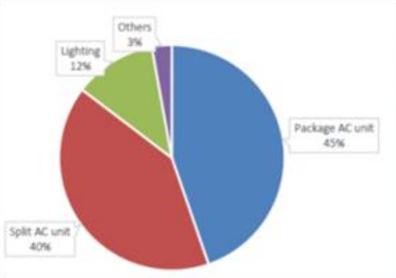
Forecasting Performance Evaluation: Mean Absolute Error (MAE), Root Mean Square Error (RMSE), nRMSE, and MAPE

Digitalization

Artificial Intelligence for Energy Forecasting

Building Energy Consumption Forecasting

Energy Audit Results

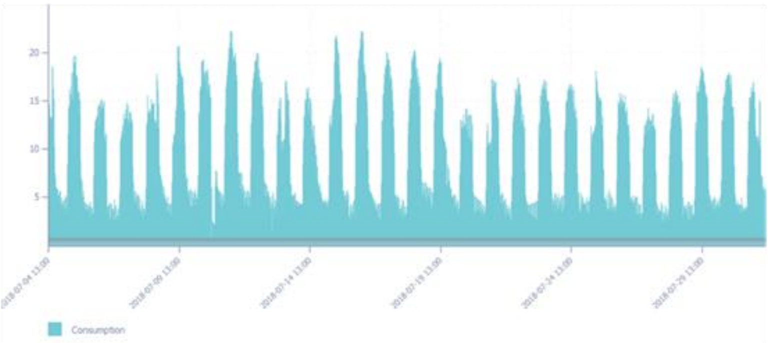


Smart Energy Meter

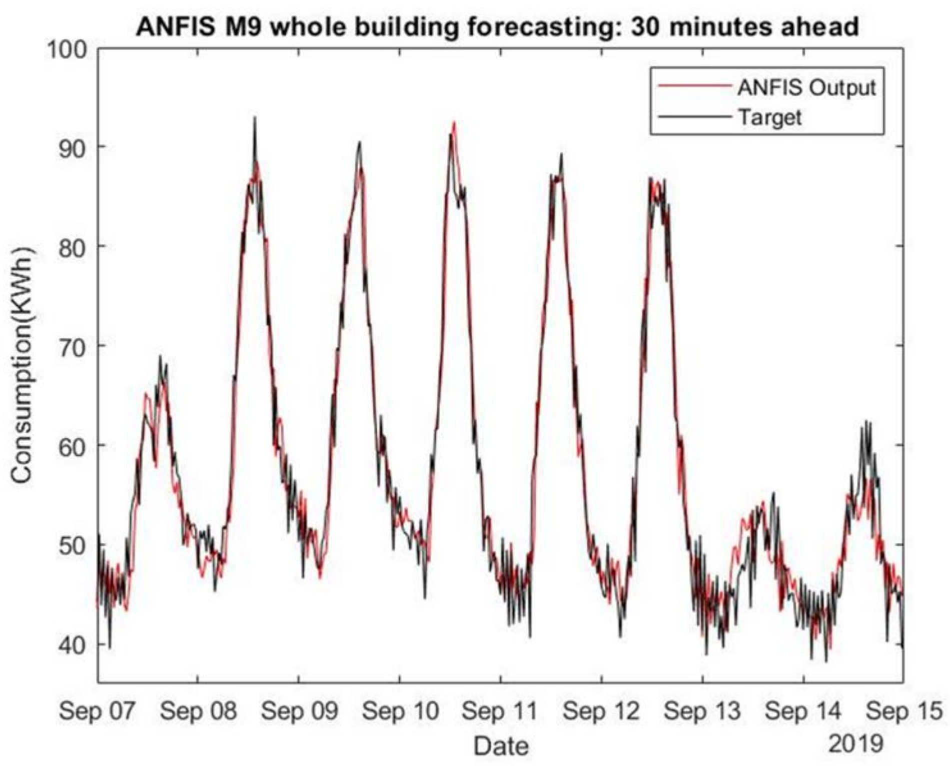
Demand & Power

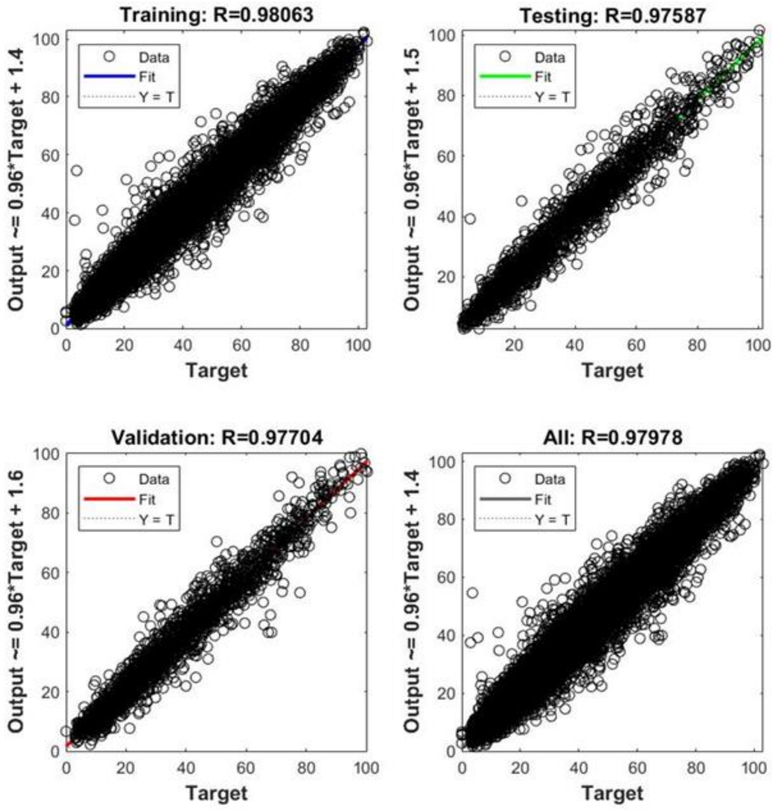
Energy Consumption: July 2018 – Present

Energy Consumption – July 2018

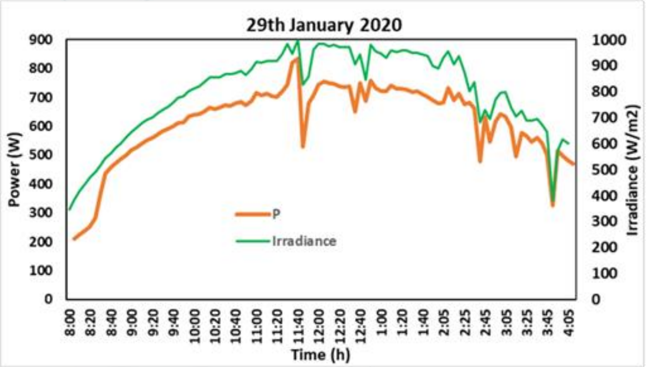


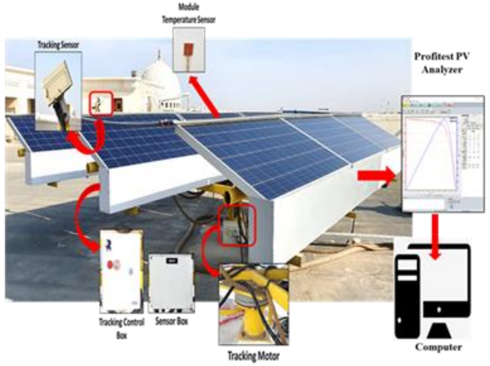
Digitalization
Artificial Intelligence for Energy Forecasting
Building Energy Consumption Forecasting





Digitalization
Artificial Intelligence for Energy Forecasting
Solar PV Power Forecasting





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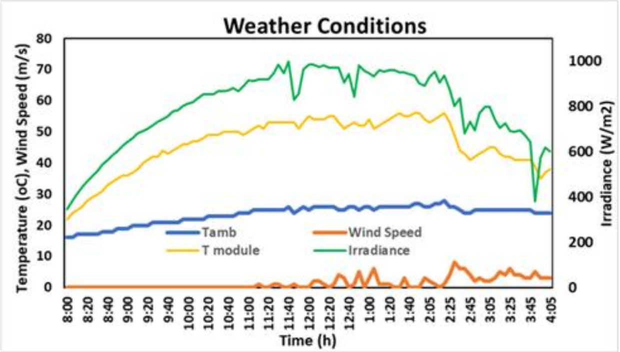
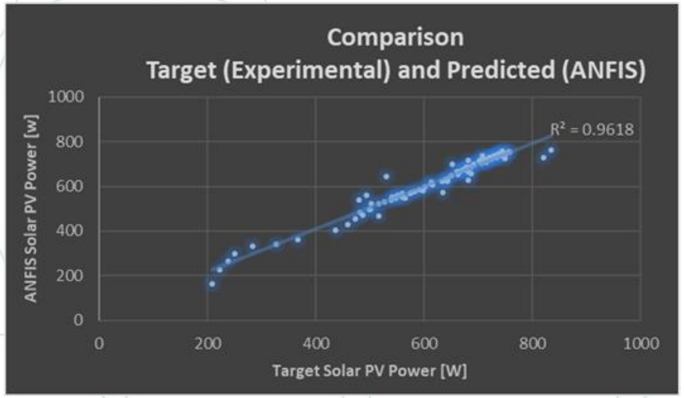
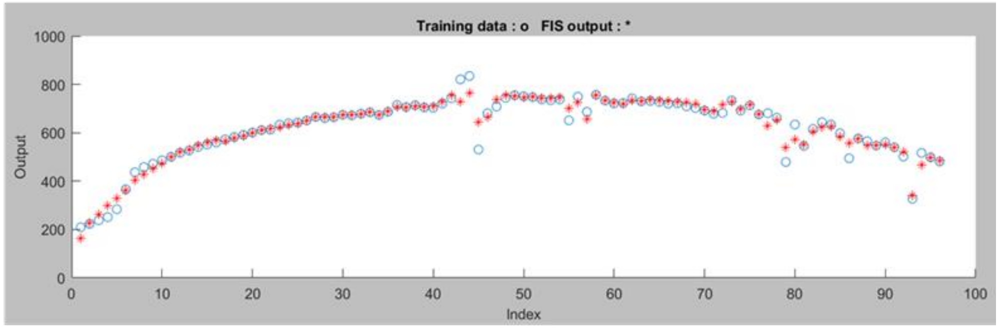
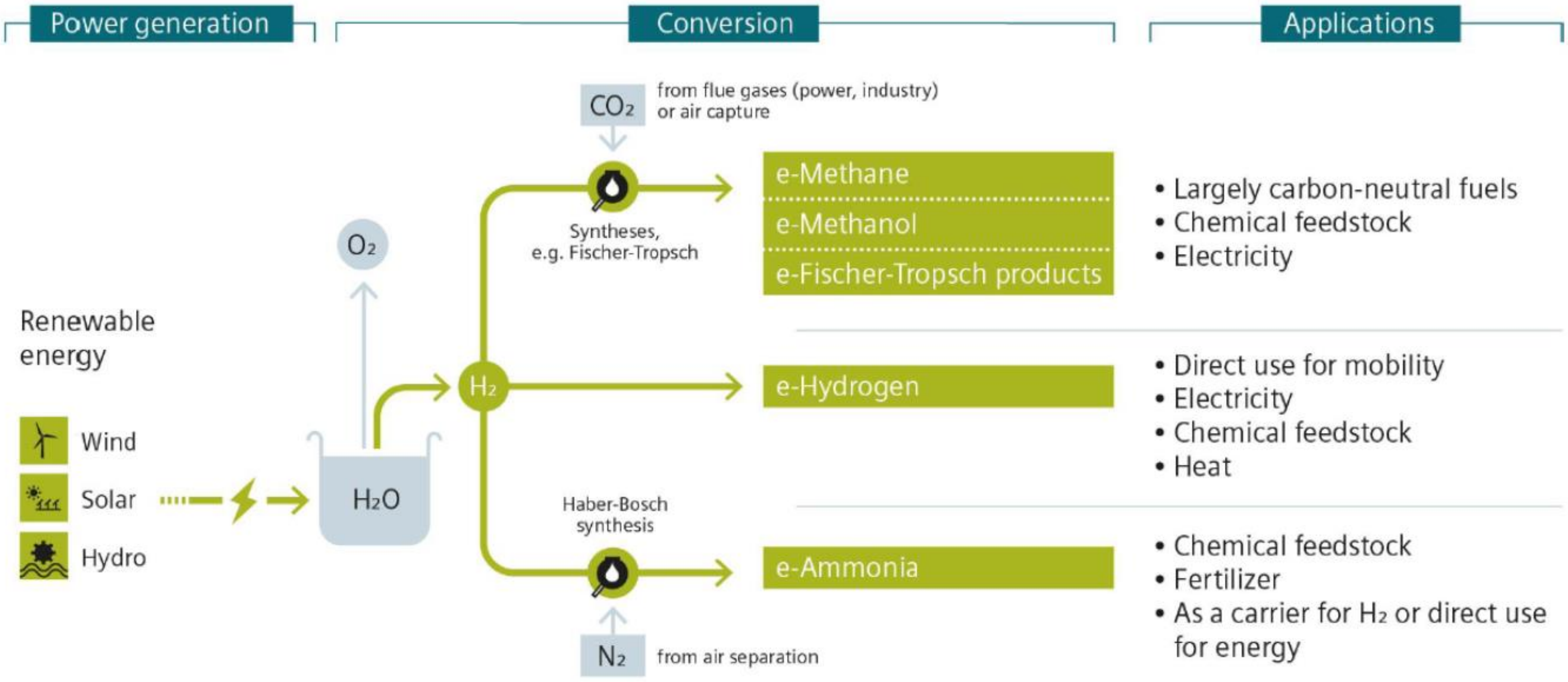






Decarbonization
Power-to-X Technologies



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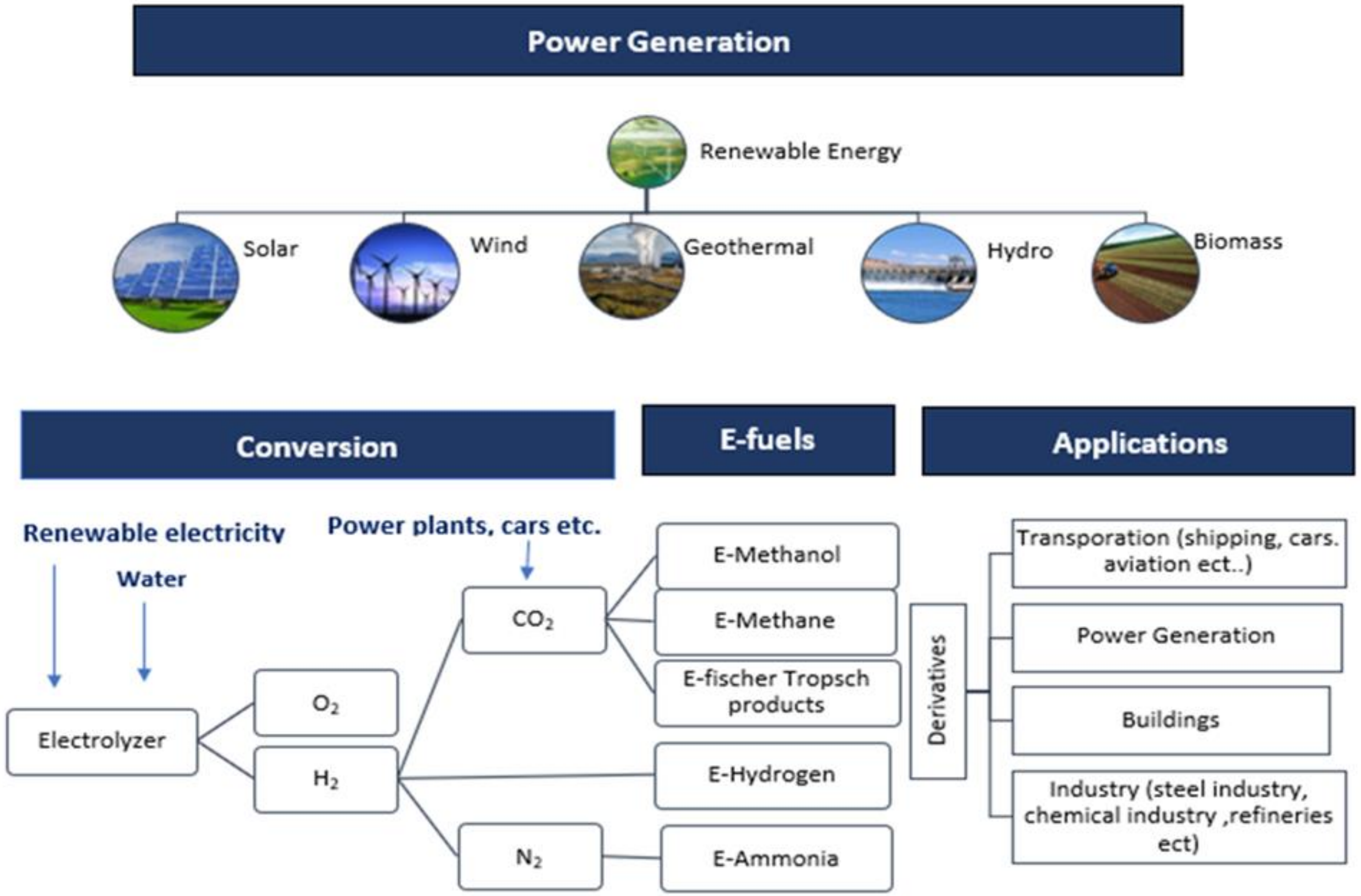
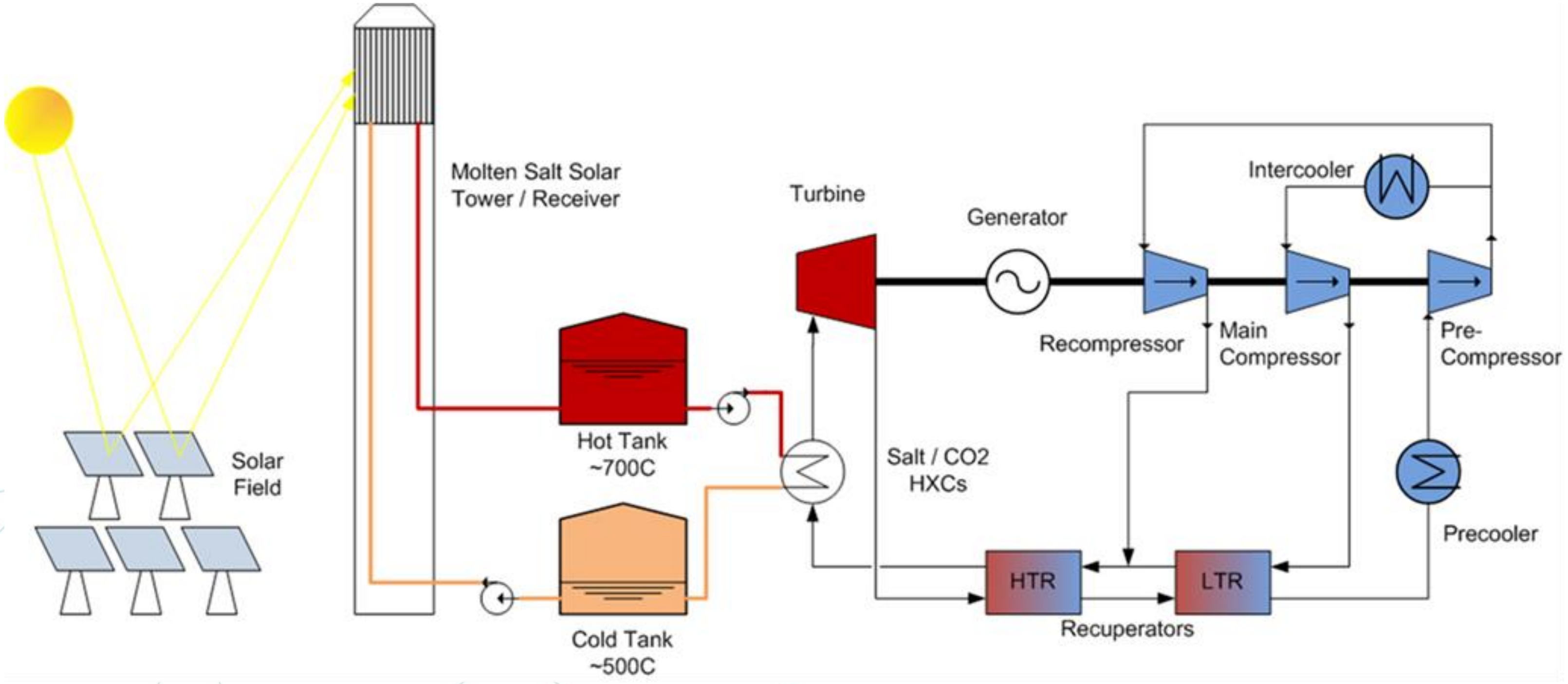


Decarbonization
Supercritical CO2 Brayton Power Cycle
CSP powered sCO2 Brayton Cycle



Working Fluid: CO_2

Decarbonization: CO_2 capture - Power & Industry

Higher Efficiency: Increase the operational flexibility and efficiency of existing and future CSP plants by using sCO2 power cycles: Higher temperature levels

Water: Eliminate the use of water in the power cycle.

Sustainability: Help unlock the potential of CSP in GCC and worldwide to reach decarbonization targets.

Cost-Competitiveness: Use novel sCO2 plant designs for generating solar thermal electricity in a more cost-competitive way

Conclusions

- Energy Transition: 3-D Energy Model for Decarbonization, Digitalization and Decentralization of Energy Sector
- Technology Innovation and Emerging Energy Technologies to accelerate Energy Transitions.
- Decarbonization of the Energy Sector:
  - Renewable Energy (Solar, Wind, Biomass, Geothermal, etc…)
  - Energy Efficiency – Buildings, Transportation, and Industrial Applications
  - Alternative Fuels: Low and Zero Carbon Fuels
  - Carbon Capture and Sequestration
- Digitalization of the Energy Sector:
  - Smart Meters, IoT, AI/ML, Optimization, Automation and Control Strategies
  - Digital Twin Technology
  - Block Chain
  - Cybersecurity
- Decentralization of the Energy Sector:
  - Distributed Energy Generation
  - Advanced Energy Storage
  - Micro Grids
  - Smart Cities

THANK YOU

Under the patronage of His Highness **Sheikh Humaid Bin Rashid Al Nuaimi**,

Member of the Supreme Council and Ruler of Ajman

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"TOWARDS 2071 SHAPING THE FUTURE FOR ENVIRONMENTAL SUSTAINABILITY"

Monday & Tuesday, 28 -29 March 2022 at Sheikh Zayed Centre for Conferences

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