

# PV Based Cooling and Cold Storage

*A way to reduce the costs of energy supply in MENA Countries*

*Dii Desert Energy*

*A Contribution to Working Group Storage*

*Dubai, October 2018*

# PV based Cooling and Cold Storage to be optimally integrated in Power Supply in MENA



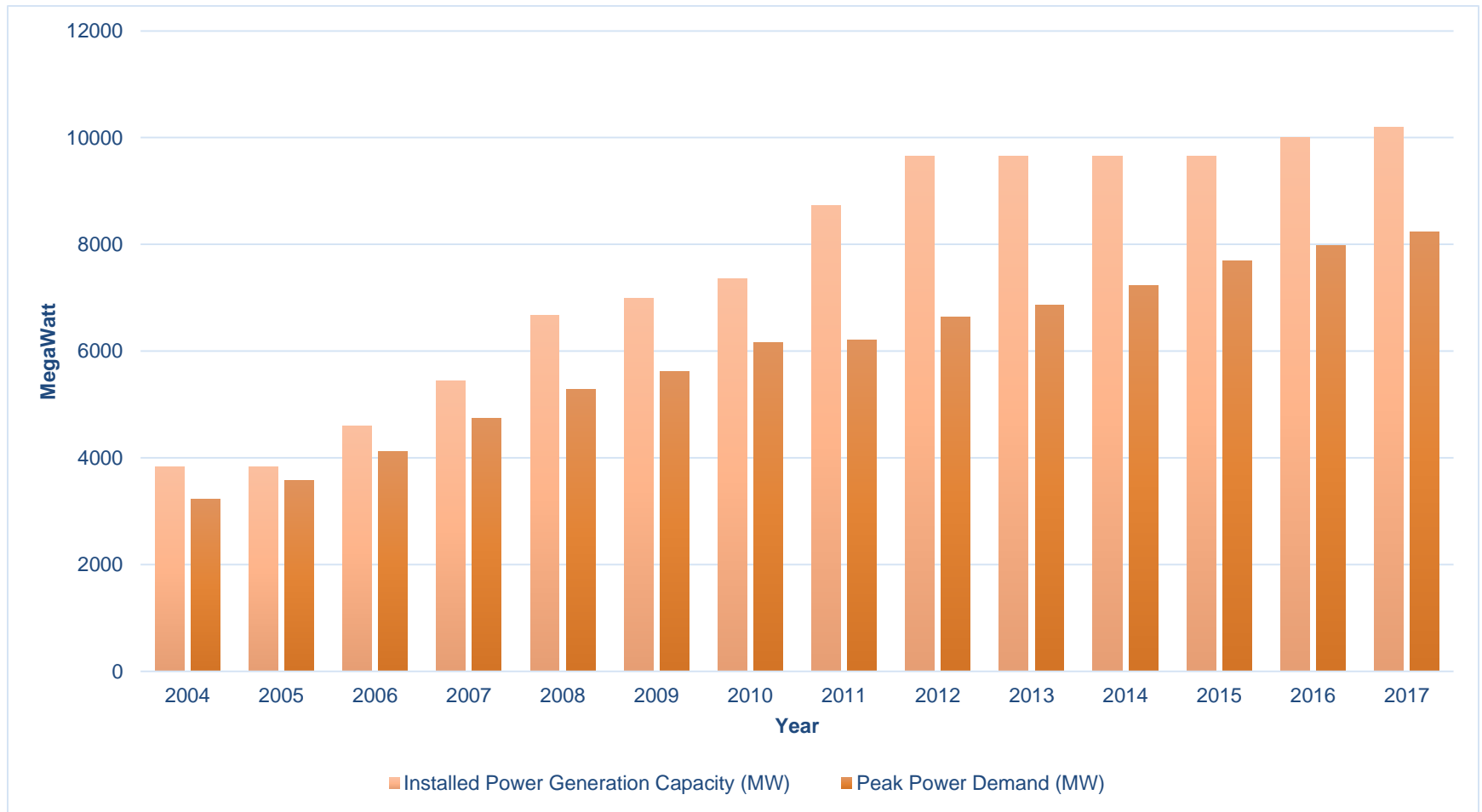
- Dii Working Group '**Storage**' includes the subjects of hydrogen and solar cooling
- This contribution dedicates to the **Synergies that can be captured by linking decentralised and centralised PV power generation, to cooling demand and cold storage**
- The **Purpose** of '**PV Based cooling and cold storage**' is to:
  - **Cover the daily cooling demand** as much as possible by PV based power production in sun-rich areas
  - **Stabilise short term unbalances** in the power system through cooling demand control
  - **Shaving peak demand** in order to off-load the grid
  - Ultimately **bring the cost of cooling down** to the level of PV production costs (e.g. below 2 ct/KWh)

# Considerations of PV based Cooling and Cold Storage

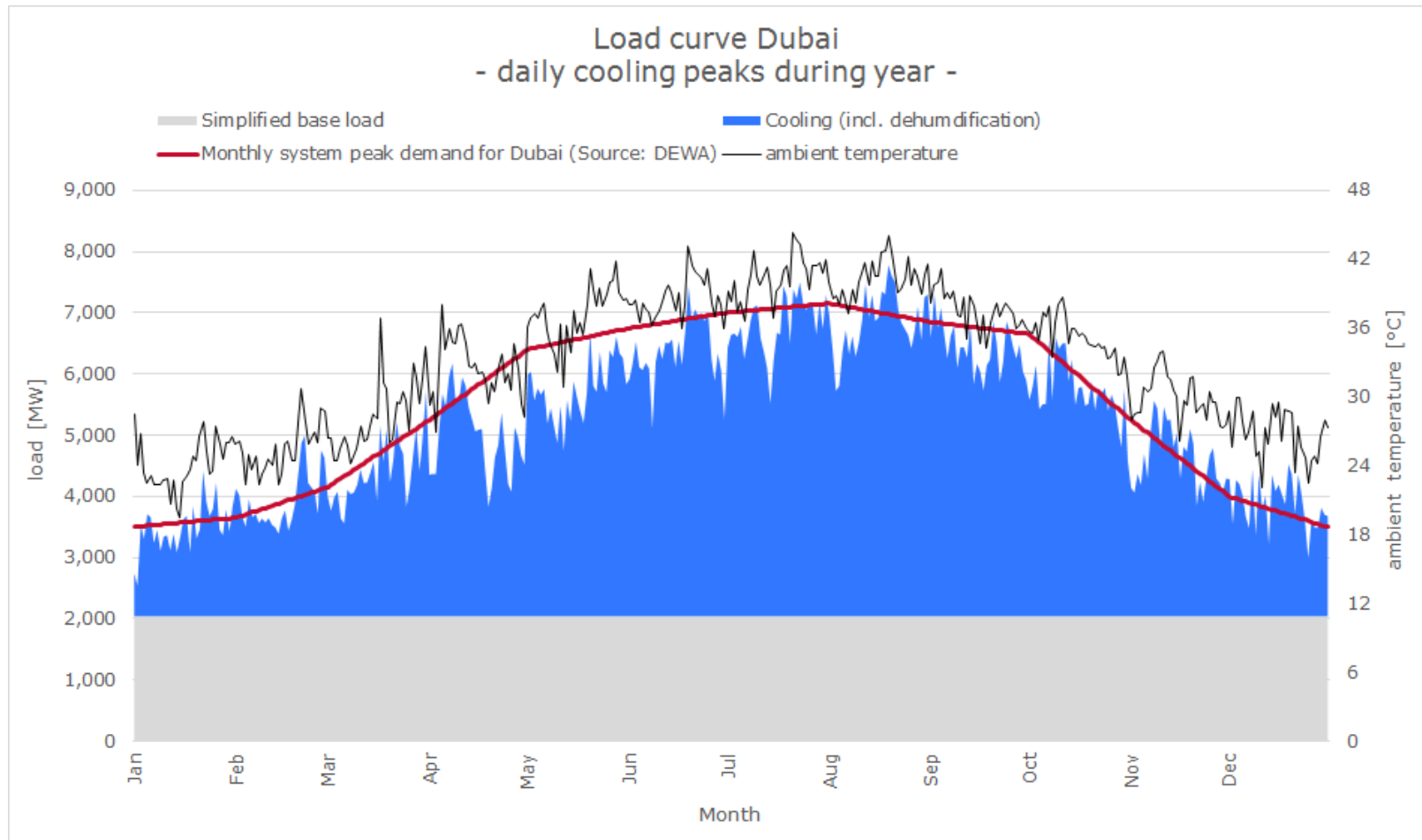


- Cooling demand is rapidly increasing in hot regions such as MENA. Cooling demand is often the biggest load component in the regional system. Take for example the Emirate of Dubai, which experiences cooling demand up to 70% of total power demand in summer times
- Cooling demand in the industry, commercial sector and households is often stand-alone, not highly efficient and it is not capturing synergies along the energy value chain
- Cooling demand is often putting unnecessarily leading to stress on the grid at peak times. Such stress can be reduced by cooling control, storing and shifting
- The correlation between PV production and cooling during the day is usually strong. New additional PV capacity and/or existing surplus production may be stored as cold energy (e.g. ice) to cover cooling demand in the evening and night
- Control of cooling demand may serve to offset short term unbalances in the power system
- District cooling in connection with industrial scale PV may lead to economy of scale

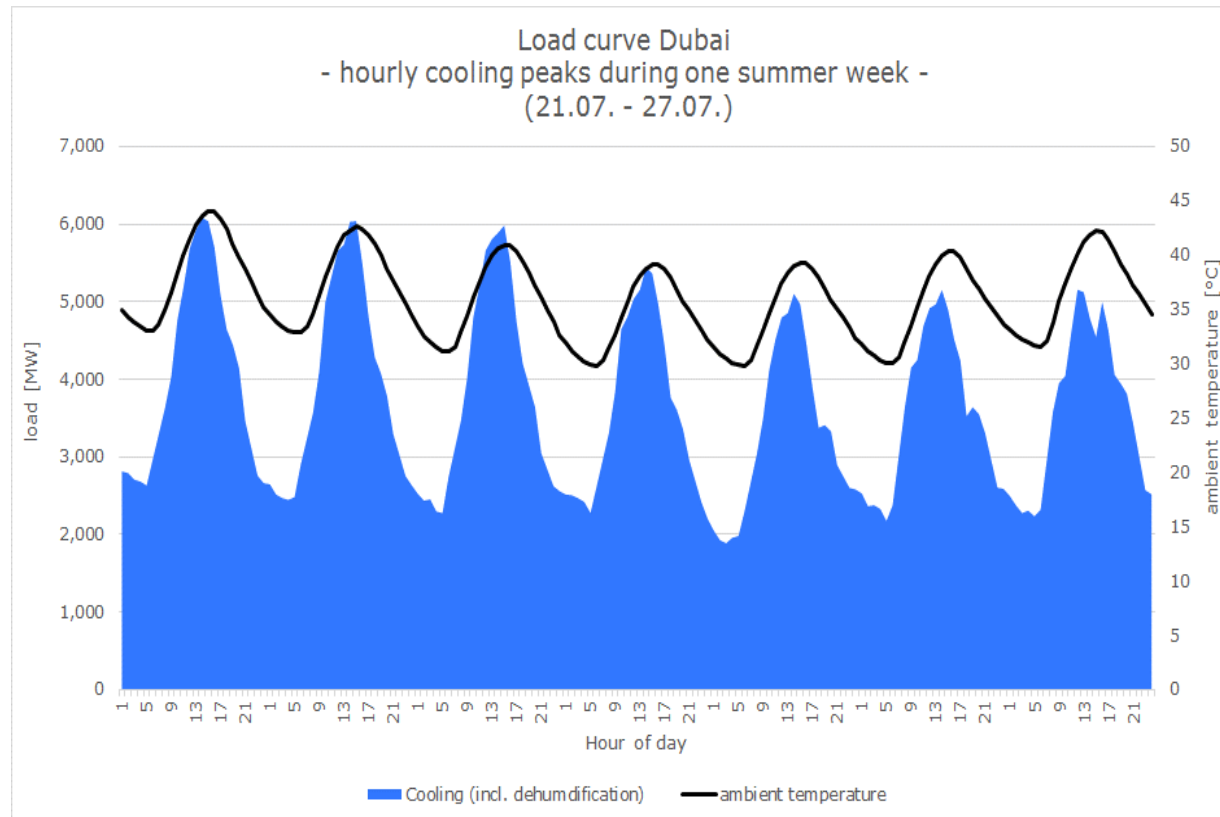
# Example Dubai: Installed Capacity (including PV) and Peak Demand is continuously growing



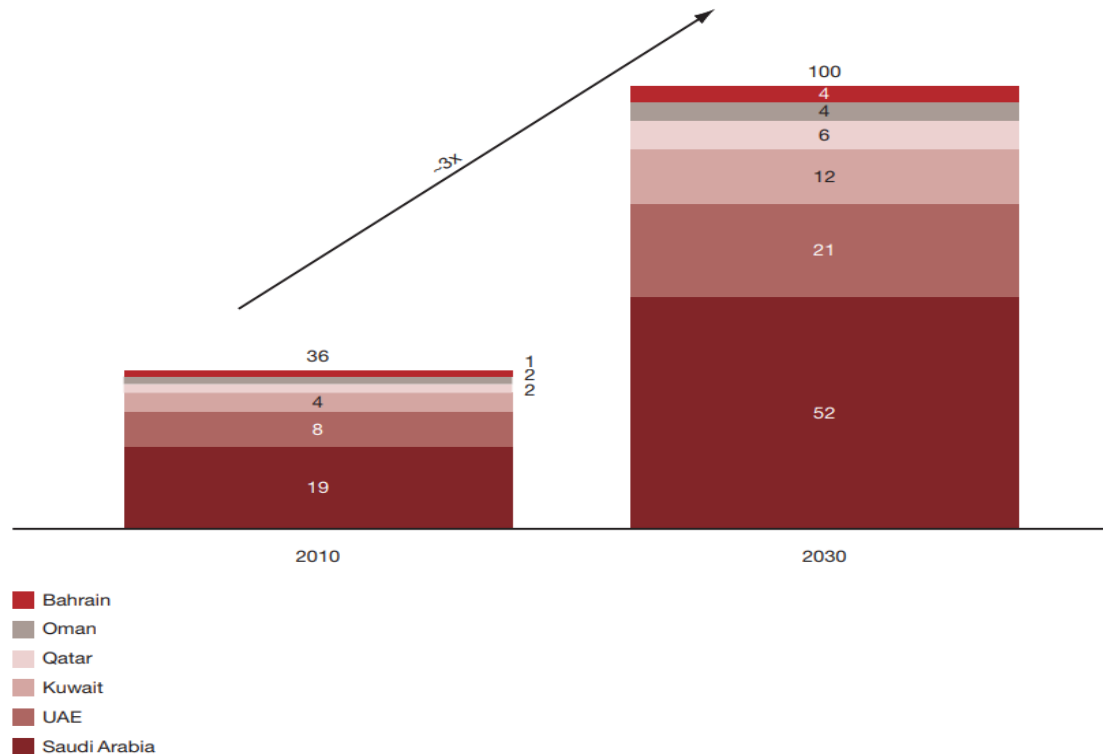
# Example Dubai: Load Curve, Temperature and Daily Cooling Demand correlate strongly



# Example Dubai: A typical weekly Load Curve and Related Cooling Demand

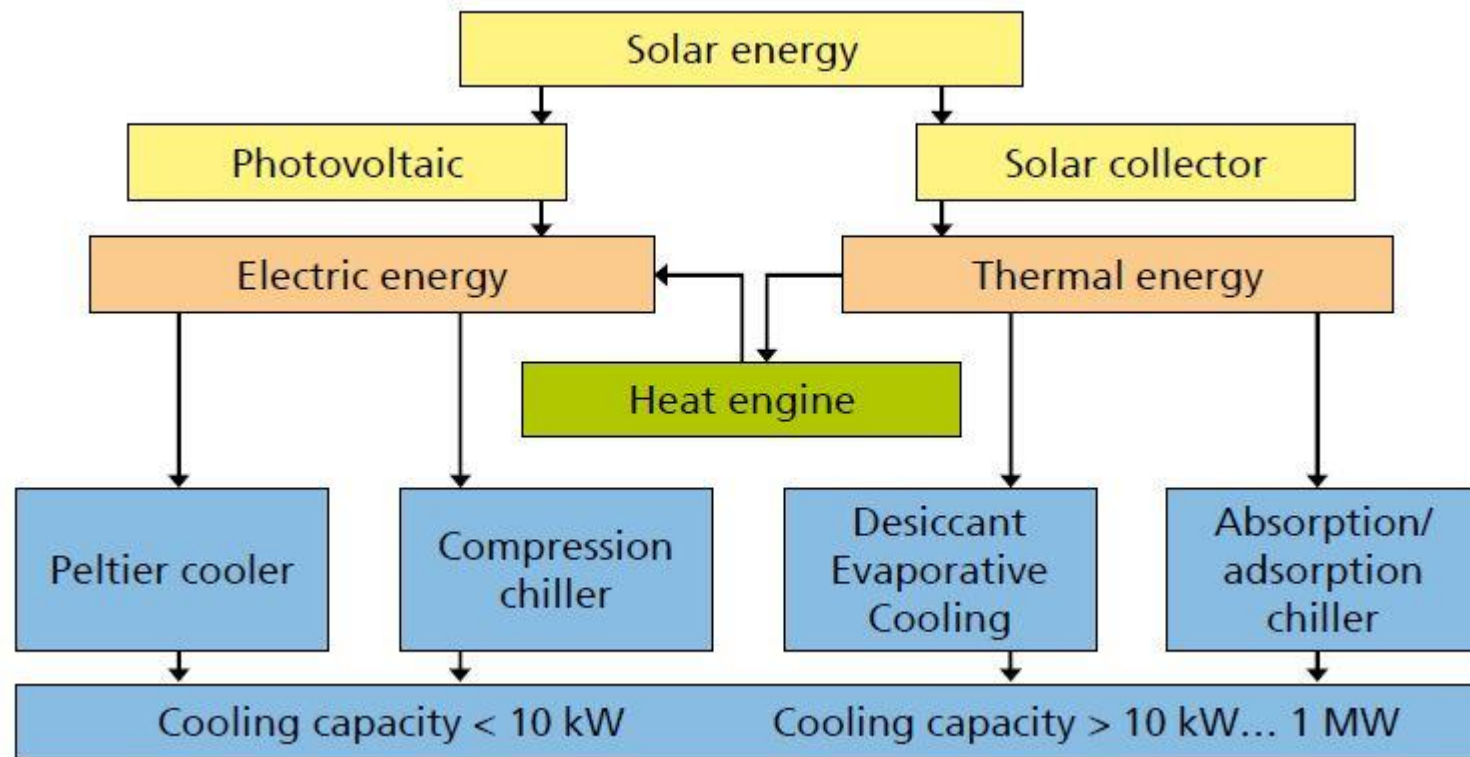


# Expected growth of cooling demand in GCC (In millions of Refrigeration Tonnes)



*Source: MEED; GWI; national statistics; World Bank; Strategy& analysis and forecast*

# Solar based Cooling via PV and/or Solar Thermal (connected with the grid or not)

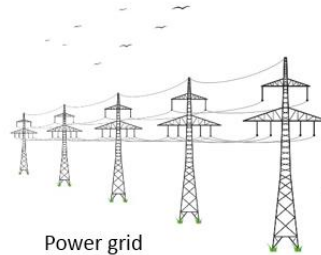
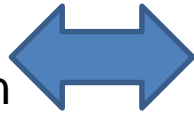




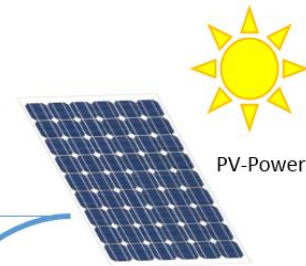
# Example Solar PV based cooling with Ice Storage interacting with the Power System

Power System

- Production
- Transmission
- Storage
- Demand



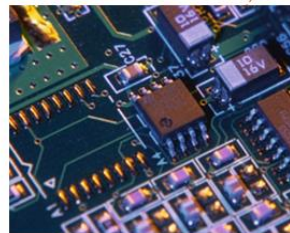
Power grid



PV-Power



Compression refrigeration with Single-Split



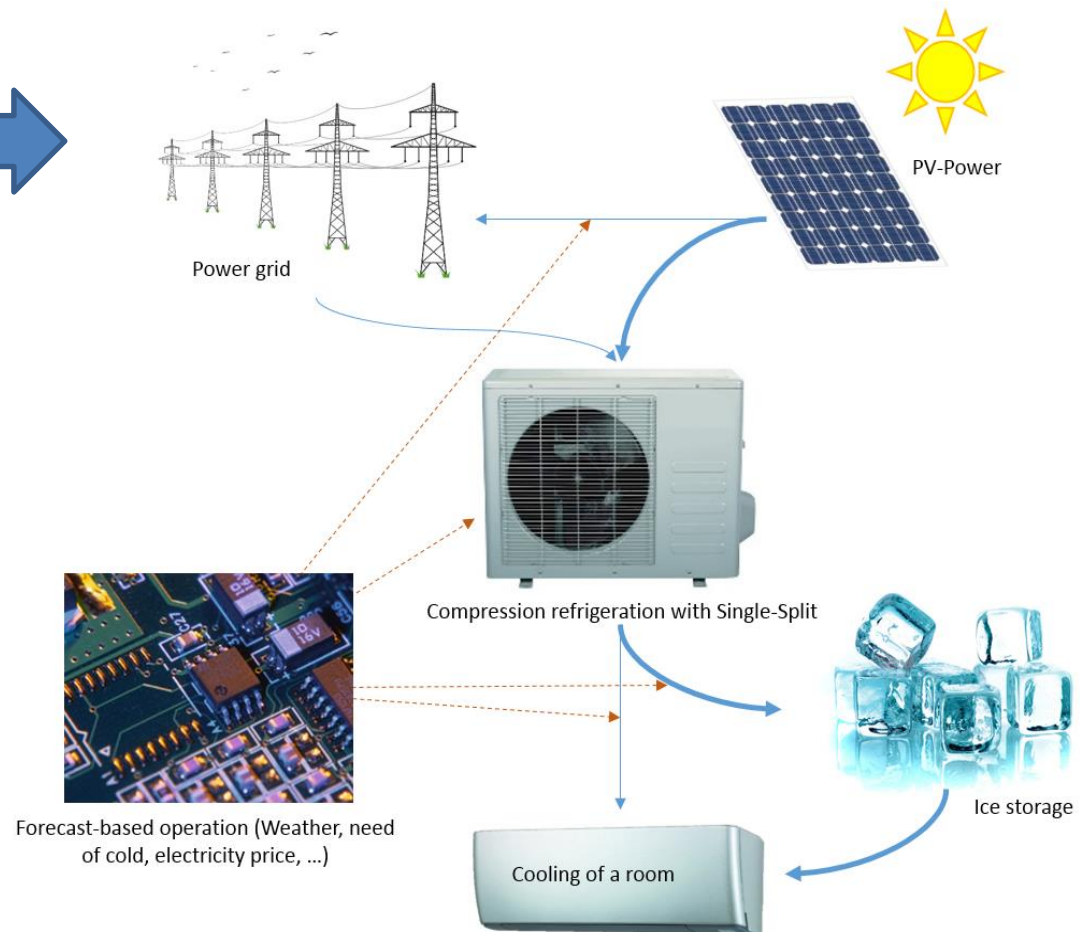
Forecast-based operation (Weather, need of cold, electricity price, ...)



Ice storage



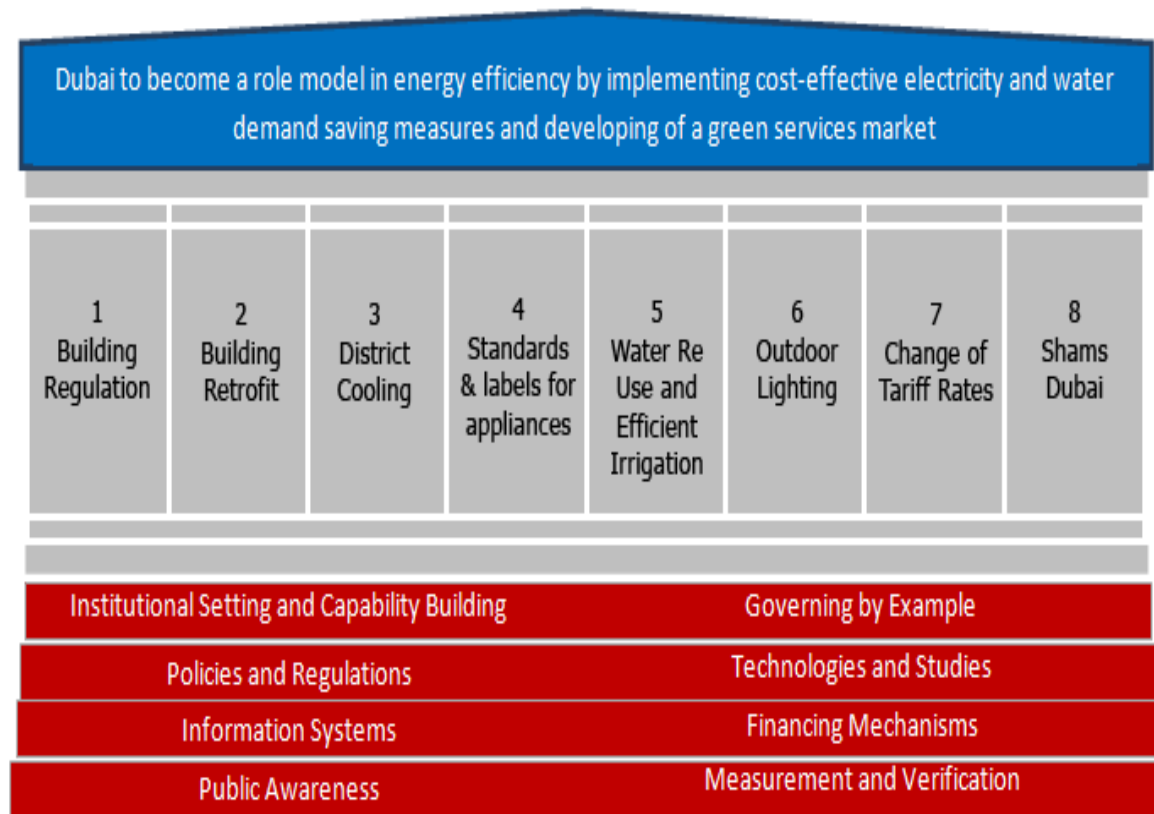
Cooling of a room



# District Cooling may lead to economy of scale in urban areas

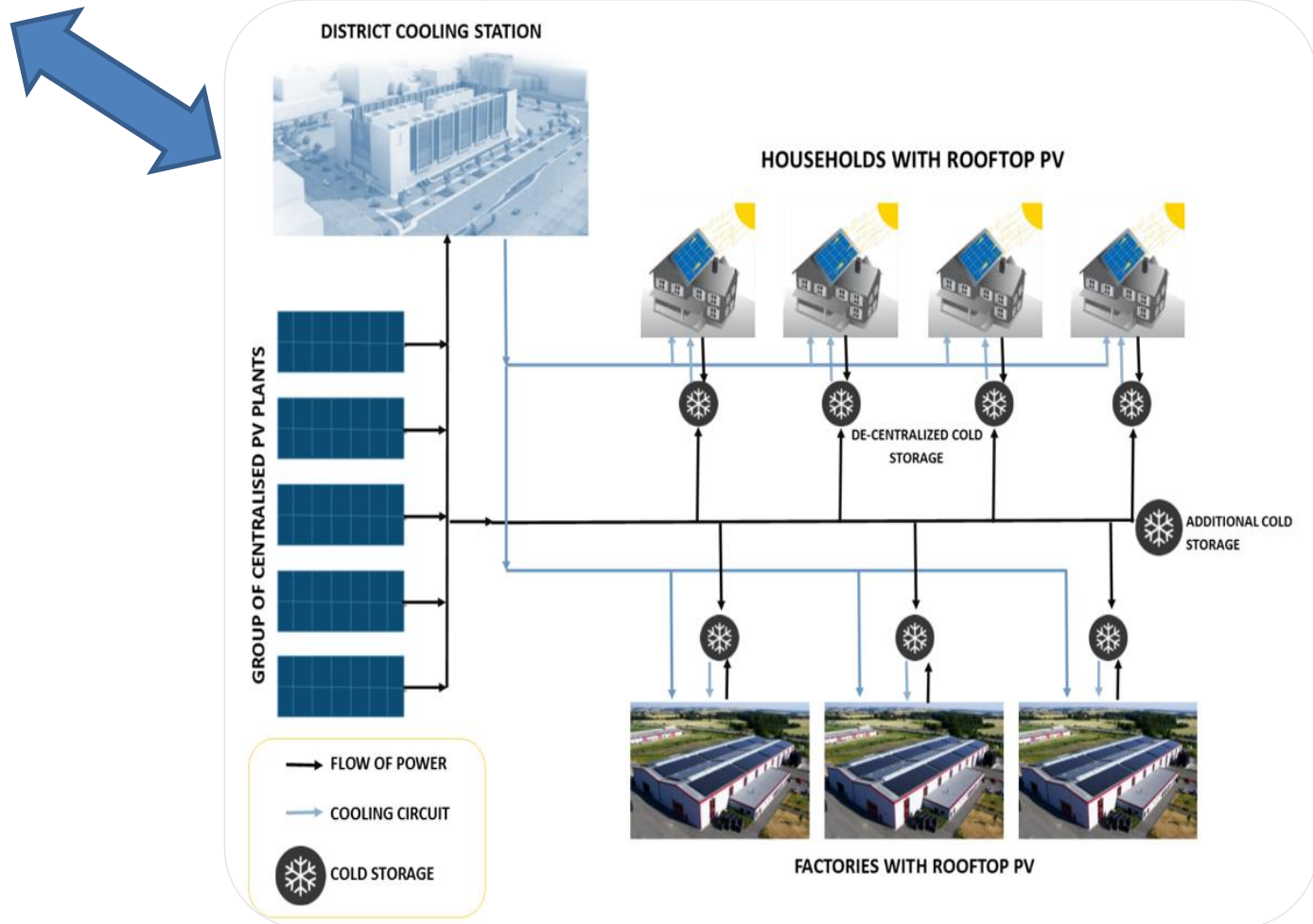


# Example Dubai: District Cooling and Shams Dubai as key elements in smart City Supply

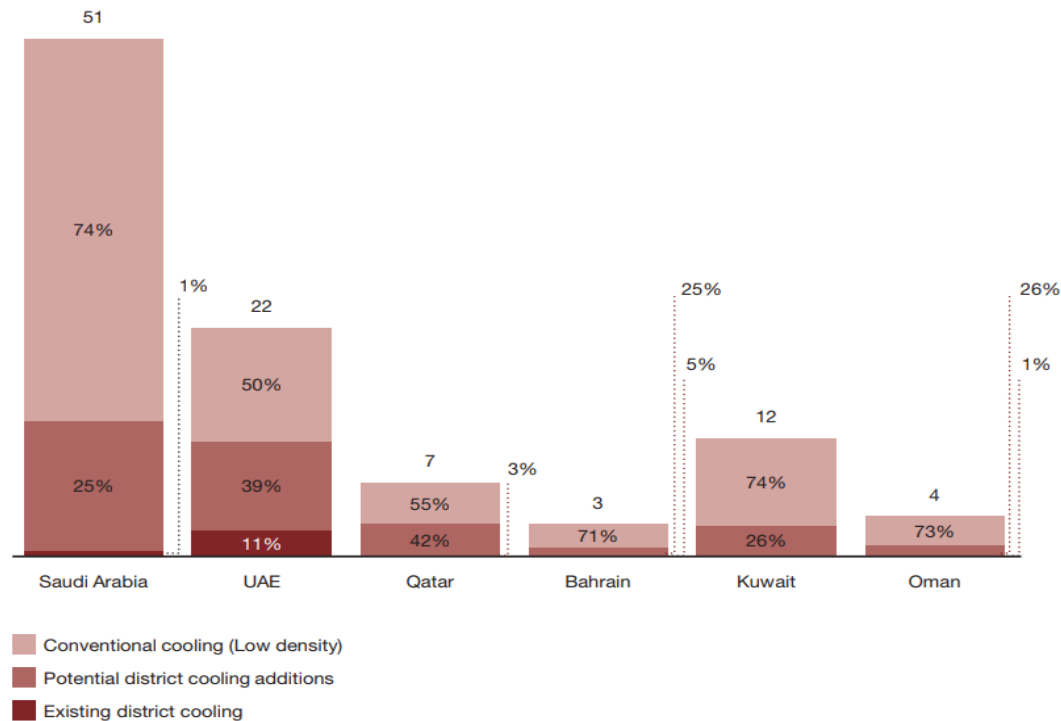


# Sample Structure of District Cooling

Power System interacting with District Cooling

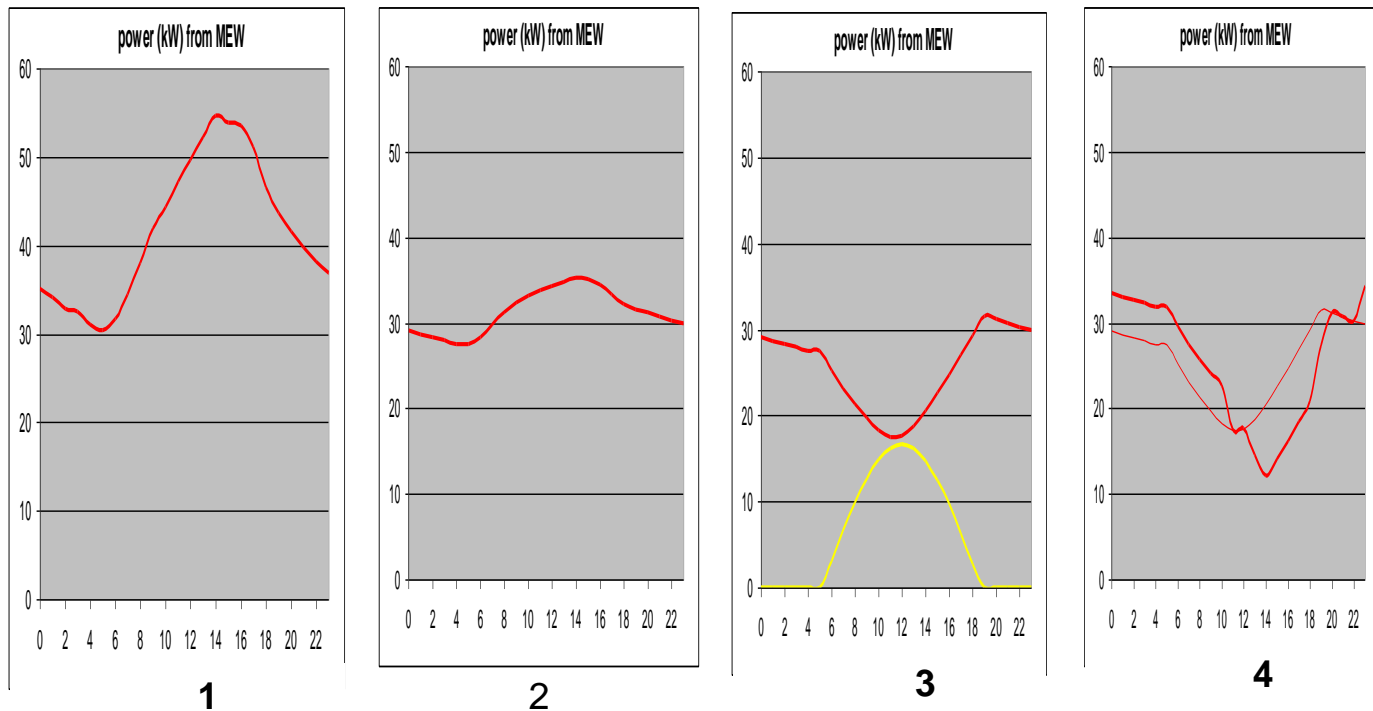


# Conventional decentralised cooling system and District Cooling in GCC Countries

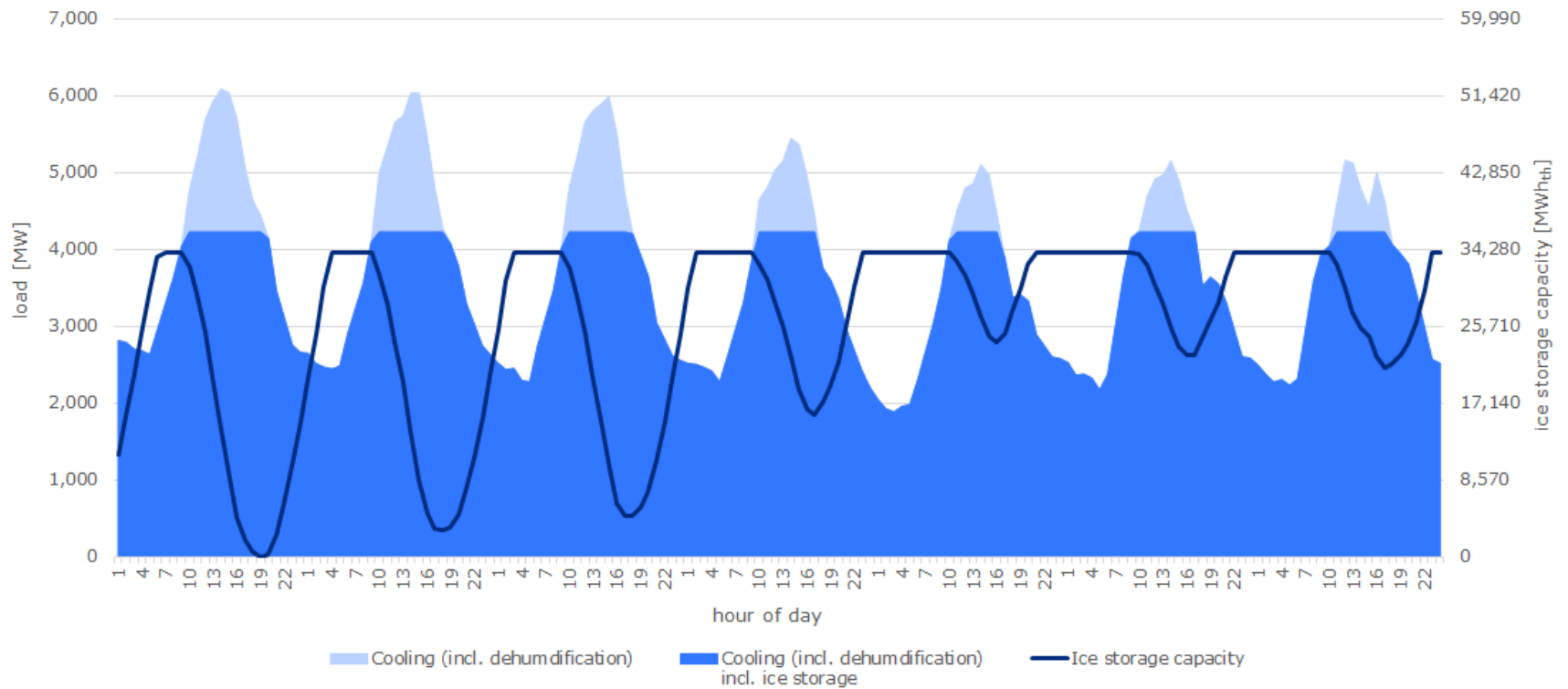


# The Effect of Cooling and Cold Storage on the Demand Curve

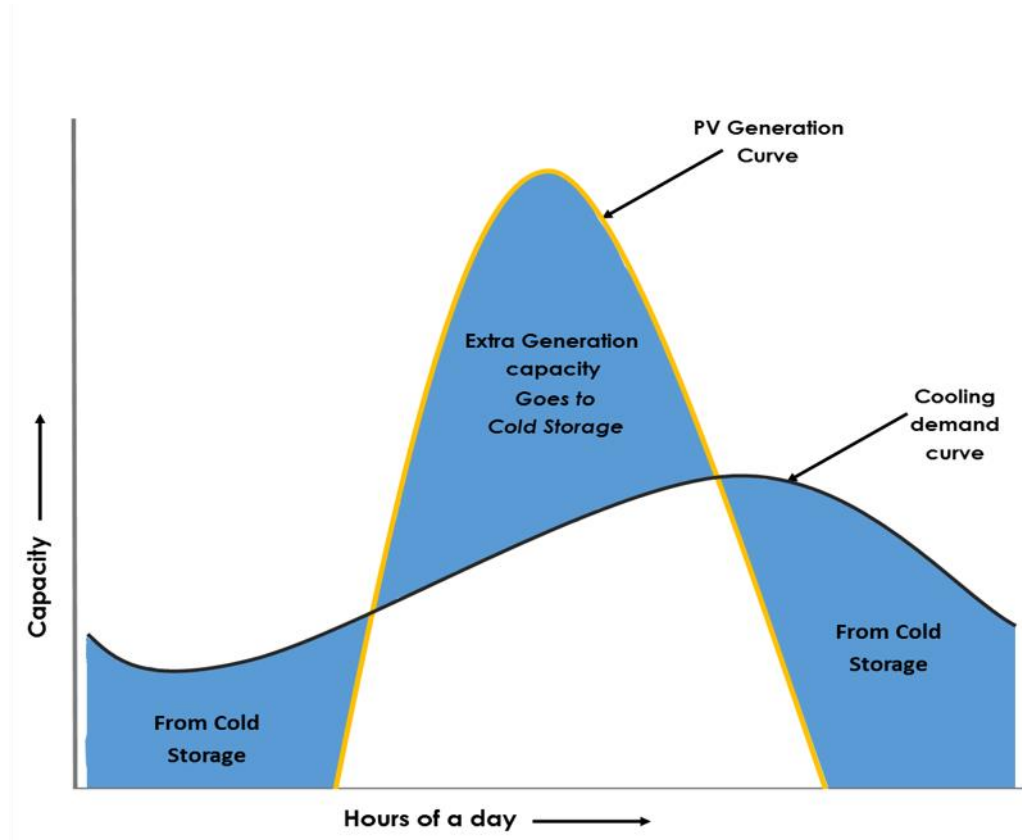
- (1) situation without measures (2) after reducing cooling demand, (3) after introducing local solar PV and (4) after applying shifting demand out of the system peak



Load curve Dubai (incl. ice storage), load threshold: 4,227 MW  
 - hourly cooling peaks during one summer week -  
 (21.07. - 27.07.)



Cooling Demand can ultimately entirely be covered by PV power production  
**Hence at a cost level of a few cents per KWh!**





# Questions to be elaborated by the Subgroup

## PV Based Cooling and Cold Storage

- What cooling and cold storage technologies are being offered by the market?
  - grid connected or isolated
  - directly or predominantly PV based or thermal based
- What can we learn from experiences in different MENA countries
- What improvements can be achieved by scaling up individual decentralised cooling, district cooling and cold storage in a controlled interaction with the power system?
  - Cost reductions along the value chain
  - Support of system stability and system control
  - Peak shaving for grid loading purpose
    - start with 2 examples (e.g. Dubai and Bahrain)
- How can solar based heating be brought into the equation?