

Solar 2021: Empowering a Sustainable Future

Digital Energy: The Future of Power

If it's digital, it's direct current

CONTENT BY

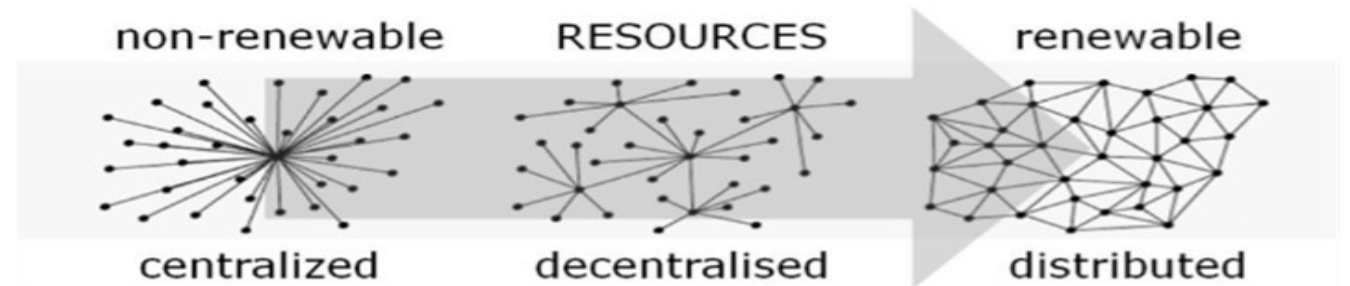


NORTH AMERICA SMART ENERGY WEEK



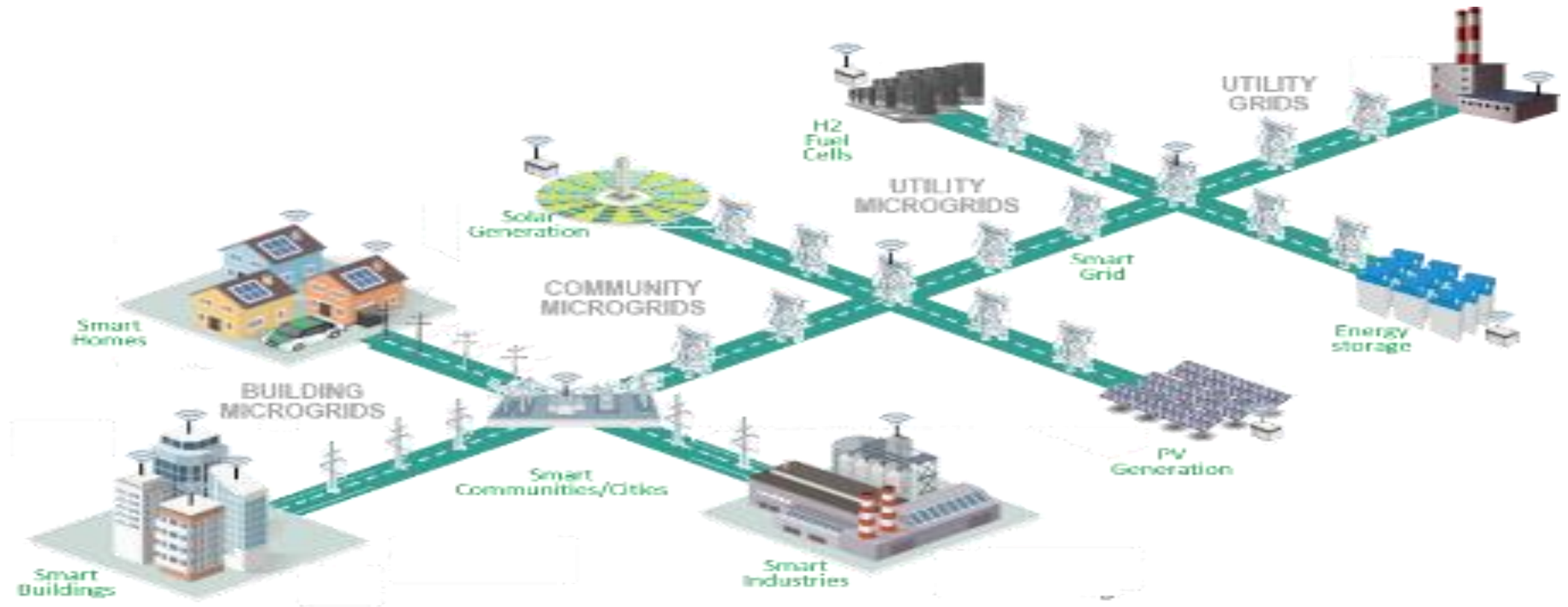
Distributed Renewable Energy?

- **Solar (Photovoltaic)**
- Wind Turbine
- Hydro Generators (Dams)
- Hydrogen (Fuel Cell)
- Bio Fuel ICE Generators
- Thermoelectric Generators
- Combined Heat and Power Generators (CHP)
- Piezo-Electric Generators
- Wave/Tide Generators
- Future?



Facilitated by Microgrids:

Doing for electricity what the Internet did for information



Key New Technologies ...

A greater use of
Direct Current Power Electronics...



- Digital Electronics
- Portable & Fixed Loads
- Smart Controls
- Bi-directional Integration
- Added Reliability & Safety

Key New Technologies ...

An expanded array of
New Sources and Efficient End-use Devices...



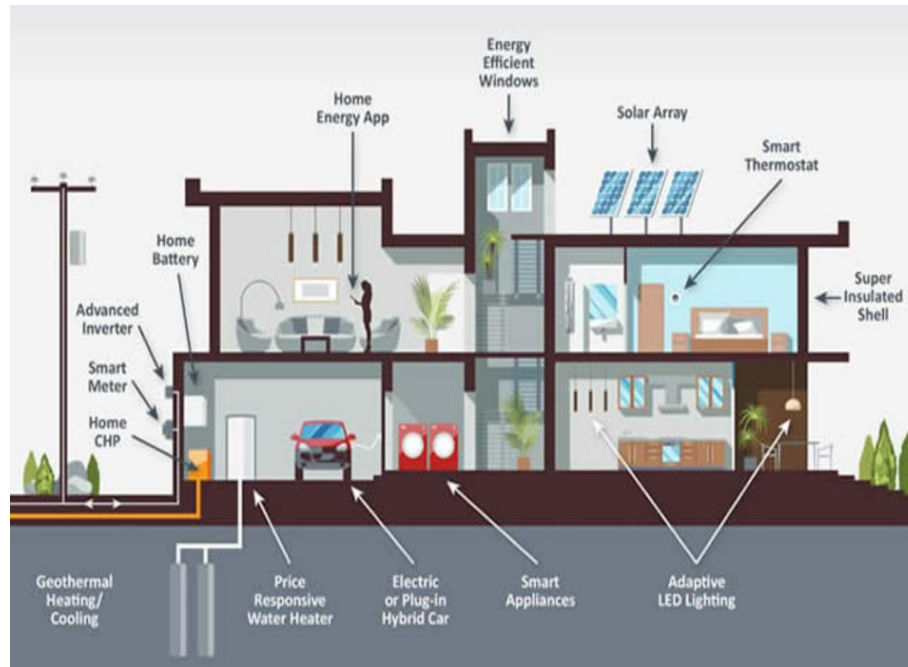
- High Efficiency Electronic Lighting & Appliances
- Portable (battery) & Fixed (connected) Loads
- Smart Controls – Power/Signal Integration
- Bi-directional Integration
- Integration of CHP & CHCP
- Added Reliability & Safety

New Building Level Business Models ...

Services

- Pwr. Sys. Design & Installation
- Sys. Ops., Mgmt. & Service
- Energy Intell, Optm. & Mgmt.
- Virtual Power Plants
- Community Microgrids
- Intg. Pwr., Comm., & Security
- Preemptive Maintenance
- Transactive Pwr. Mgmt.
 - Consumer Retail
 - Retail to Distributor
 - Distributor to Wholesale
 - Bulk Prod. to Wholesale

Key Drivers



Apps

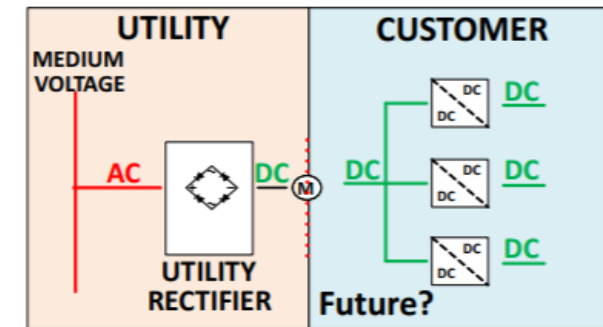
- Smart Building/Home
- Renewable Energy Prod.
- Power Storage
- Electric Vehicle Charging
- Electro-active Environments
- Augmented Reality
- Dist. Sys. Support
 - VARs
 - Peak Demand
 - Freq. Maint.
 - Fault Resilience

Fast Vehicle Charging: Direct Current as a Utility Supplied Service



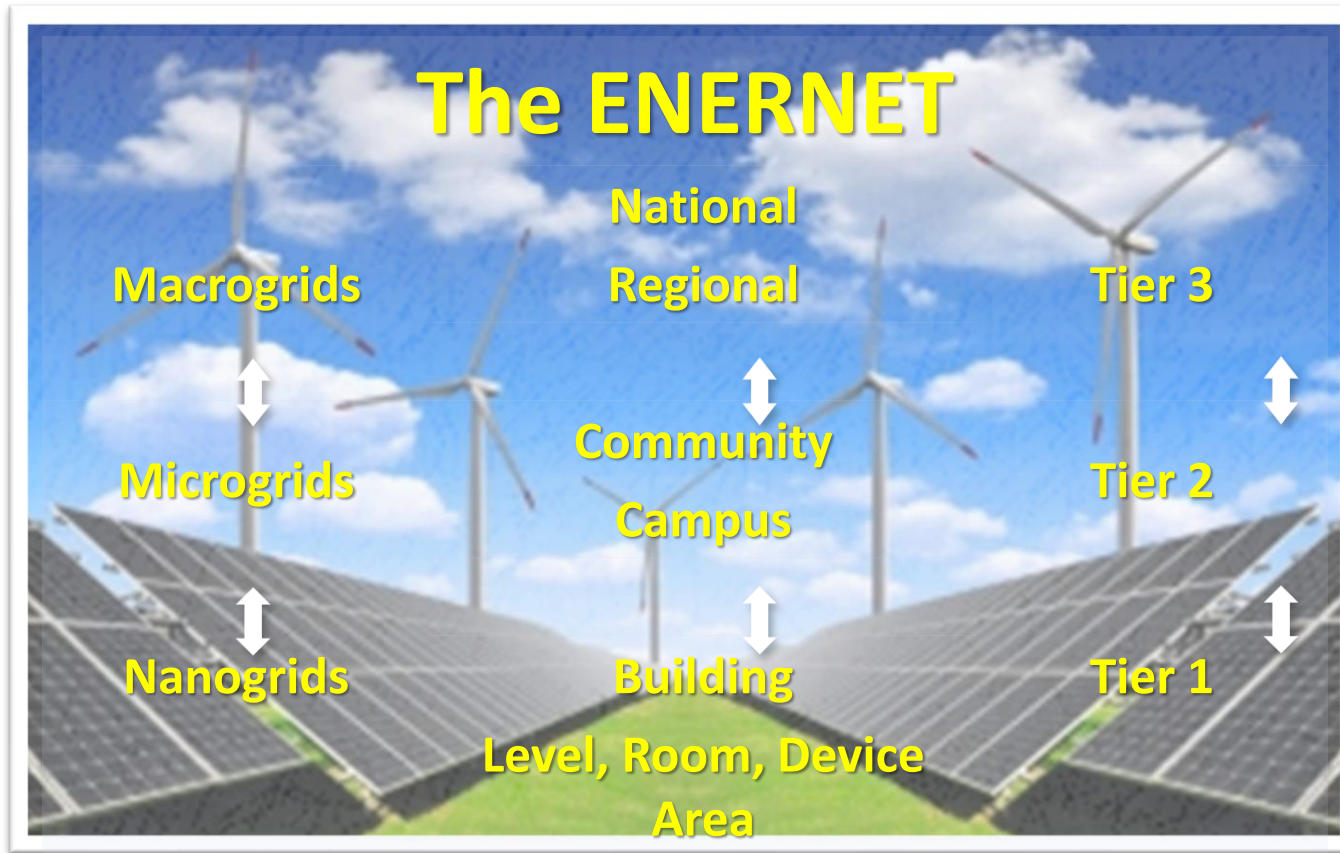
Technology Includes:

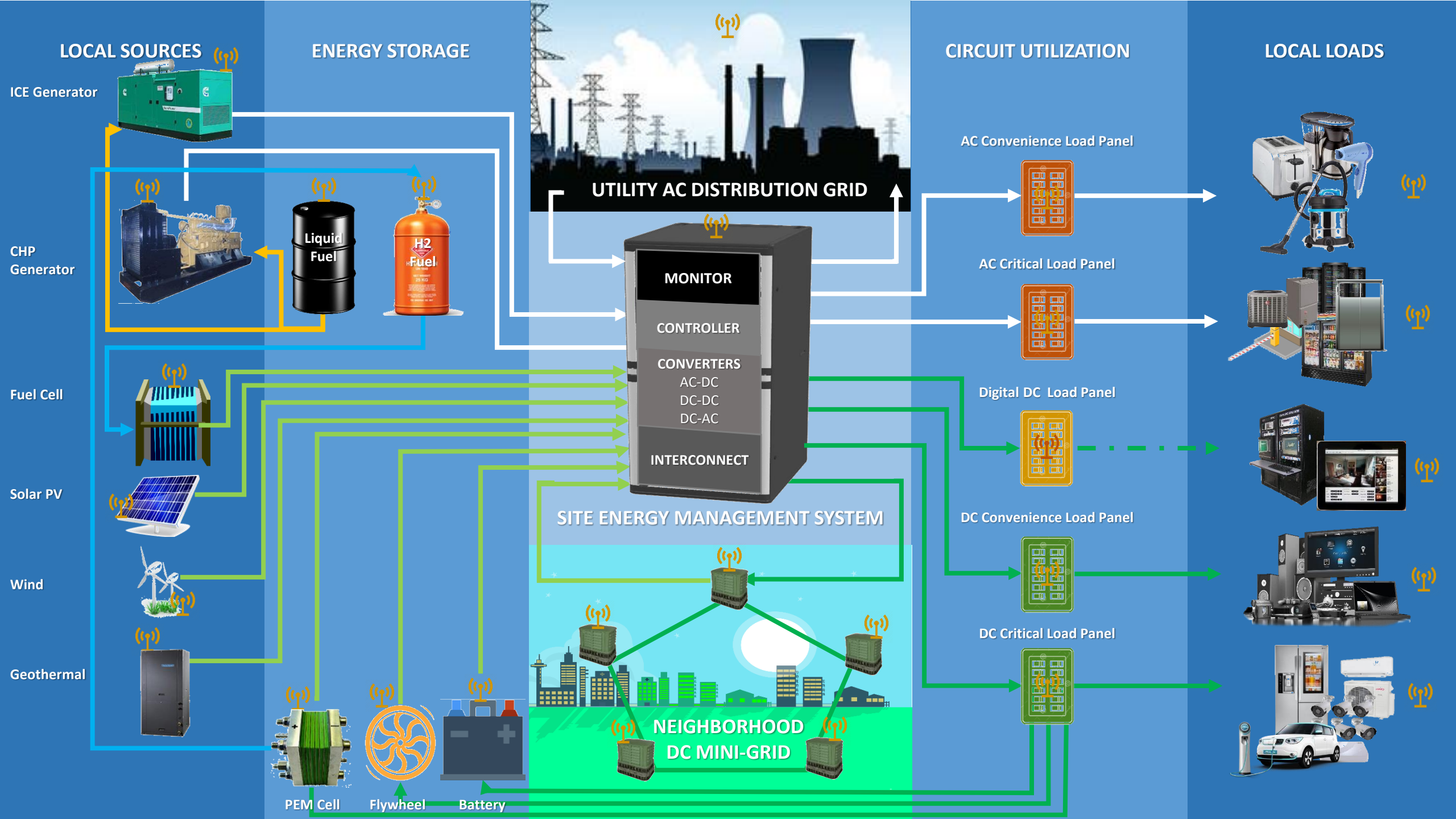
- DC as a Service (DCaaS)
- Bulk/Reserve Storage
- Co-located Production
- Bi-directional Flow
- integration of Renewables
- Provide Grid Service
- Resilient Grid Connection
- Open communication Links



...of non-synchronous nanogrids, microgrids & macrogrids...

Organized in a Tiered Framework





Event Scenarios

- Loss of Utility power
- EMP Event
- Daytime with sun
- Daytime without sun
- Nighttime with wind
- Nighttime without wind
- Excess on site generation
- Grid demand Response
- Duck curve
- Pricing
- System Maintenance
- Additional Generation
- Regenerative Hydrogen
- Incremental Resource addition

Solar Power Direct
Current for Energy
Storage

Uninterruptible Power Supply

AC Power



AC Converted to DC for **Energy Storage** *DC inverted to AC*

"less efficient pathway"



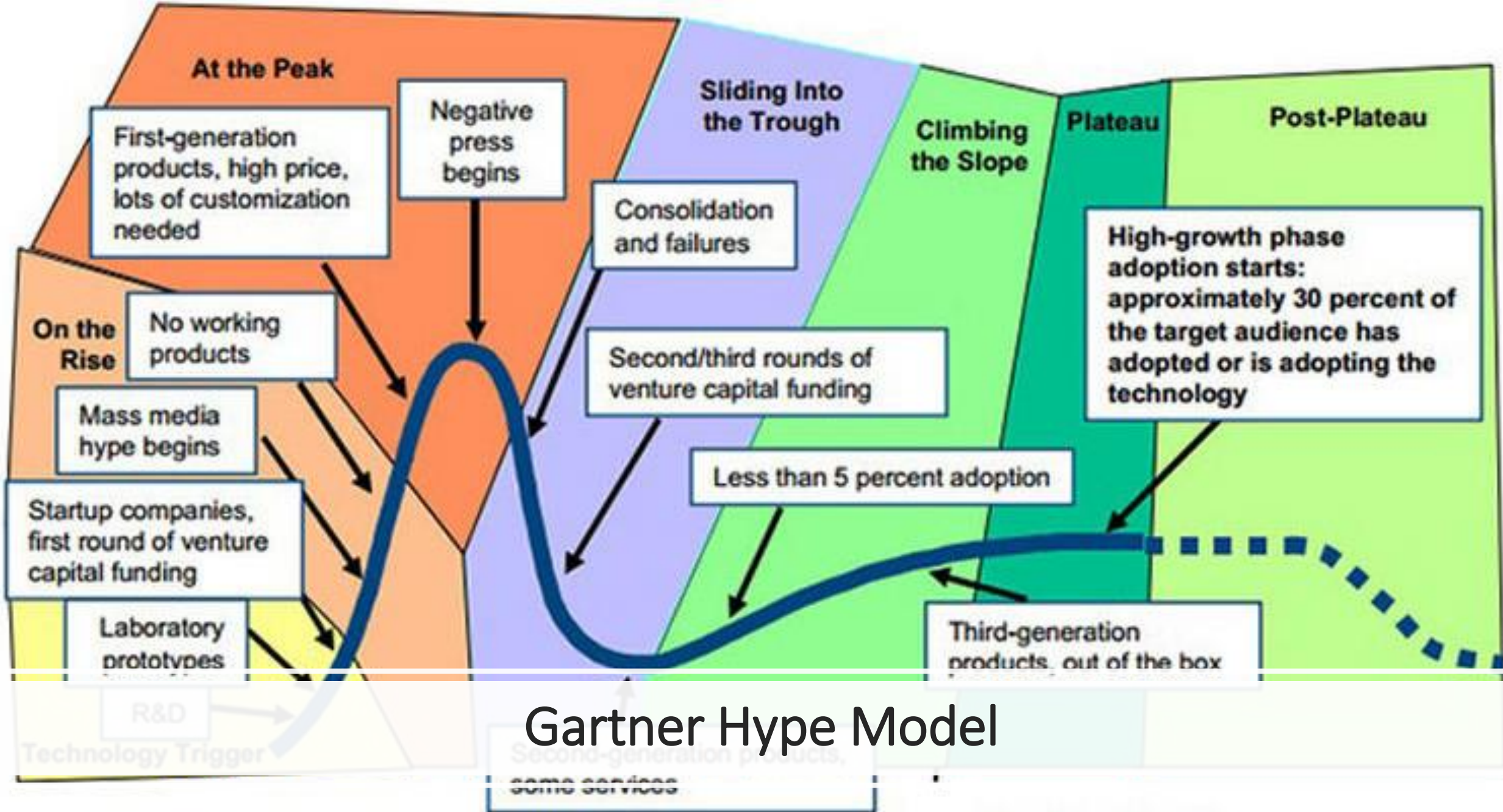
AC Power



Converted to
DC for Digital
Equipment



Direct Current for
Digital Equipment



Gartner Hype Model