Hybrid Microgrids

Diesel Power and Renewables

Chris Pye

ComAp
The heart of smart control

1 Global Distributor Network

250+ Products and Accessories

More than **25** Years of Success and Experience

9 Subsidiaries

100+ R&D Staff

350+ Employees

150+ Countries

1 Global Headquarters, Prague, Czech Republic

ComAp's Global Subsidiaries

One ComAp

Worldwide distribution network

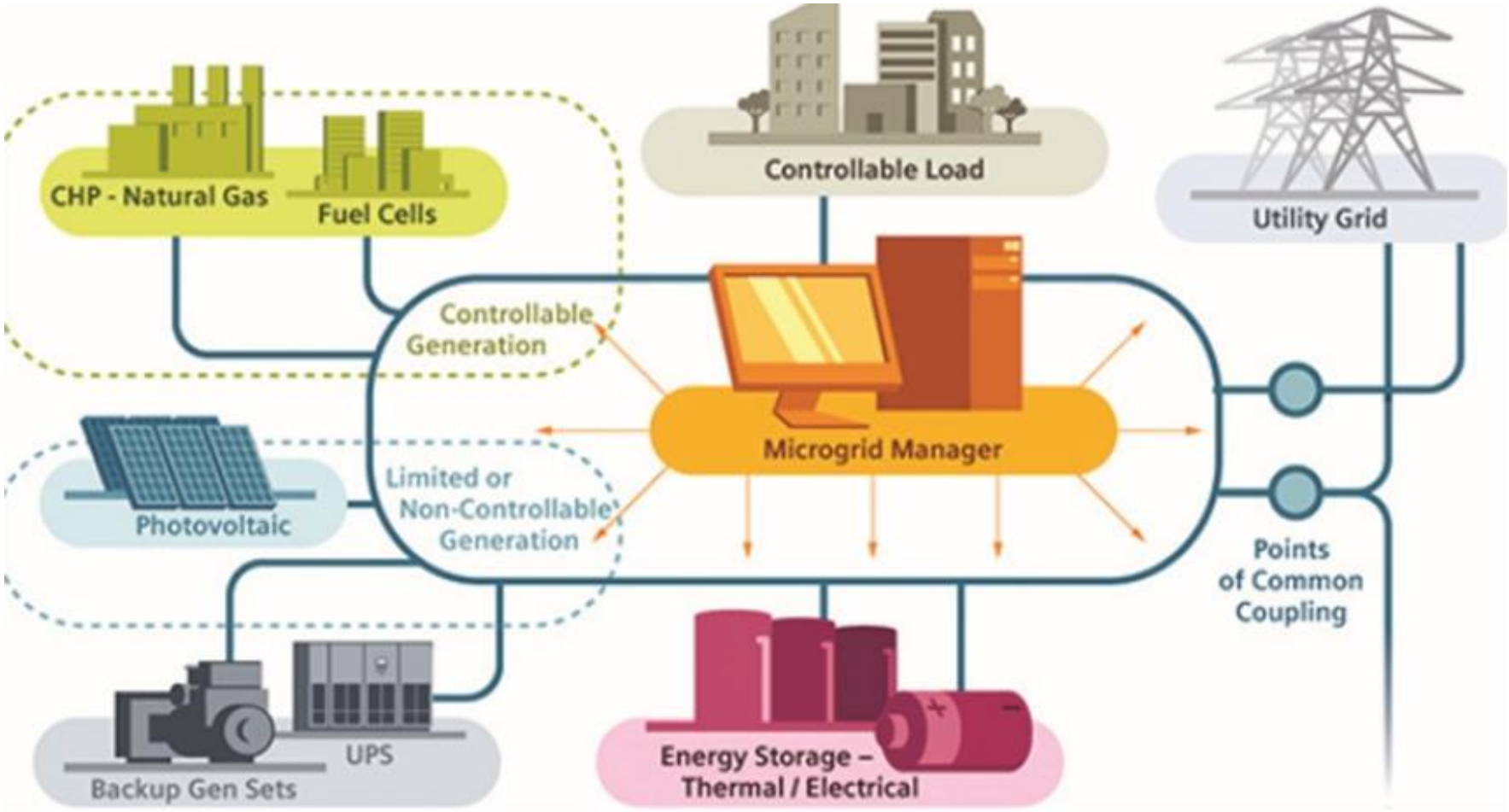
ComAp´s Market Segments

ComAp
The heart of smart control

Smart and reliable solutions for every application

- Single gen-set applications
- Parallel gen-set applications
- Complex power generation applications
- Mains Protections
- Engine driven applications
- Advanced drive applications
- Bi-fuel applications
- Hybrid applications
- Telecom applications
- Gas applications

Hybrid Microgrids – the trend of today



PV-Diesel Hybrid System

Diesel generator system

Photovoltaic or wind turbine system

Hybrid power system

- Hybrid application combines reciprocating engine/s (genset/s) and a renewable source/s of power
- On-grid as well as off-grid applications

The benefits of a Hybrid System

Diesel generator system

+ Reliable source of power
+ Variable load coverage
+ Quick availability and reaction

− Cost of fuel and maintenance
− Pollution and emissions

Photovoltaic or wind turbine system

+ No fuel is burned
+ Environmentally friendly technology
+ Less maintenance

− Intermittency of production
− Unable to react on changing load
− Expensive energy storage required

Hybrid power system

+ Lowering electricity costs and pollution, while keeping reliability
+ Less dependency on fuel shipments
+ Lower maintenance costs
+ Save fuel
+ Economical, even without subsidies
+ Lower requirement for power storage

Microgrids – benefits for all parties?

- **Utilities & DNOs**
  - Enable higher penetration of RNW energy resources without the risk of power outages and/or instability.
- **Aggregators**
  - New business models, innovative technologies, challenging system integration
- **End users**
  - Significant reduction of OPEX
  - Lower dependency on the fuel supplier and pricing structure
  - Reduced emissions production and air pollution
- **Investors**
  - Help the end users to avoid the upfront investment

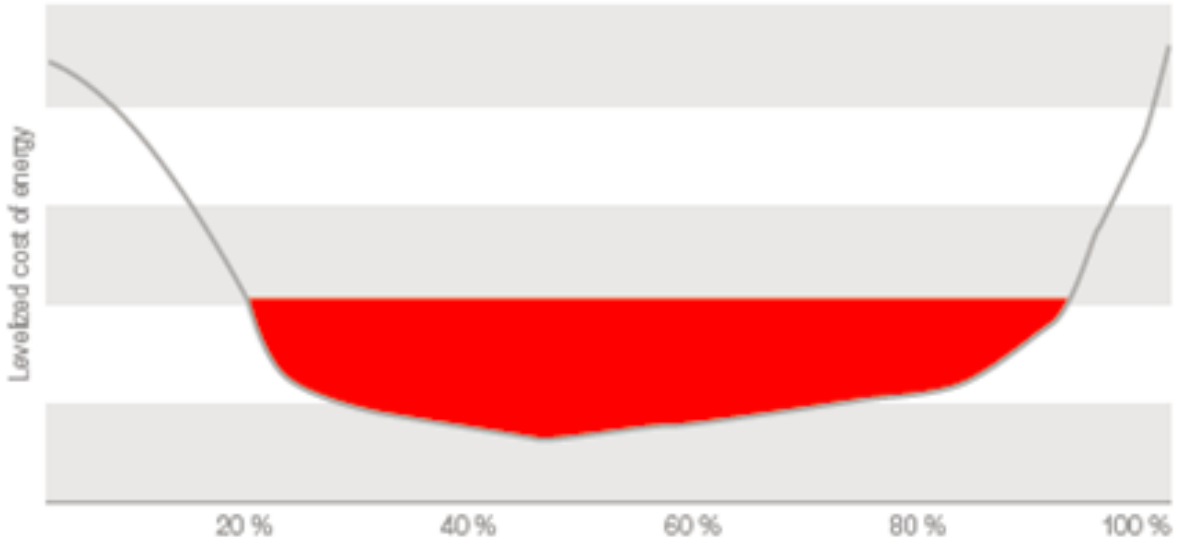
Challenges

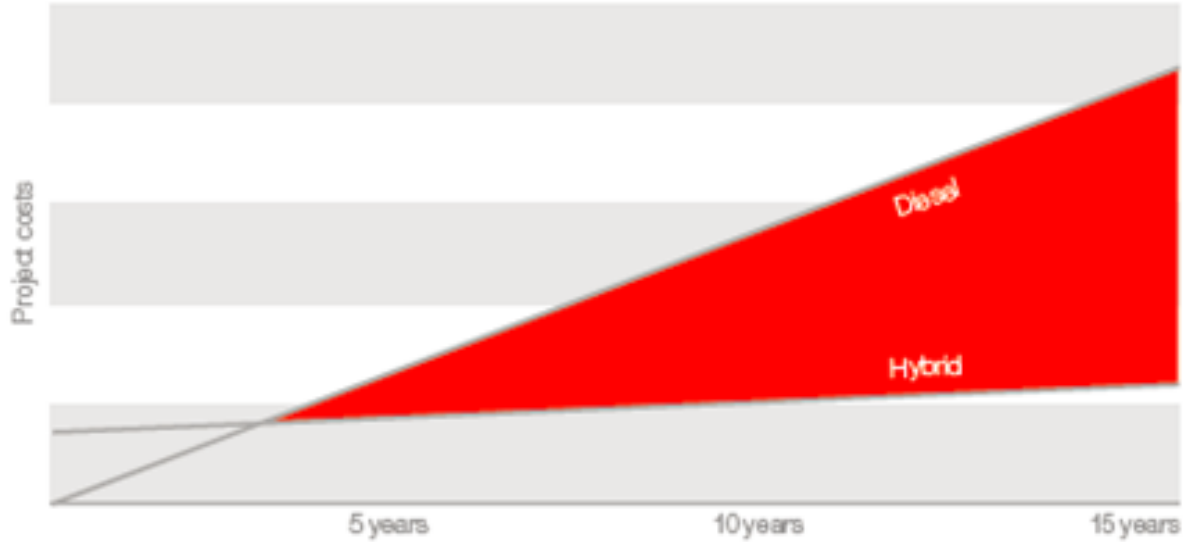
- **Technical**
- Parallel operation of various resources still not an easy option for many
- The demand on control is high only with high penetration (over 60% penetration)
- Stability and reliability of the system is the most challenging issue

- **Financial**
- Territories with diesel subsidies are not motivated to invest
- The upfront investment is often the barrier
- The IPP business model can be a solution, but price dependency on the provider can be a deal breaker

End user landscape

The economy of the system

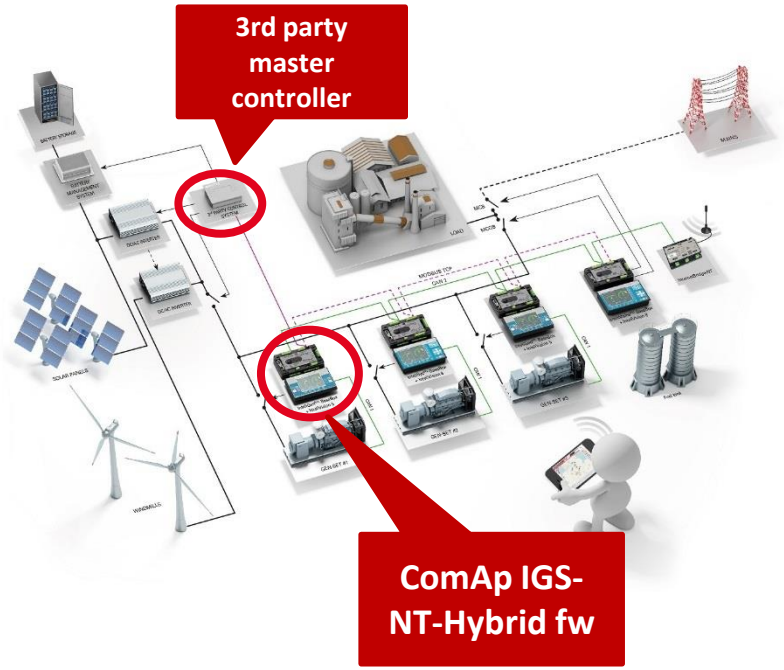




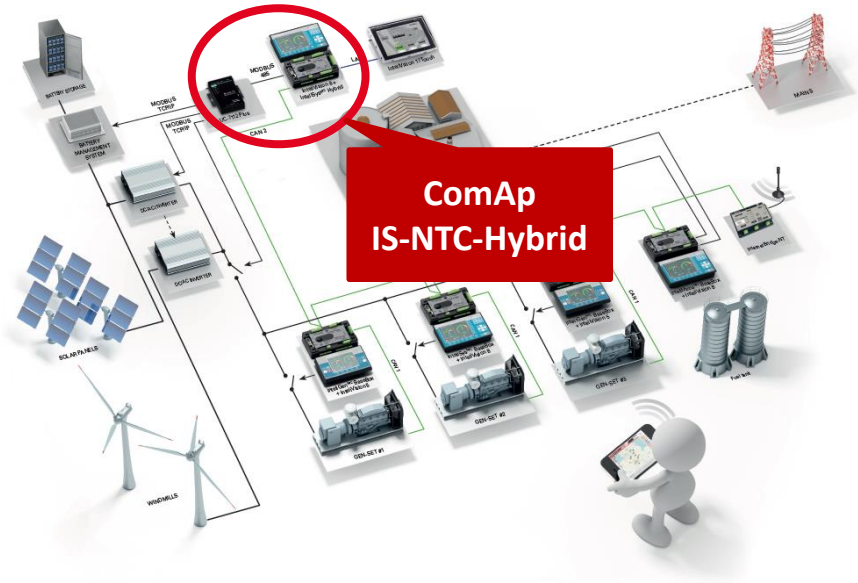
- The highest system profitability is achieved within **40 – 60% of PV penetration**
- The typical break even point can be as short as **4 years**

Microgrids/Hybrids – Commercial Offerings

Solution 1 – ComAp slave



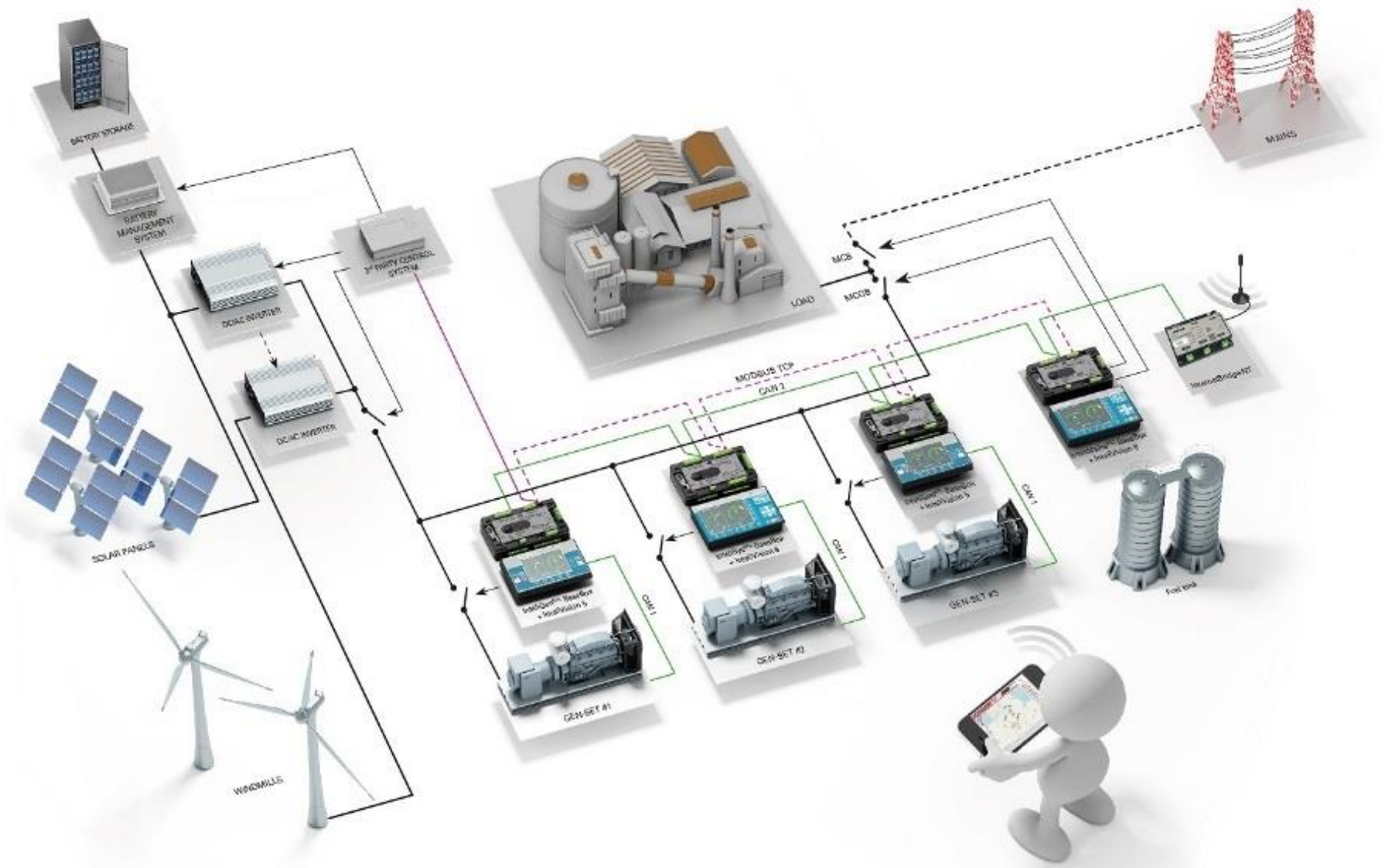
Solution 2 – ComAp master



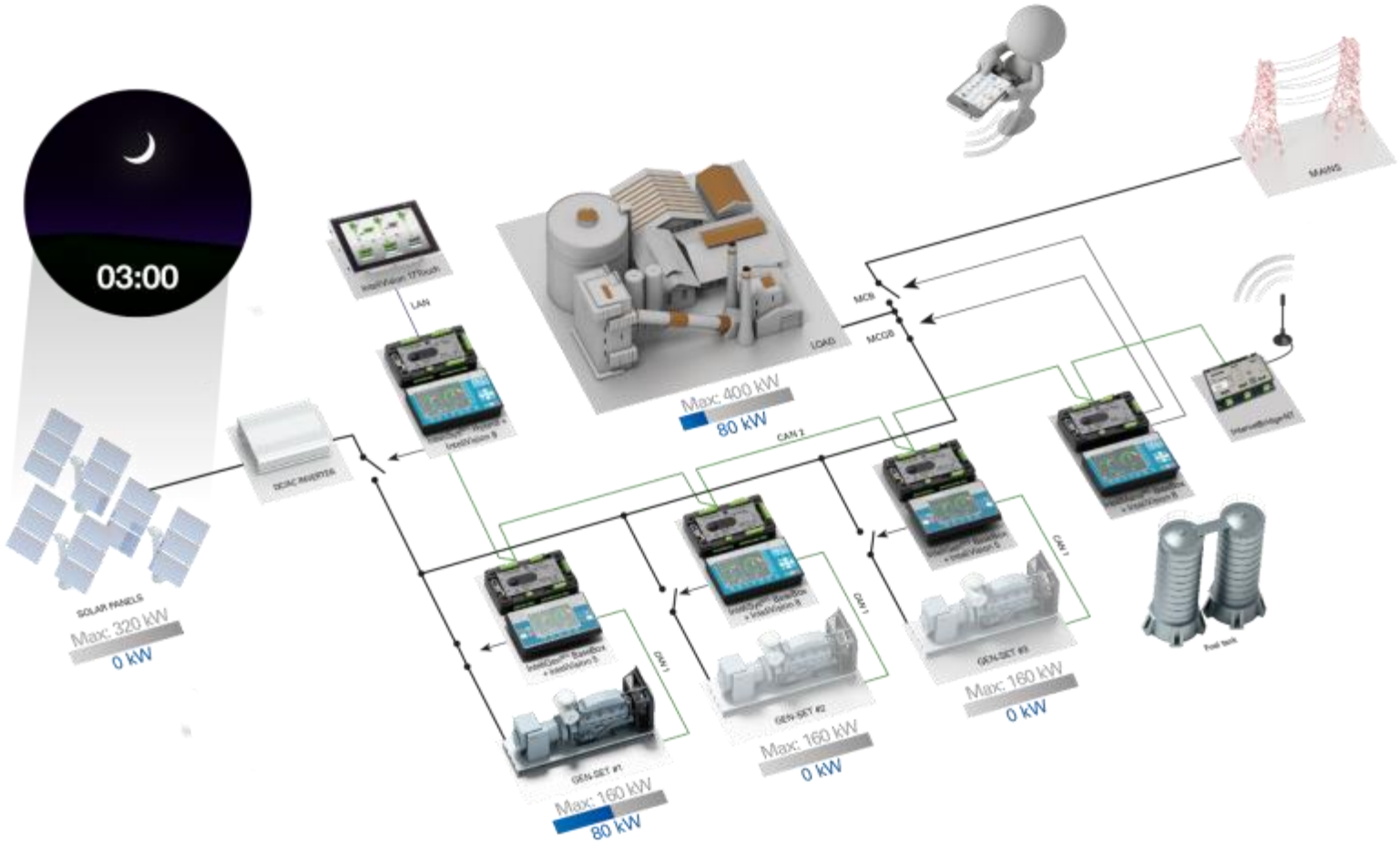
InteliSys NTC Hybrid control system

- Master controller for hybrid applications
- Smooth interface with gen-set controllers over CAN
- Communication with the PV inverters over Modbus (RTU or TCP/IP)
- Predefined interface to a number of well-known inverters
  - SMA, ABB, Fronius, Delta, Huawei, KACO
- Extensive statistics of renewable energy production
- Extensive statistics of gen-set(s) energy production
- Prevention of the gen-set(s) underloading
- Reduction of the PV output only when necessary
- Smart power management and load sharing to accommodate maximum RNW energy

Complex hybrid application

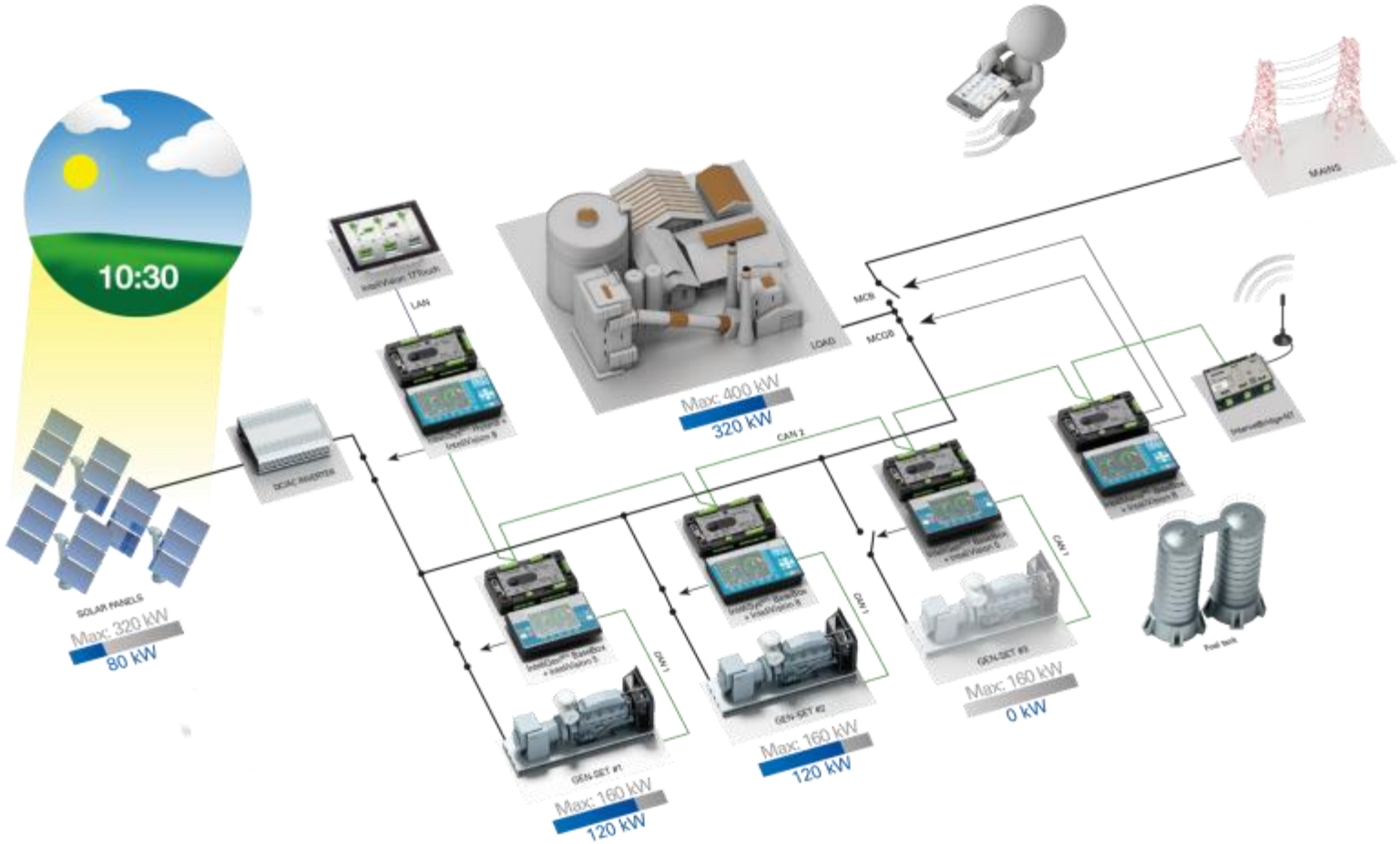


ComAp hybrid power management



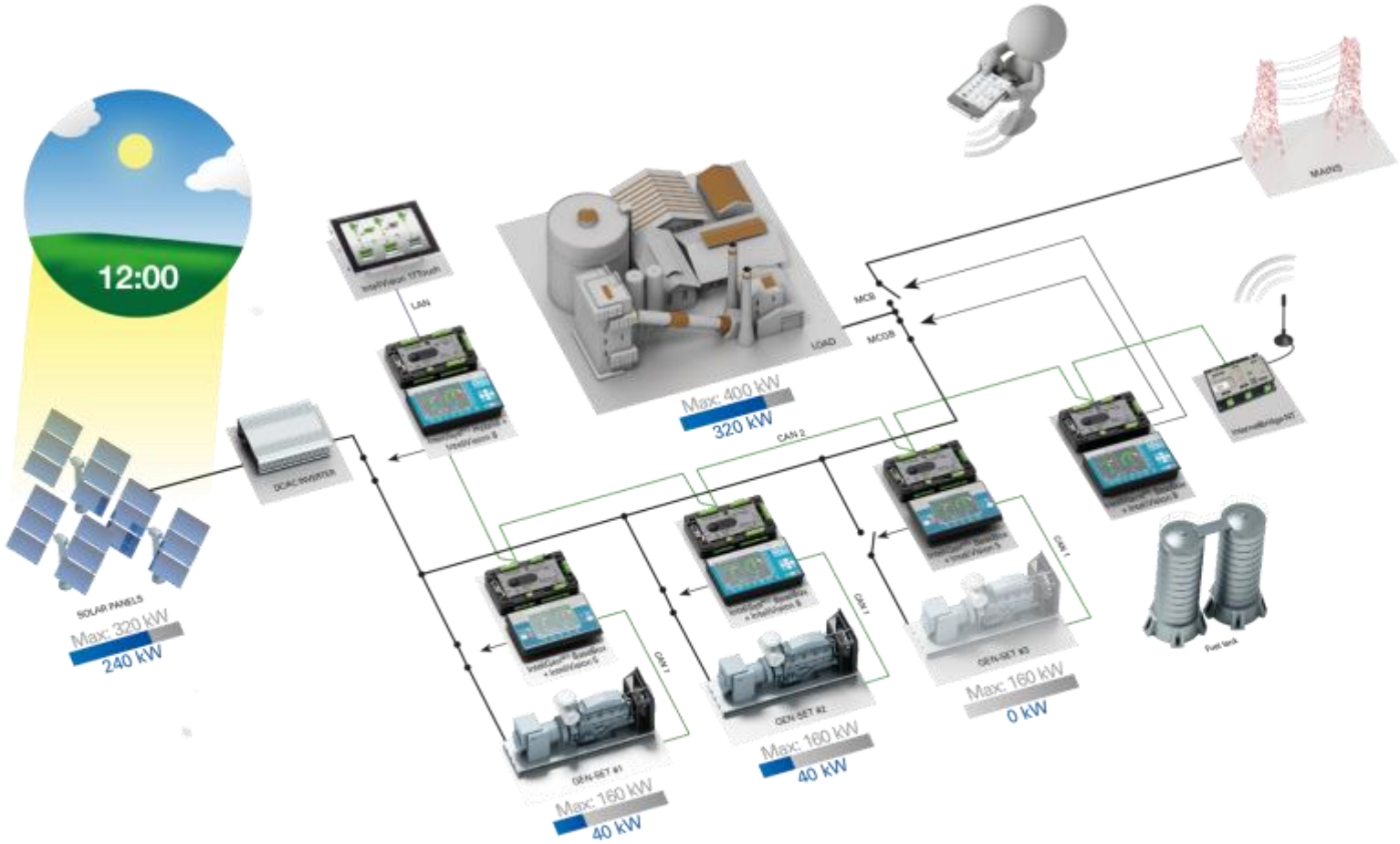
- In the case that grid is not available, ComAp controllers will control the site to match the genset output with the load
- This picture represents the low load during the night

ComAp hybrid power management



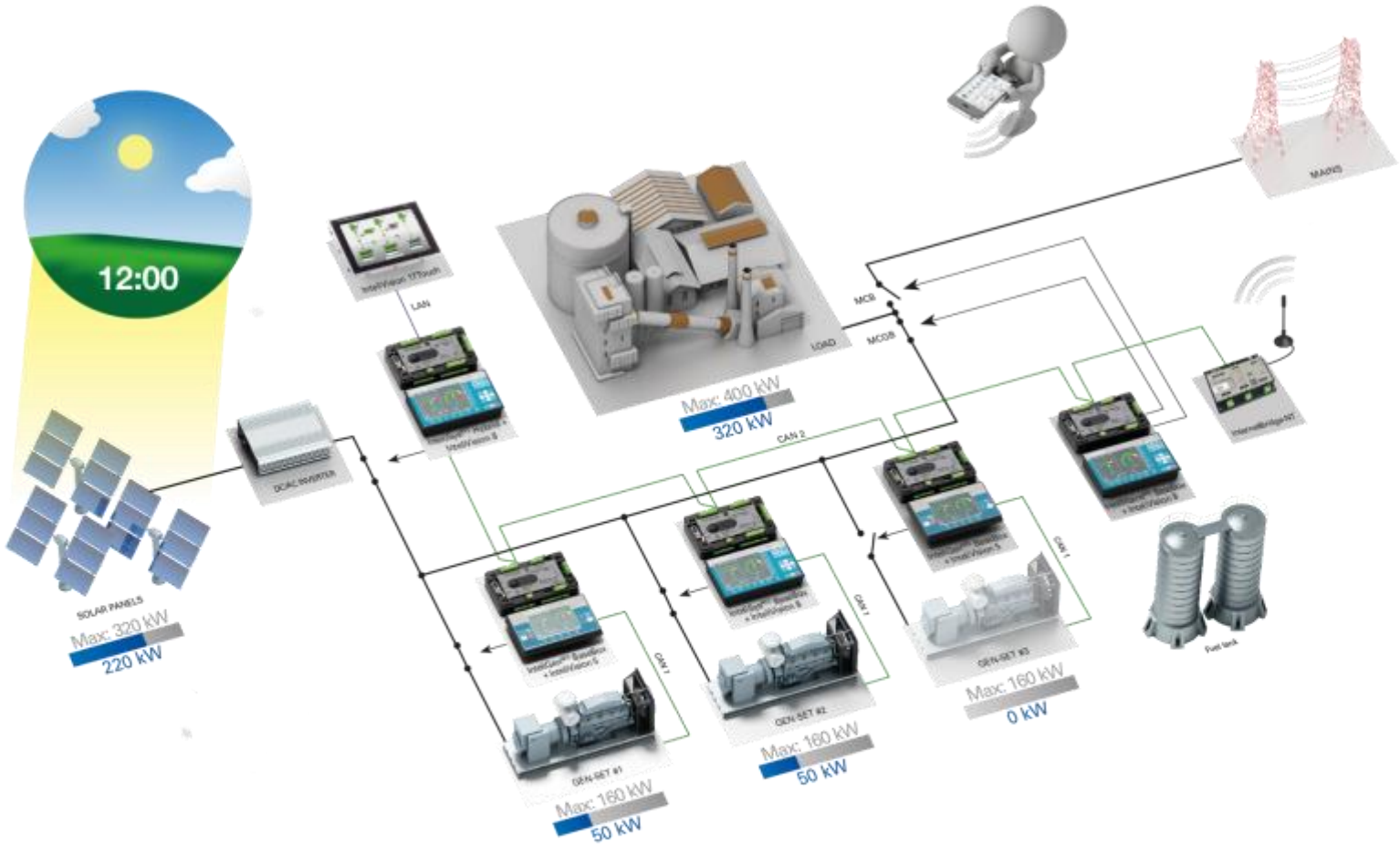
- During the morning the PV power plant starts to produce power
- ComAp controllers adjust the output of the gen-sets according to the PV output to match the load

ComAp hybrid power management



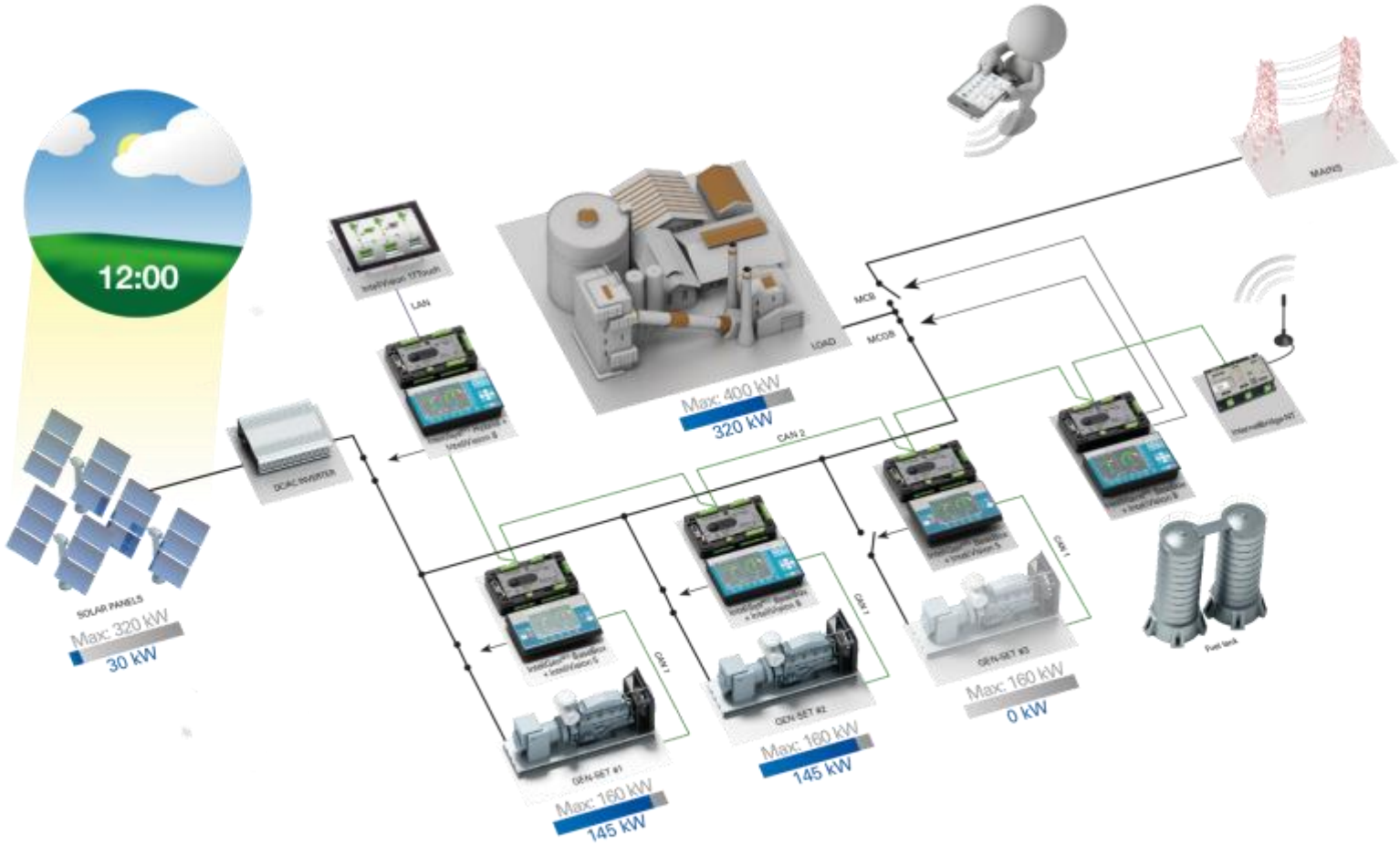
- In the middle of the day the PV output reaches the highest output
- In this case the gensets run under-loaded

ComAp hybrid power management



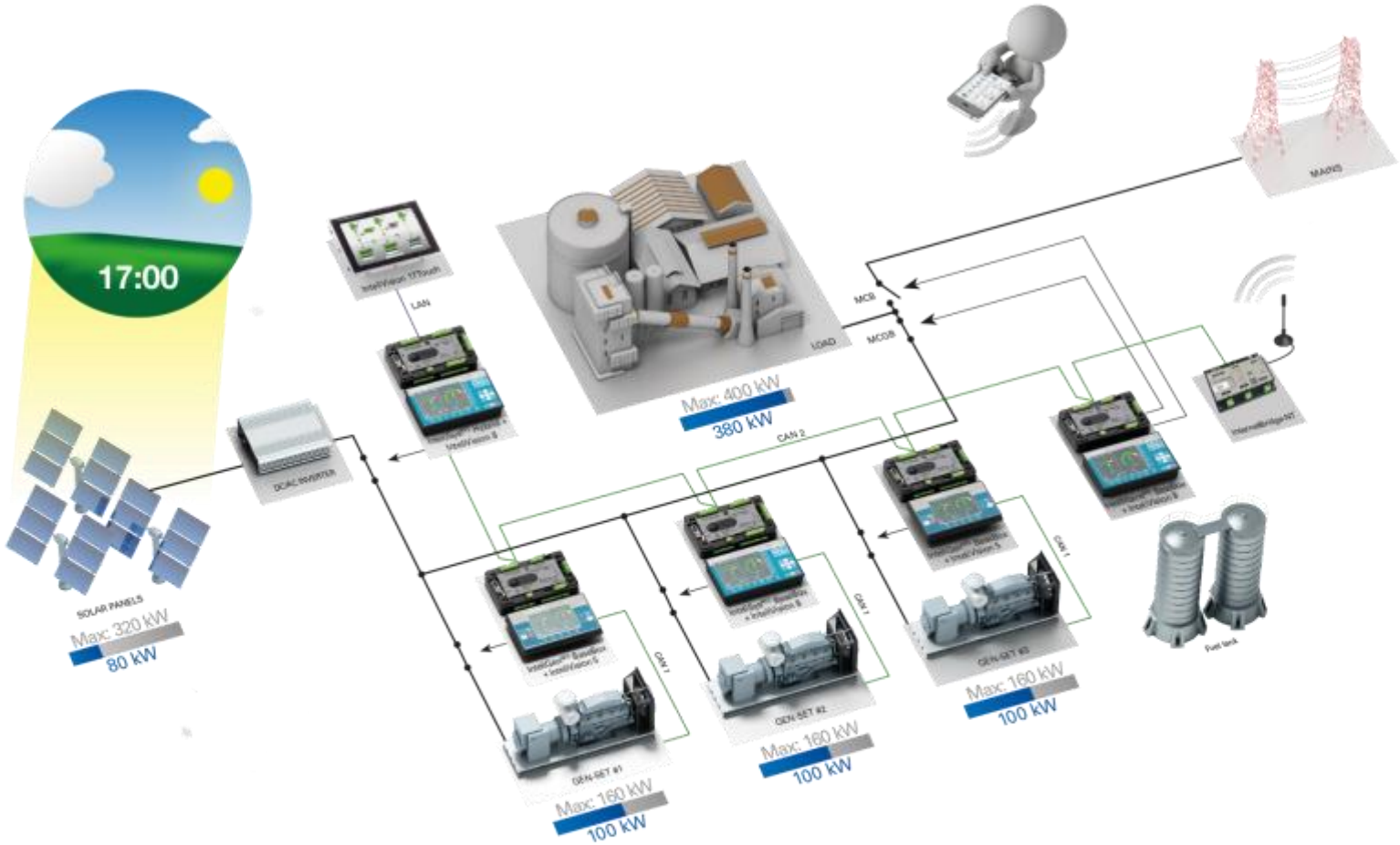
- In standard power management one of the gen-sets would be shut down but in this case this would endanger the reliability of the whole system
- The output of the PV is reduced in order to protect the gen-sets from being under-loaded

ComAp hybrid power management



- When the PV plant is covered by cloud ComAp controllers will automatically load the gen-sets to keep the smooth power delivery

ComAp hybrid power management



- During the afternoon the PV output is decreasing and the load is typically increasing
- The controllers will start, synchronize and load more gensets to cover the load

Energy storage in microgrids

Different usage

- Storing excess energy
- Offsetting the power output of the renewable energy source
- Offsetting load fluctuations
- Peak shaving
- UPS (Uninterruptible Power Supply)
- Prime power supply

Energy storage options

- Pumped hydroelectric storage
  - \- Favourable environmental conditions necessary
  - \- Time consuming construction
  - \- High investment costs
  - \+ Most cost-effective means of storage for large amounts of energy
  - \+ Renewable Energy
- Flywheel
  - \+ Long lifetime (from 10^5, up to 10^7 cycles of use)
  - \+ Little or no maintenance
  - \+ High specific energy and large power output
  - \- Costs
- Super capacitors
  - \+ Very high energy per unit volume
  - \+ Much faster charging than batteries
  - \+ Many more lifecycles than batteries

Batteries for microgrids

Li-Ion

- Low capacity
- Lot of control electronics due to the risk of ignition
- Worse performance out of recommended temperature range
- Lower number of cycles
+ Affordability

Lead-Acid

- Low energy-to-weight and energy-to-volume ratio
- Not designed for deep discharge
- Dangerous components
+ Low price
+ High energy-to-power ratio

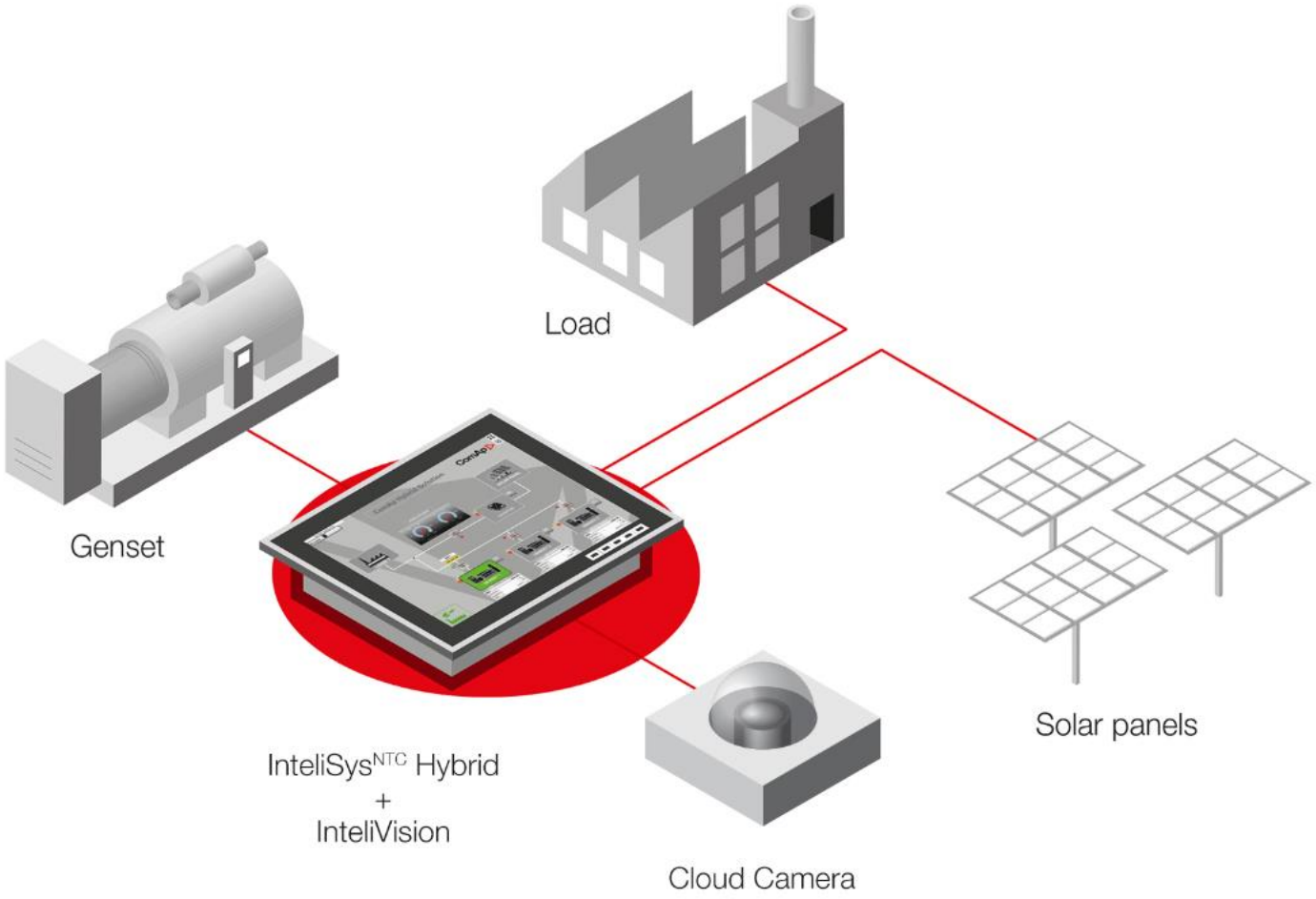
NMC (Nickel-Manganese-Cobalt)

NCA, LCO, …

LiFePO4 (LFP)

- High price
+ High safety
+ High number of cycles
+ High discharge currents
+ One big pack – simple and less prone to failure

Cloud forecasting system



- **Fuel** consumption reduction
- Efficient **power** outage risk elimination
- Extended gen-set **life**
- Operational **cost** optimization
- **Emissions** reduction

Reference projects
- Lessons learnt

Peter Island, British Virgin Islands

- **Four diesel gen-sets (540kW each) and two wind turbines (259kW each)**
- **ComAp provided highly optimized power management for lower load reserve and efficient automatic control of the gen-sets operation to offset wind farm output fluctuations**
- **Fuel consumption costs cut by $500,000 per year**

Wind-diesel power plant
Burgos Island, Philippines

Burgos Wind Farm

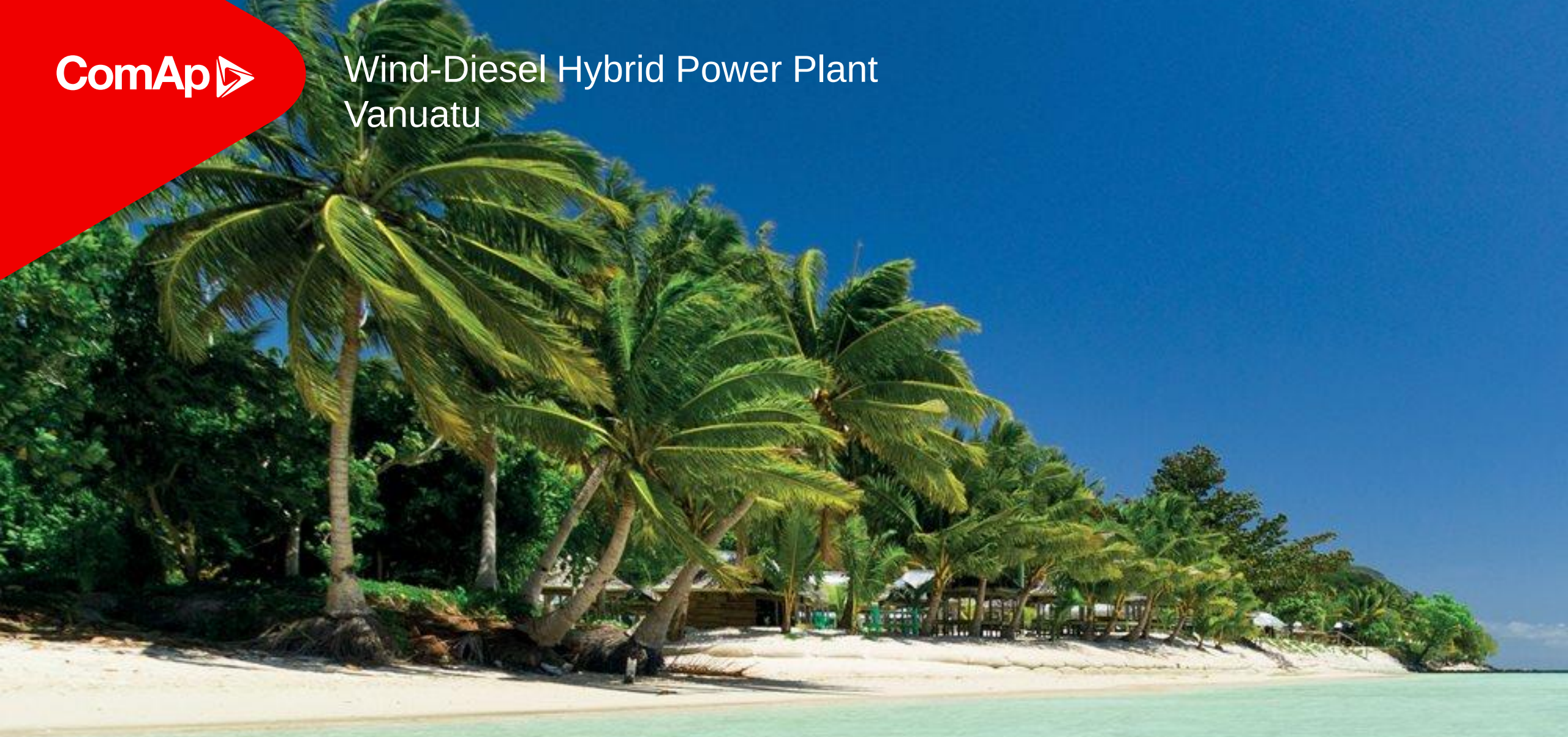
- **The largest wind farm in South East Asia; production of 233 GWh/year to provide power for a million households**
- **ComAp installed control system on back-up gensets for emergency power**
- Load picked up within 20s; zero spinning reserve required
- Prevention of damage in high speed wind
- Maximized fuel savings and efficiency while keeping high safety standard

Solar-Diesel Hybrid Power Plant Kiribati

Tarawa Island

- **Full automation of three 1400 kW low speed diesel generator systems and 500 kWp photovoltaic power plant**
- **The hybrid system saves approximately 227,000 litres of diesel every year**
- **Prevention from around 627 tons of CO_2 from being released into the atmosphere**

Wind-Diesel Hybrid Power Plant Vanuatu



- **Two 4 MW slow-speed engines along with a 3 MW wind farm**
- **The installed control system has allowed the wind energy penetration to be as high as 70% without any energy storage system**

Solar-Diesel Hybrid Power Plant Rarotonga

- **Diesel gen-sets (slow speed and high speed sets, total 8.5 MW) and PV power plant (0.65 MW)**
- **ComAp provided smart power management and load sharing between the low speed and high speed diesel gen-sets to optimize the power supply and diesel consumption**
- **Automation of originally manual operation minimized the spinning reserve, improved fuel consumption and lowered the operation costs**

ComAp's services for hybrid applications

Pre-sales service

Consultancy

Engineering – projects design

System Configuration

Gen-set controllers retrofitting

Commissioning

Training

After-sales support


ComAp
Save Fuel and
Maximize Power
System Reliability
That’s smart
control

Thank you for your attention

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