ComAp

Hybrid Microgrids

Co-ordination & Control

Chris Pye – ComAp’s Renewable Centre of Excellence

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ComAp's Global Subsidiaries

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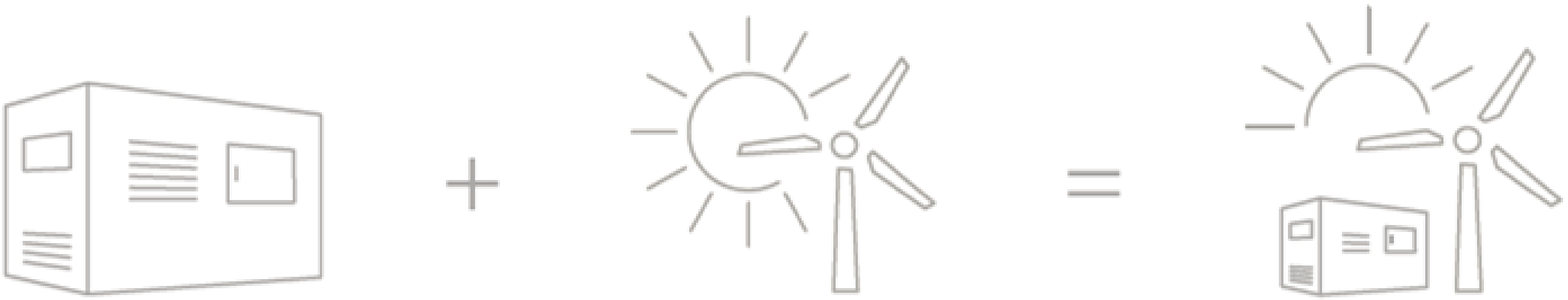
Smart and reliable solutions for every application

- 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

What is a 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

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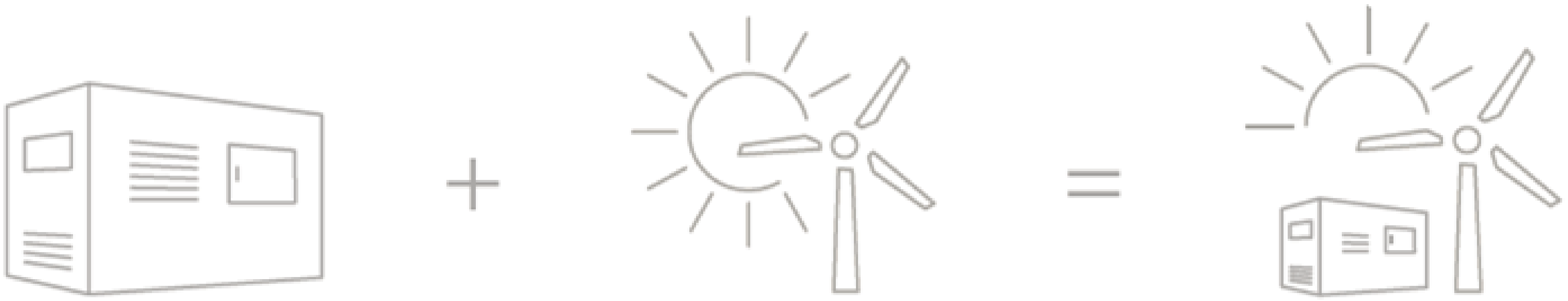
The benefits of a Hybrid System



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

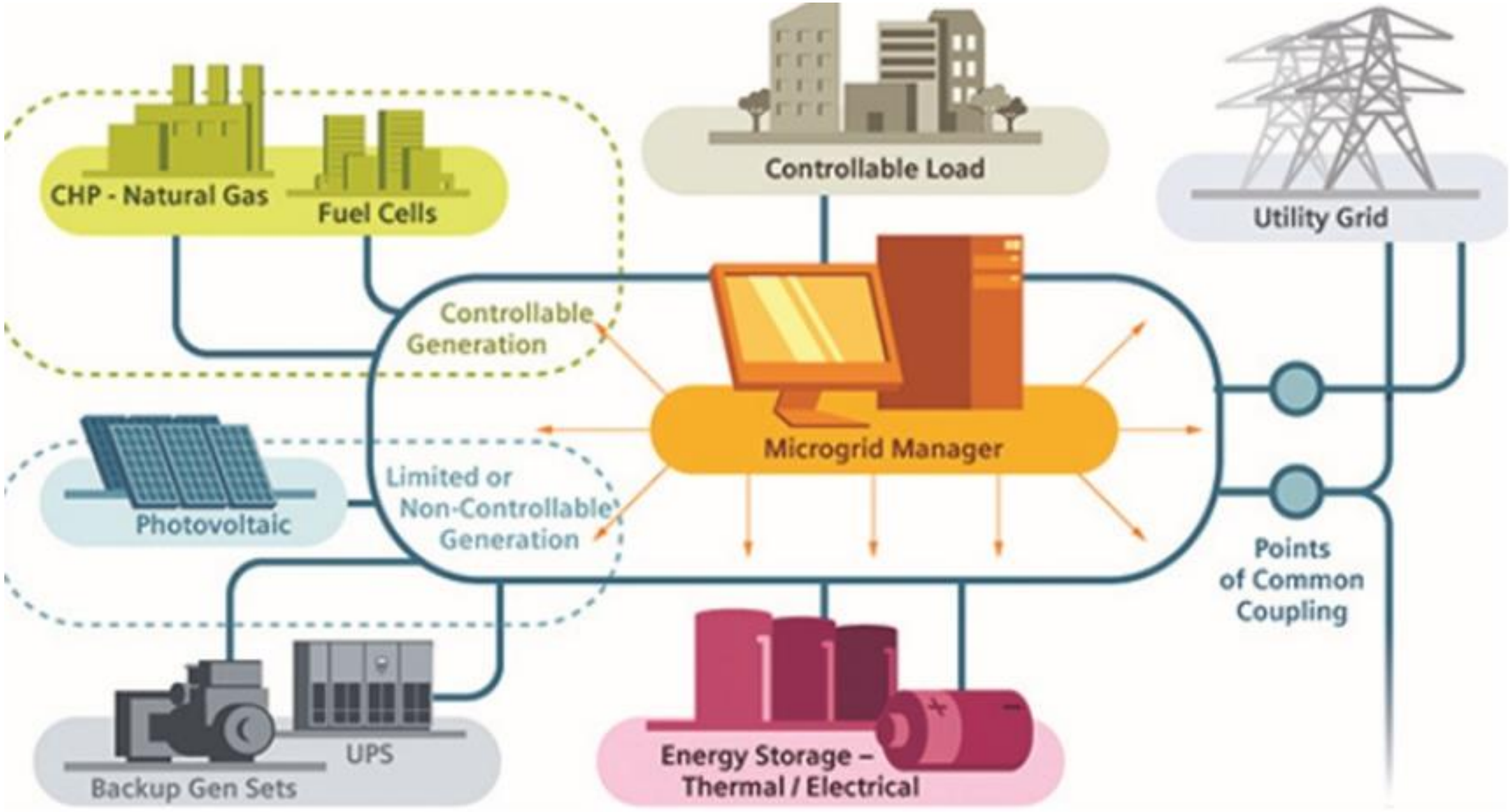
+ No fuel is burned
+ Environmentally friendly technology
+ Less maintenance

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

Hybrid power system

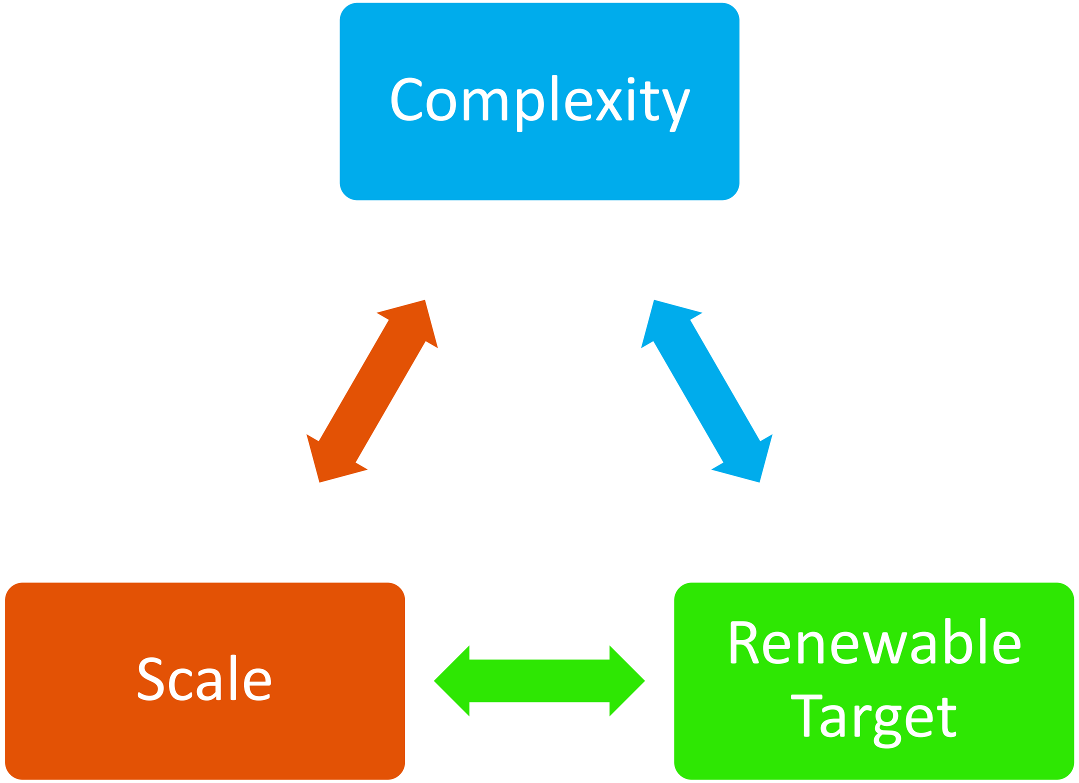
+ Lowering electricity costs and pollution, while keeping reliability
+ Less dependency on fuel shipments
+ Lower maintenance costs
+ Save fuel
+ Economical, even without subsidies
+ Lower requirement for power storage

Today's Microgrid – System Considerations



Hybrid Microgrid – Co-Ordination & Interface Requirements

- **There is no one solution suits all methodology for Hybrid Microgrids. Each design is defined by:**
- **Complexity** – specifically the number of potentially competing sub-systems required to for the hybrid microgrid
- **Scale –**
  - Simple stand-alone systems
  - Commercial/Industrial sized systems
  - Utility sized systems
- **RE Target**
  - Up to 30% Penetration
  - 31 – 60% Penetration
  - 61%+ Penetration



Complexity - Power Generation & Load Elements

Non-Renewable Thermal Generation

- Reciprocating Engine Technologies
  - Diesel Generators
  - Gas Generators
  - Low Load Diesel Generators
- Turbine Technologies
- Utility Mains Supply (Coal fired)

Renewable Power Sources

- Solar
- Wind (Induction based)
- Wind (Inverter based)
- Hydro
- Geo Thermal

Loads

- Normal Domestic & Commercial Profiles
- Dispatchable Loads
- Non-Essential removable loads
- Grid Stabilising Loads

Complexity - Energy Storage

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

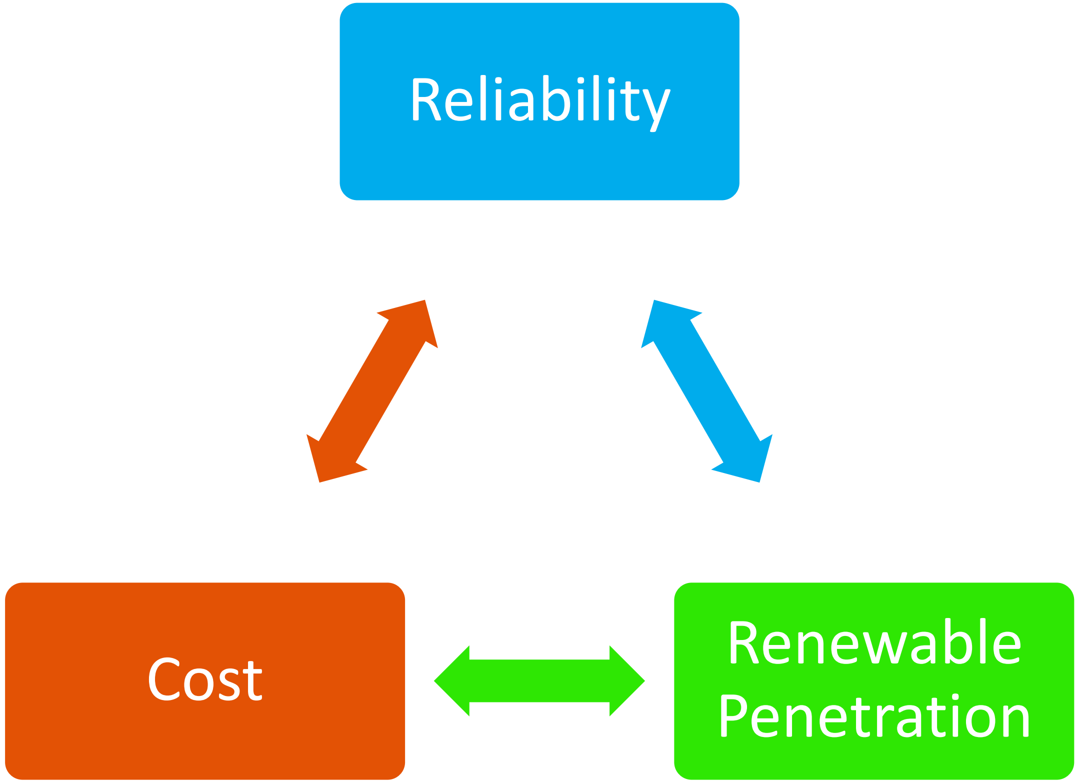
- Pumped hydroelectric storage
  - \- Favourable environmental conditions necessary
  - \- Time consuming construction
  - \- High investment costs
  - \+ Most cost-effective means of storage for large amounts of energy
  - \+ Renewable Energy

- 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

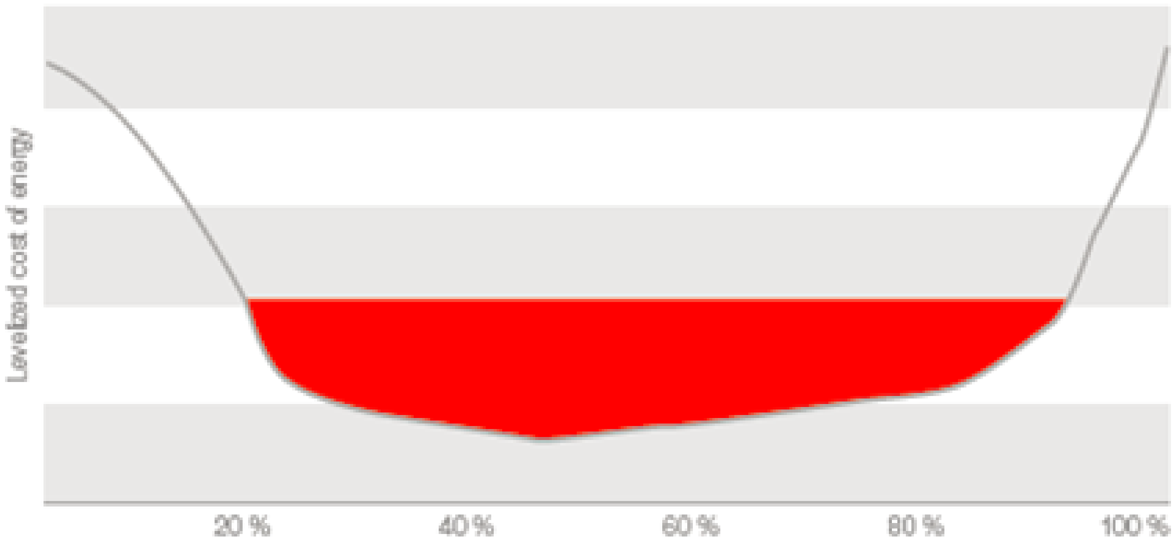
- Super capacitors
  - \+ Very high energy per unit volume
  - \+ Much faster charging than batteries
  - \+ Many more lifecycles than batteries

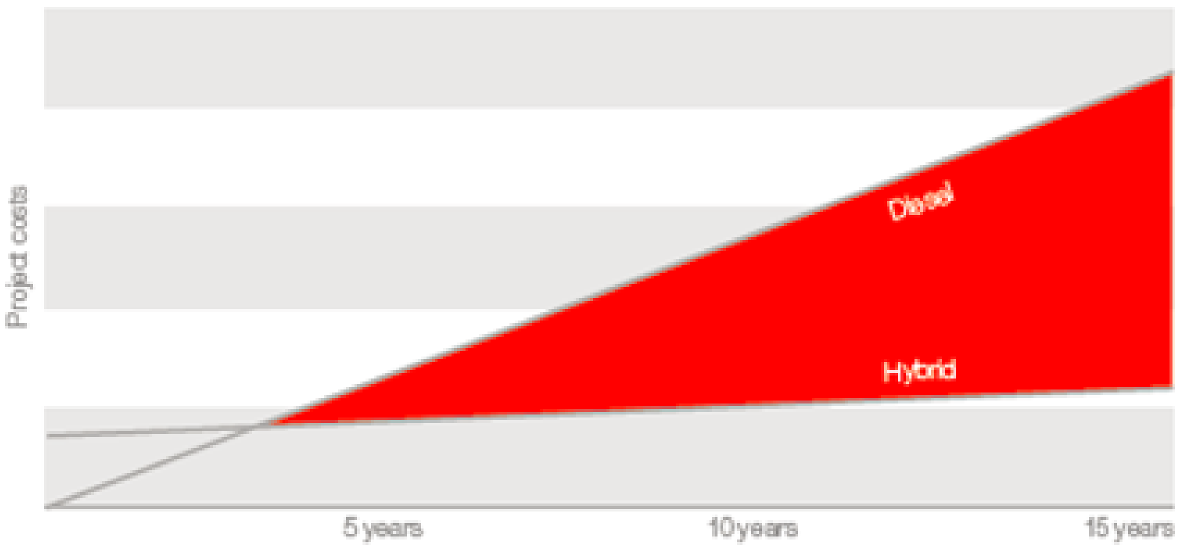
Hybrid Microgrids – System Characteristics

- **Hybrid Microgrid Systems are tied to three key factors:**
- Reliability
- Renewable Penetration % (Avg and/or instant.) &
- Cost
- **Under normal commercial conditions there is usually a compromise position that needs to be accepted.**



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**

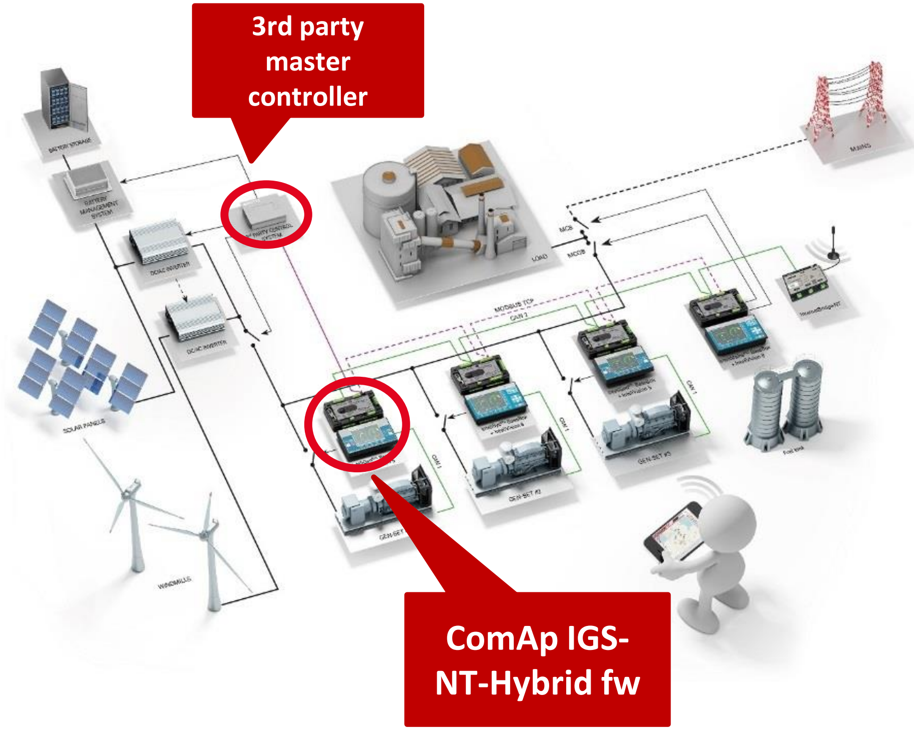
Challenges

- **Technical**
  - Parallel operation of various resources still not an easy option for many
  - Control requirements and system response times become critical for high RE penetration systems (RET > 60%)
  - Stability and reliability of the system is the most challenging issue
- **Financial**
  - End Users with diesel subsidies are not motivated to invest.
  - The upfront investment is often the barrier.
  - The IPP business model can be a solution, but pricing and commercial terms can be a deal breaker.

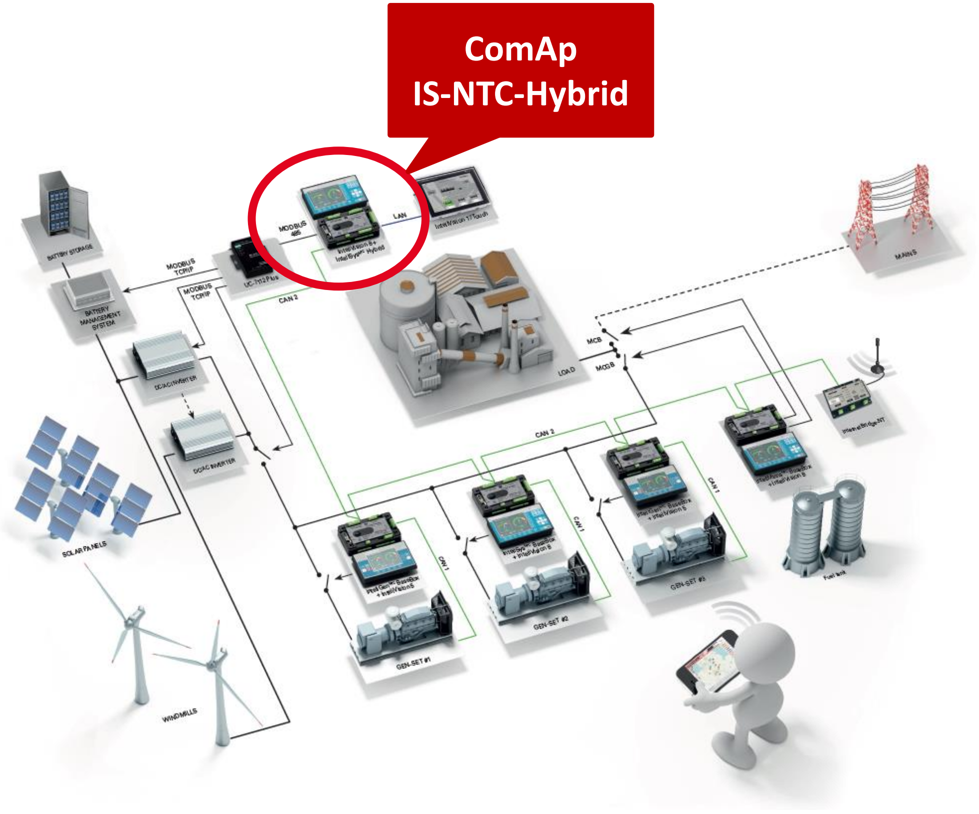
End user landscape

Microgrids/Hybrids – Commercial Offerings

Solution 1 – ComAp Slave



Solution 2 – ComAp Master



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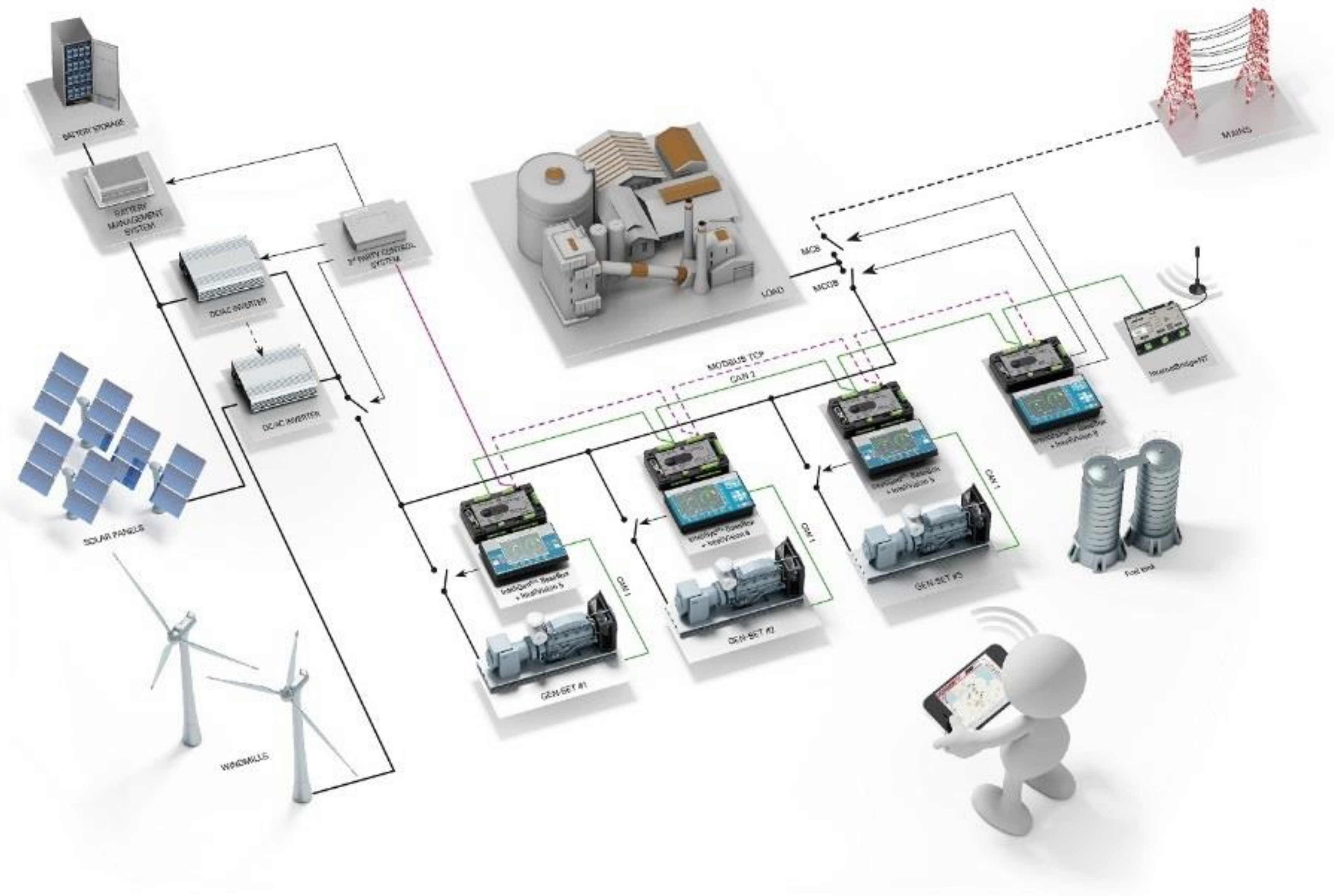
InteliSys NTC Hybrid control system

- 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



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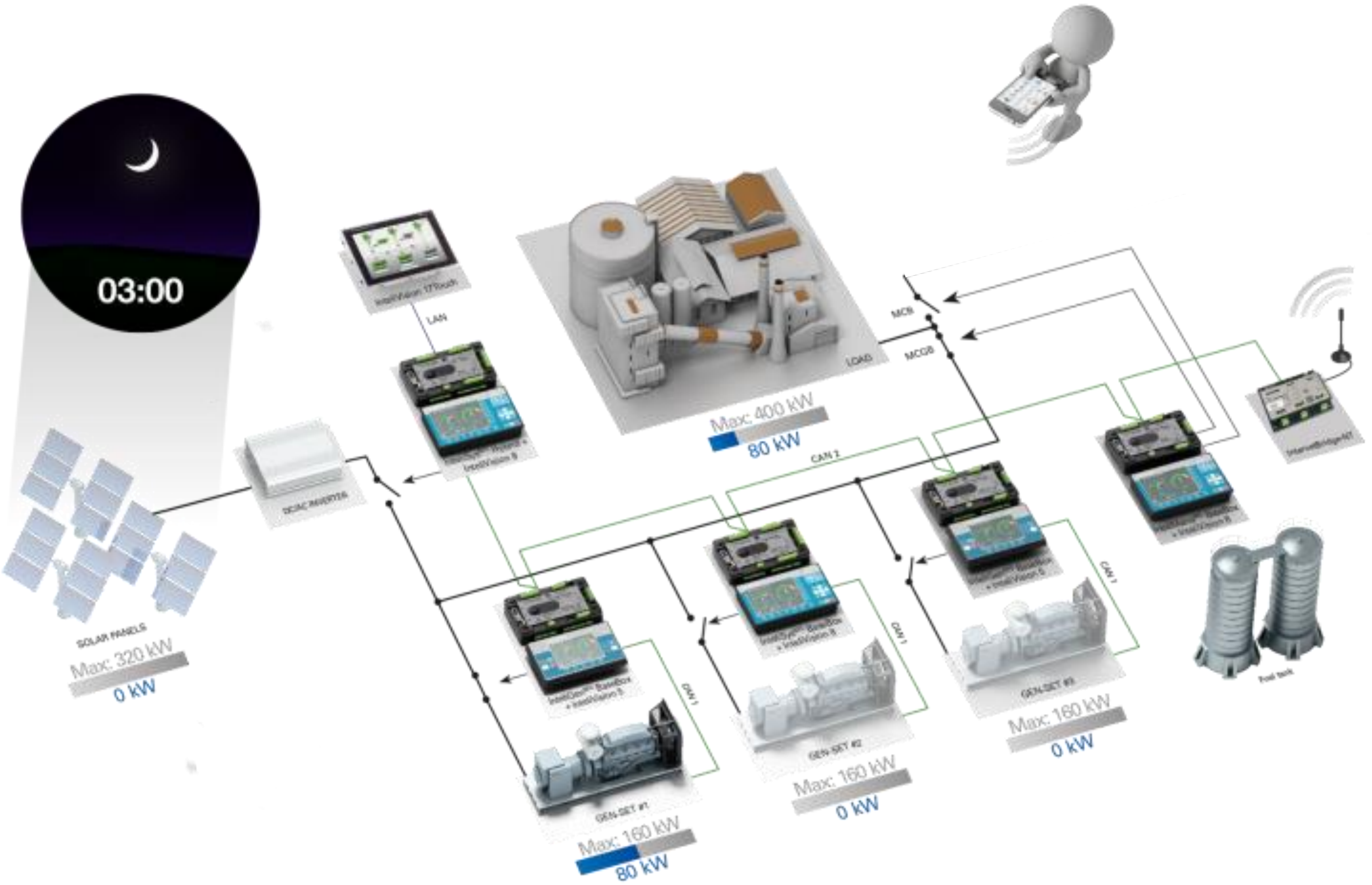
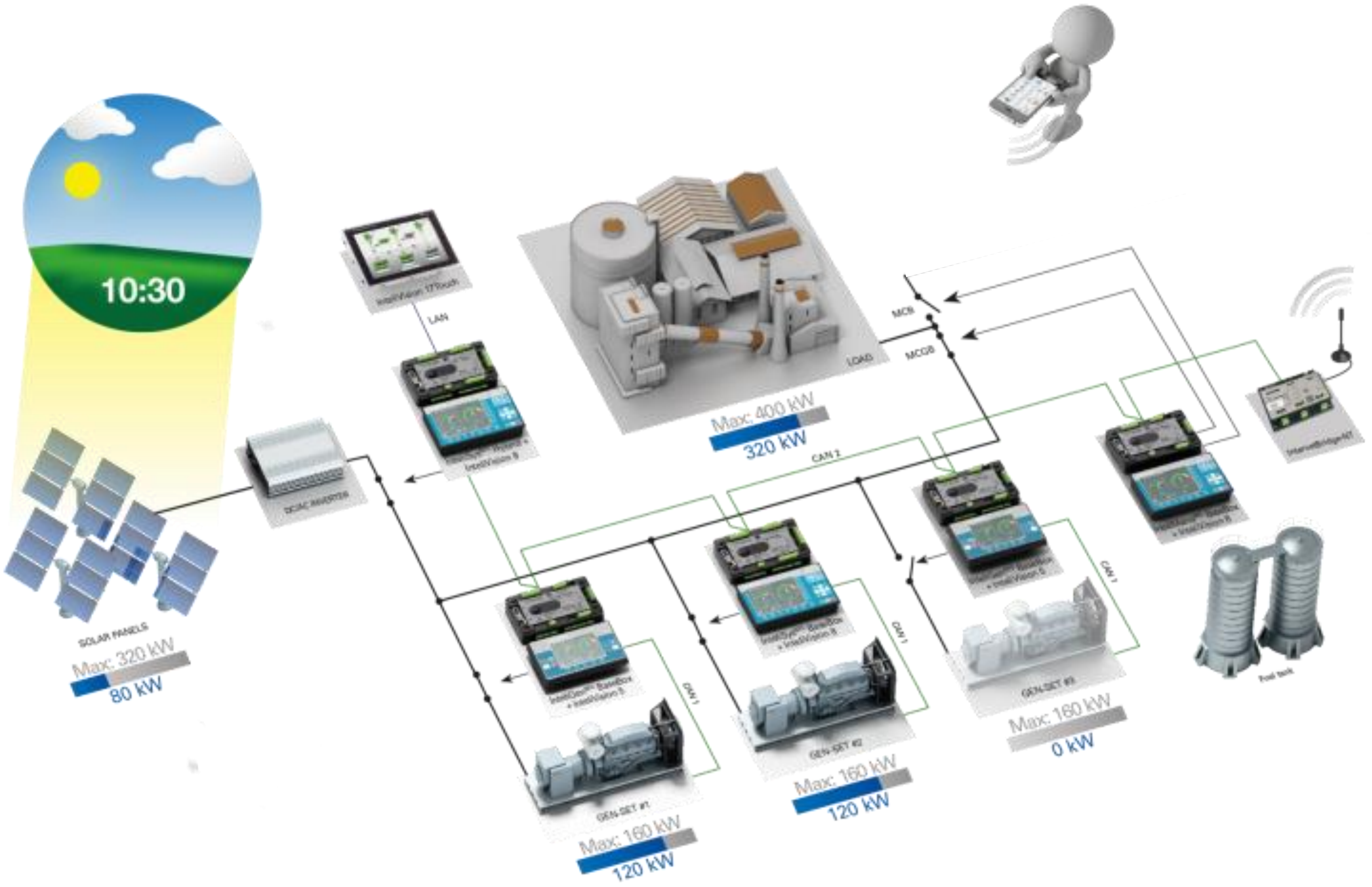
Example: ComAp Hybrid Power Management



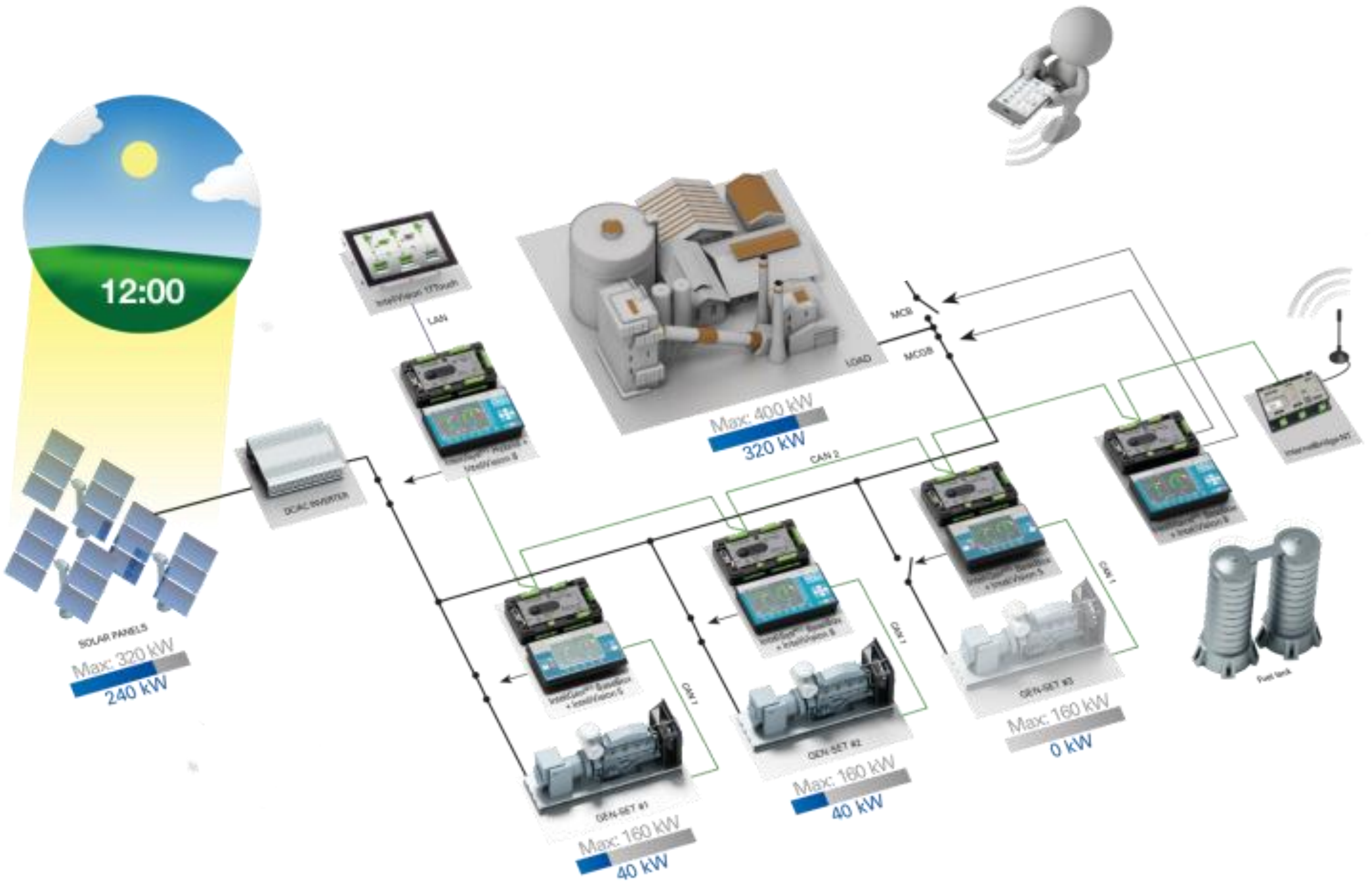
- In the case that grid is not available, ComAp controllers will control the site to match the genset output with the load
- This picture represents the low load during the night

Example: ComAp Hybrid Power Management



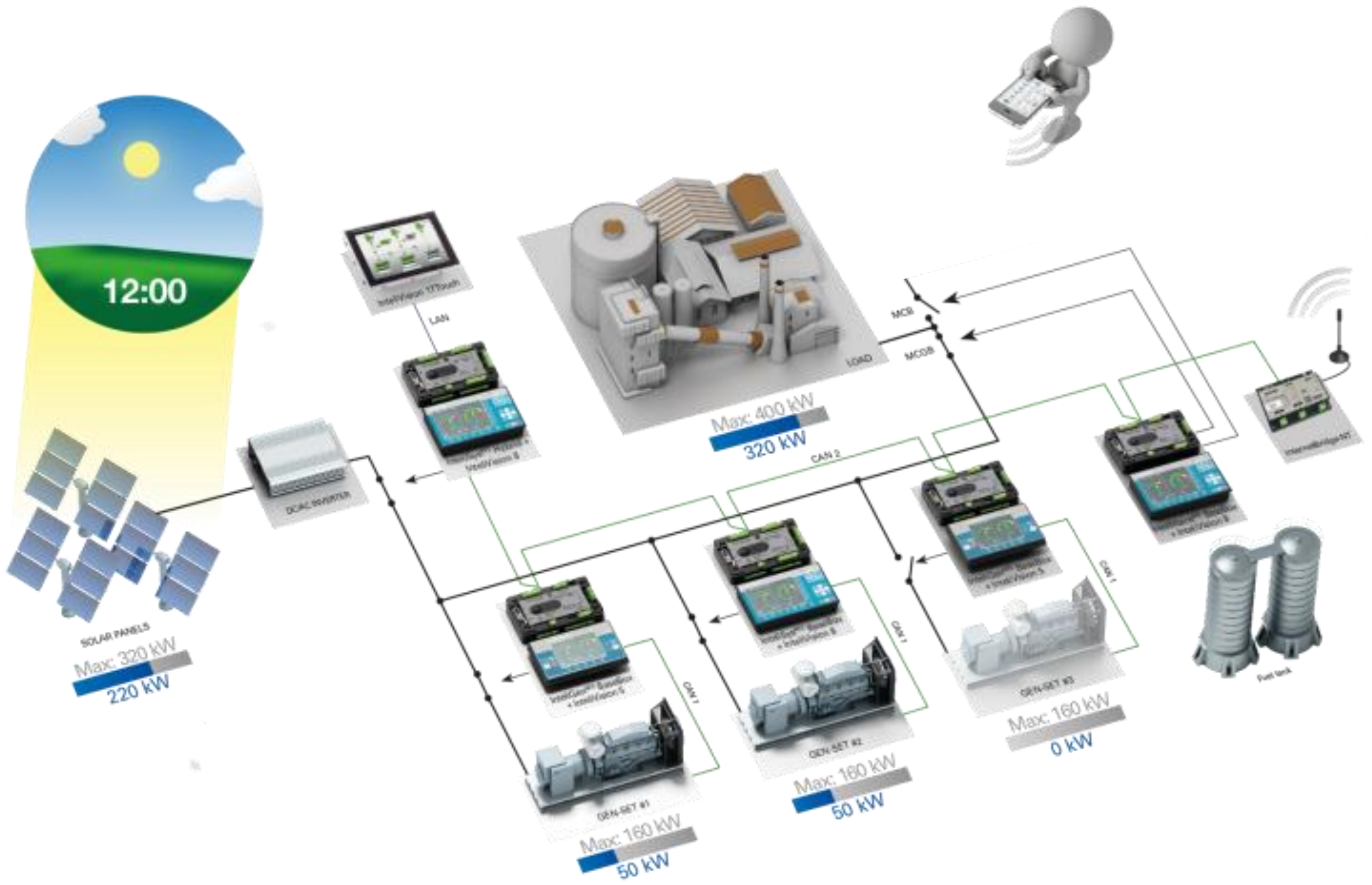
- During the morning the PV power plant starts to produce power
- ComAp controllers adjust the output of the gen-sets according to the PV output to match the load

Example: ComAp Hybrid Power Management



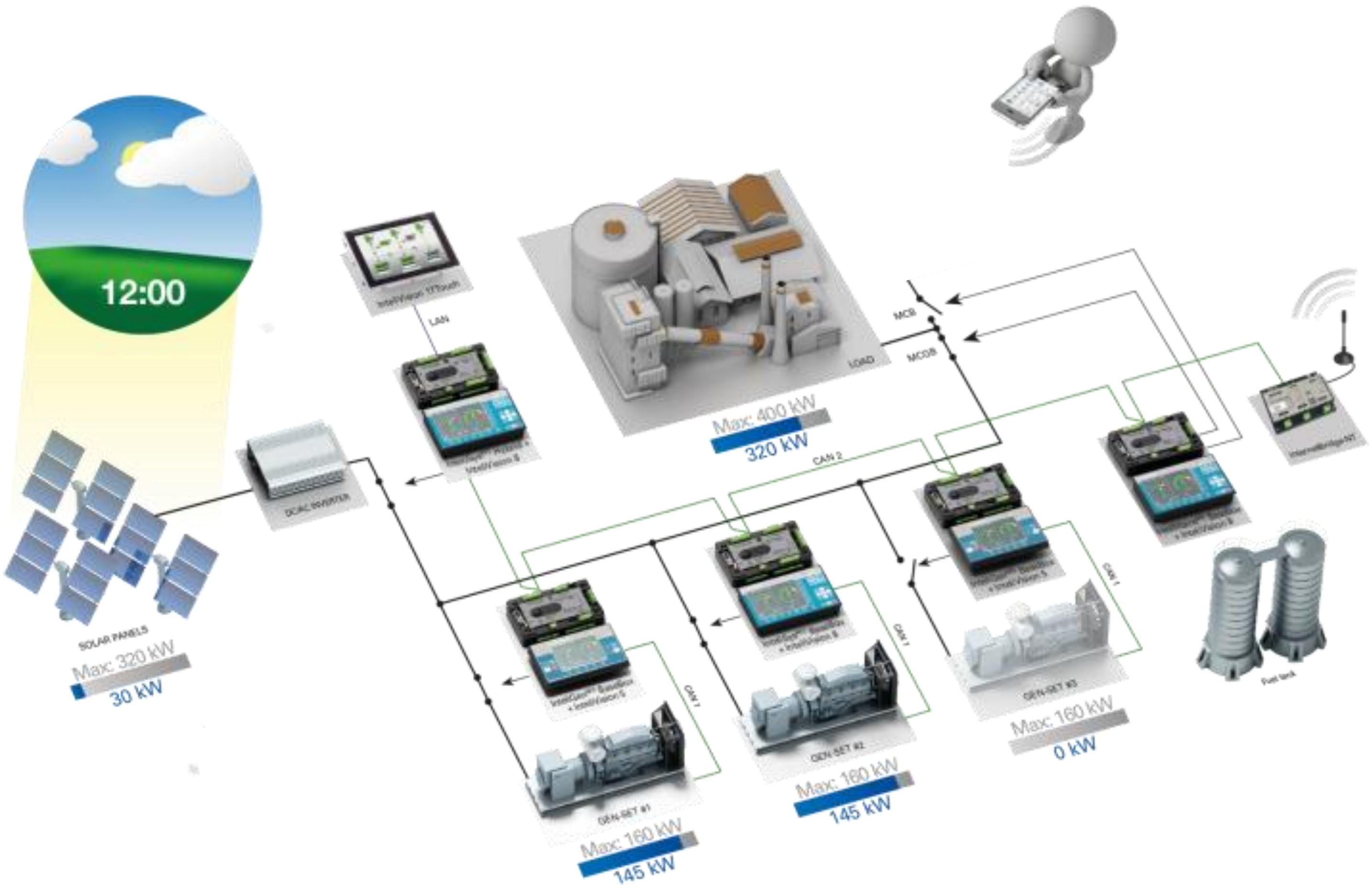
- In the middle of the day the PV output reaches the highest output
- In this case the gensets run under-loaded

Example: ComAp Hybrid Power Management



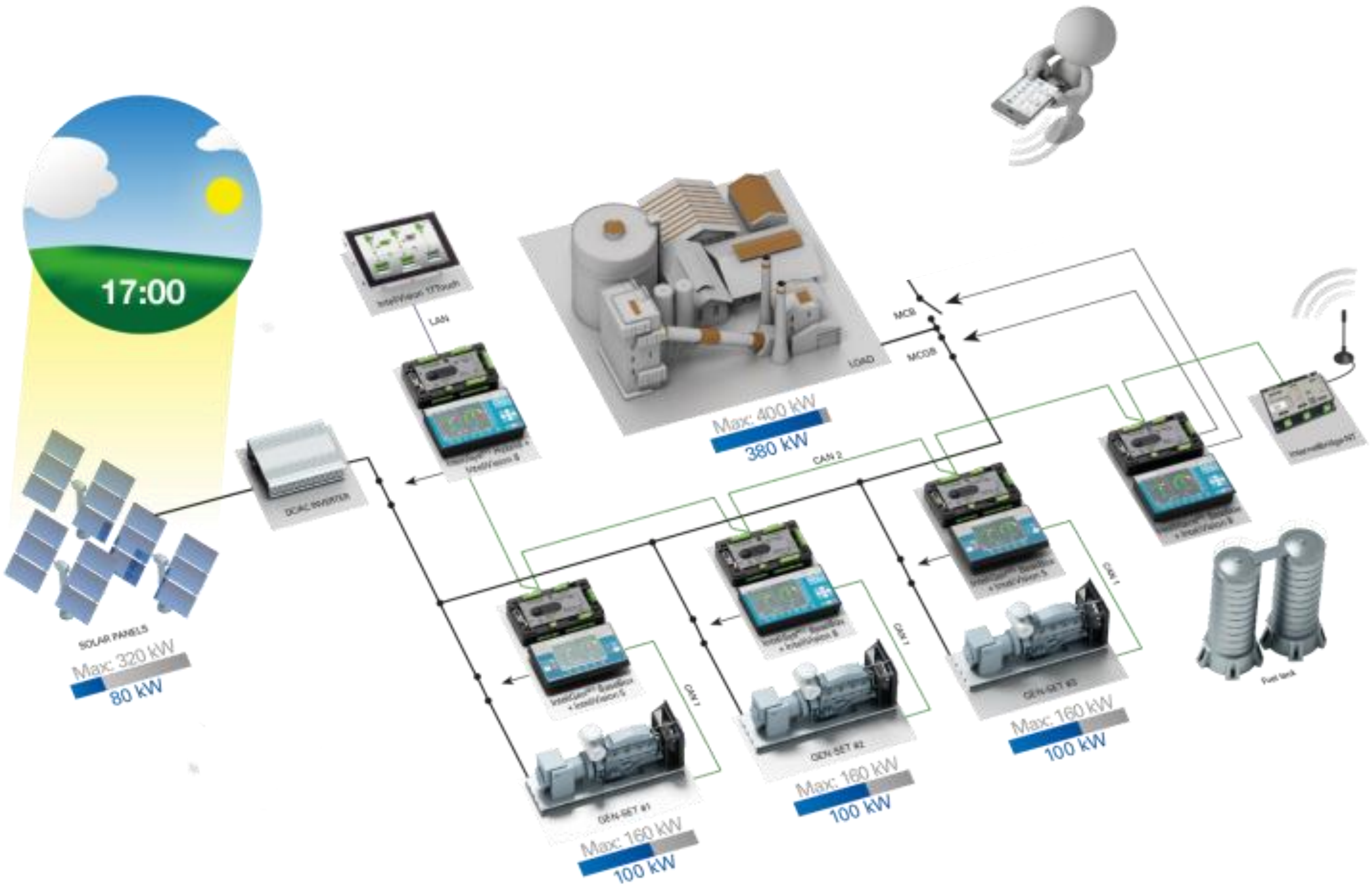
- In standard power management one of the gen-sets would be shut down but in this case this would endanger the reliability of the whole system
- The output of the PV is reduced in order to protect the gen-sets from being under-loaded

Example: ComAp Hybrid Power Management



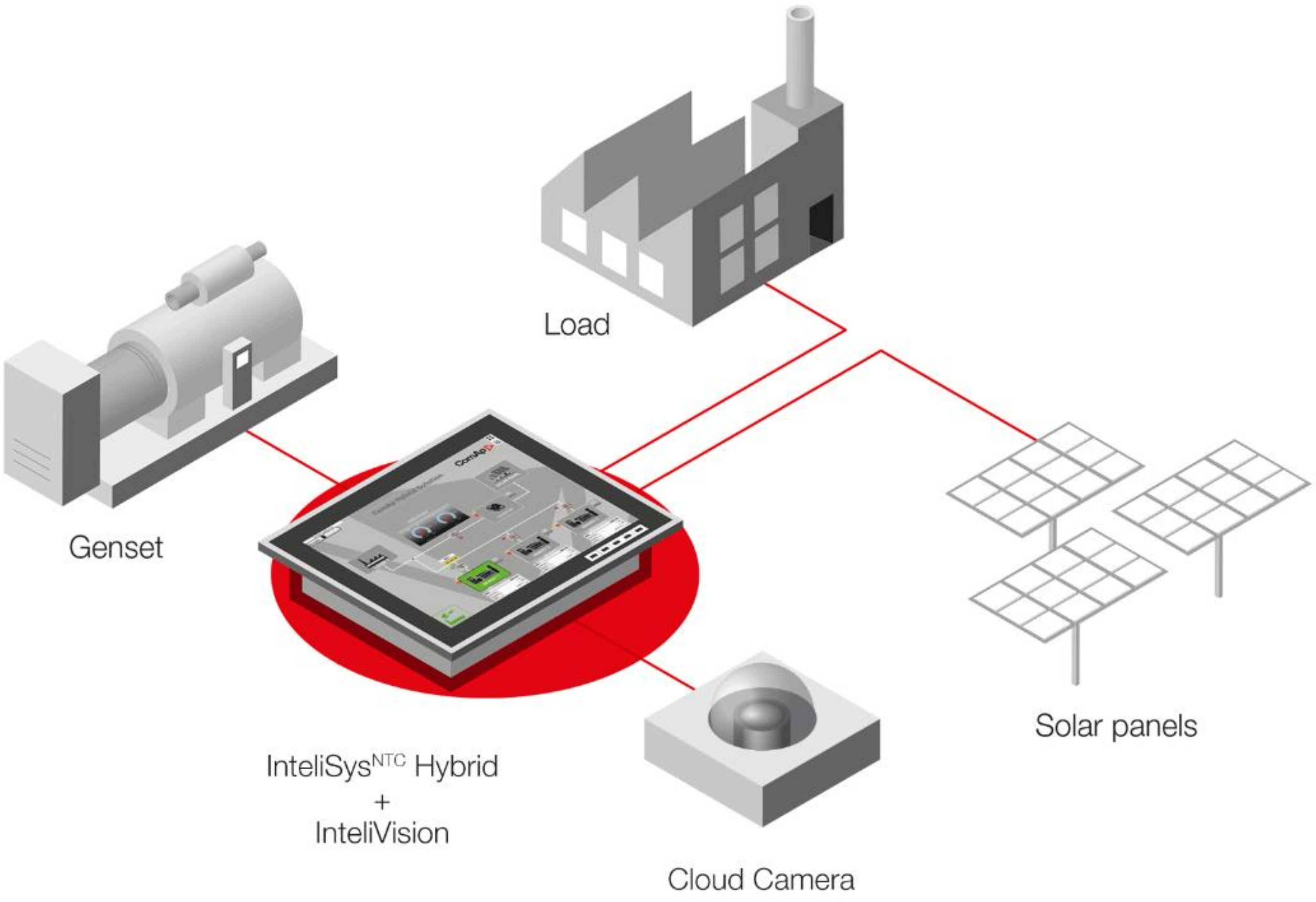
- When the PV plant is covered by cloud ComAp controllers will automatically load the gen-sets to keep the smooth power delivery

Example: 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

New Technology - Cloud forecasting system



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

Reference projects

Willinga Park Equestrian Centre, NSW, Australia

- **Fringe of Grid – Hybrid System Installed behind the meter.**
- **Three diesel gen-sets (4.5MW), 800kW of installed PV (500kW directly controlled) & BESS (500kW/2.2MWhr)**

Willinga Park Equestrian Centre, NSW, Australia

Multi Mode

Off Grid

- Normal Operation - 100% Renewable with generator backup for charging (BESS Grid forming / PV Primary supply & charging)
- Event Operation – Diesel Generation (Grid Forming) with PV set for maximum fuel displacement

On Grid

- Normal Operation – PV allowed to export to the grid, BESS used for network stability
- Event Operation – Max PV, BESS used for network stability, Diesels used for peak lopping

Willinga Park Equestrian Centre, NSW, Australia

- **Balance of Plant Monitoring, SCADA and WebSupervisor**

Peter Island, British Virgin Islands

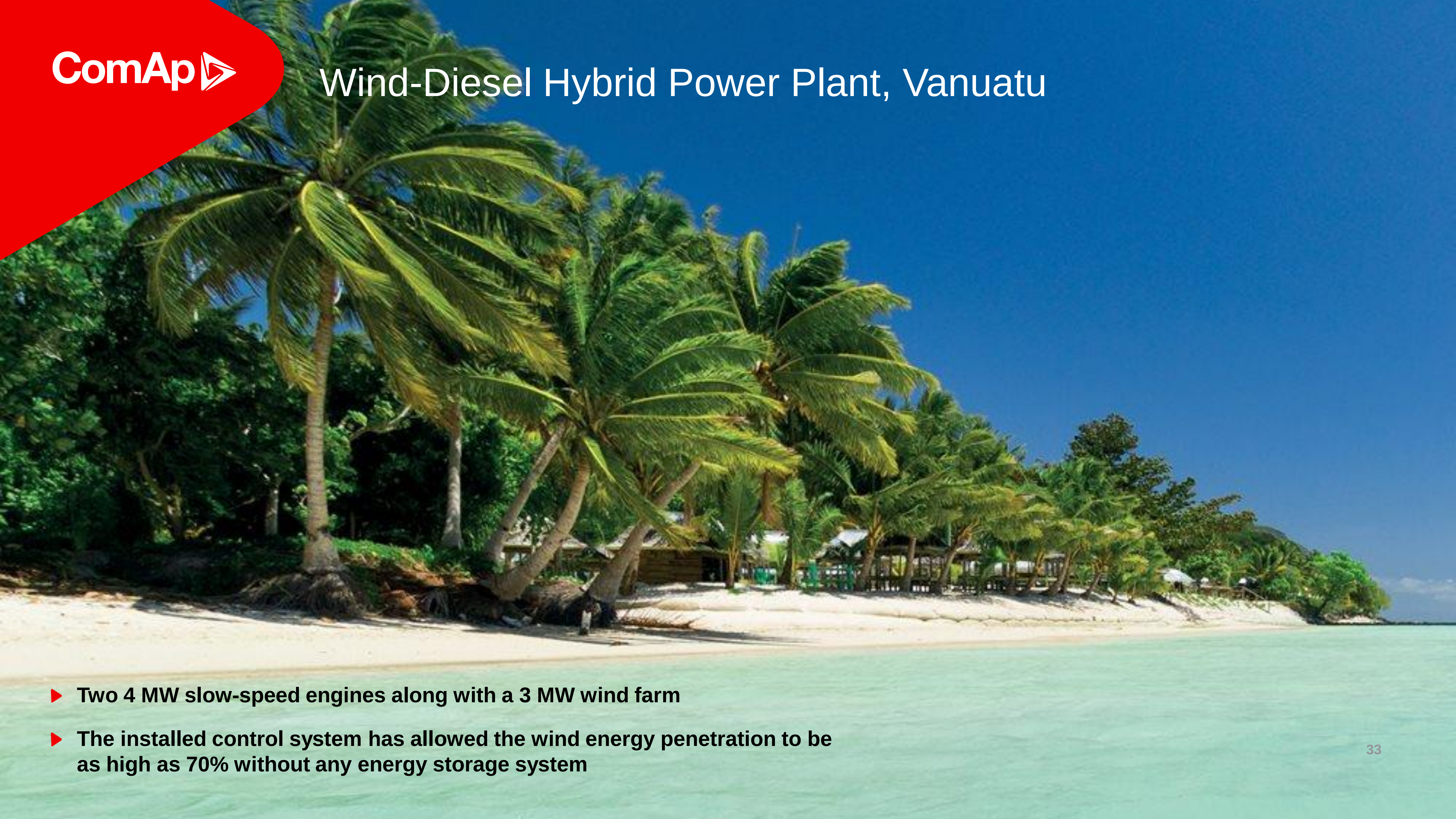
- **Four diesel gen-sets (540kW each) and two wind turbines (259kW each)**
- **ComAp provided highly optimized power management for lower load reserve and efficient automatic control of the gen-sets operation to offset wind farm output fluctuations**
- **Fuel consumption costs cut by $500,000 per year**

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
Save Fuel and Maximize Power System Reliability
That's smart control

Thank you for your attention

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