Remote Renewable Energy Solutions for the Mining Sector

Wes Kennedy
SMA America

September 2013

Agenda

1 Introduction to SMA

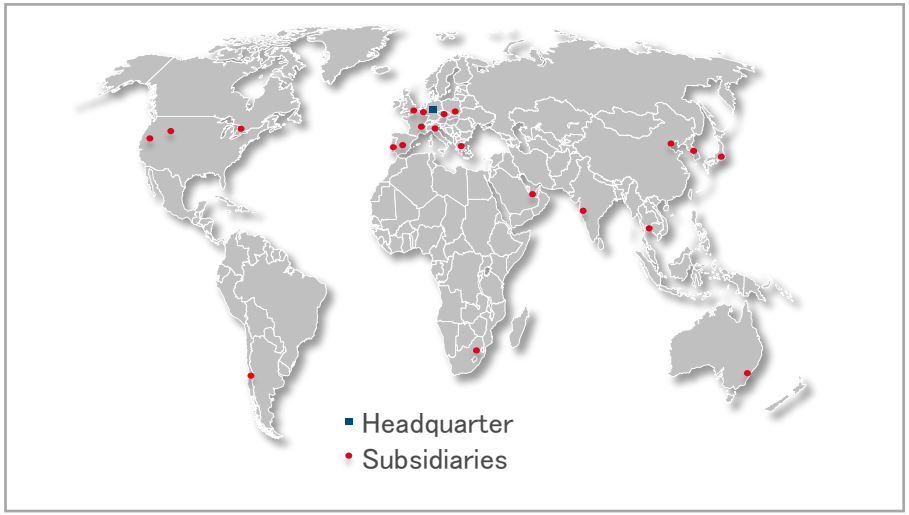
2 The business case for Renewables in the Industrial sector

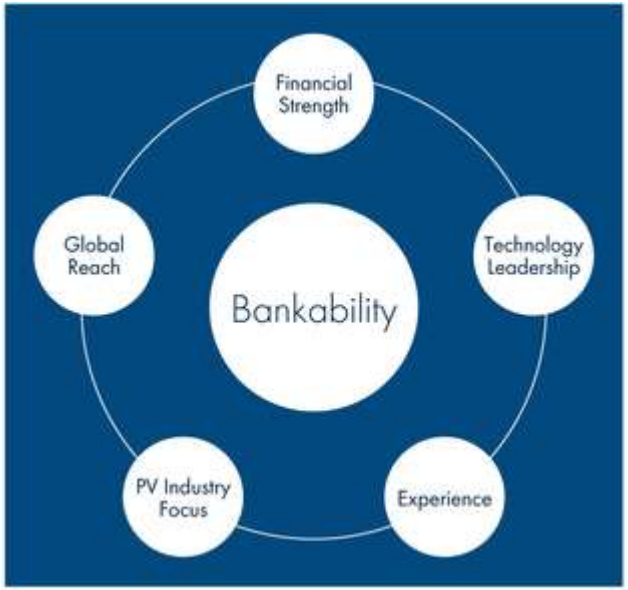
3 A Scalable Approach: Who's the Boss?

4 Lessons learned and example projects

SMA Solar Technology AG – Key Facts

- Founded in 1981
- Sales 2012: EUR 1.5 billion
- More than 4000 employees, more than 1000 professionals in research and development
- In 21 markets all over the globe
- Over 30 GW installed SMA inverter power worldwide
- More than 20MW of SMA inverters installed globally each day.
- 750 highly trained service professionals to keep projects functional





A variety of criteria determine a supplier's bankability

Source: SMA

Agenda

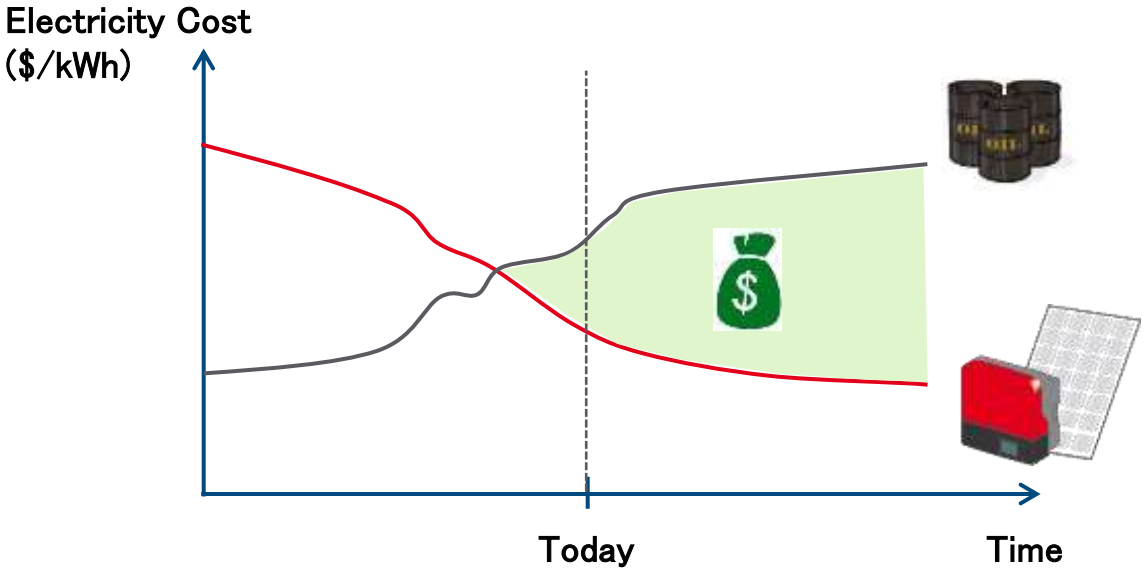
1 Introduction to SMA

2 The business case for Renewables in the Industrial sector

3 A Scalable Approach: Who's the Boss?

4 Lessons learned and example projects

Why PV-Diesel-Hybrid systems?



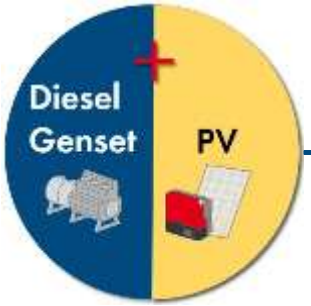
- PV system cost decreased by > 50% in the last 3 years
- Fuel cost for Diesel Gensets are steadily rising
- PV-Diesel-Hybrid applications provide a good business opportunity for
  - Genset operators/end customers
  - Players from the Genset world
  - Players from the PV world

Already today, we see a significant cost advantage of PV-Diesel-Hybrid systems compared to conventional Diesel Gensets.
This gap will become even bigger in the future.

Source: SMA

There are 6 key levers favoring PV-Diesel-Hybrid systems minimizing both, cost and risk

PV-Diesel-Hybrid system



1. Reduction of variable costs
Significant reduction of fuel consumption

2. Reduction of CO_2 emissions
Fullfilment of obligations and/or selling of certificates

3. Scalability
PV penetration rate can be scaled up continously.

4. Energy independence
The solar ressource is always on site

5. Planning security
Project is less dependent on fuel price volatility

6. Social aspects
Project is „greener“ and more accepted by people

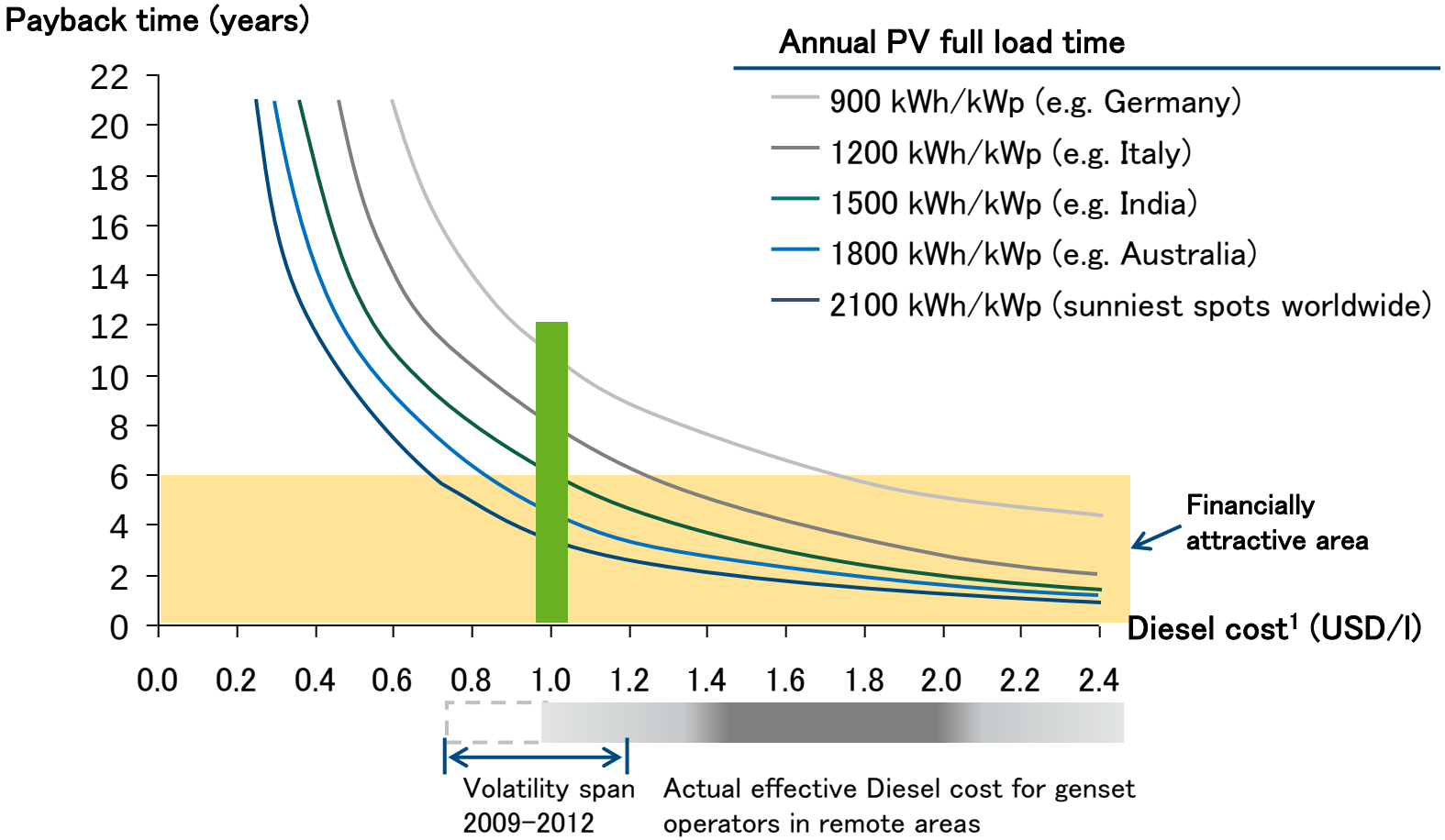
Enhanced business case / minimised cost

Enhanced supply security / minimised risk

How can these benefits be quantified?

Source: SMA analysis

PV-Diesel-Hybrid has a strong business case : compare solar resource with delivered cost of fuel



Given the Diesel price volatility and genset industry mindset, a short payback time is crucial.

1. Effective cost at point of consumption including fuel transportation and storage cost etc.
Assumptions : 1 MW PV plant; 100% consumption of PV power possible; CapEx=2,000 USD/kWp; OpEx= 2% of CapEx p.a.; PV financing with 30% equity/70% debt with 7% interest rate and amortization time of 5 years; Genset efficiency 3.5 kWh/l (net electricity production); CapEx and Maintenance cost for Diesel genset not included, since PV is considered as add-on here, not as genset hardware substitution Source: Web

Agenda

1 Introduction to SMA

2 The business case for Renewables in the Industrial sector

3 A Scalable Approach: Who's the Boss?

4 Lessons learned and example projects

SMA's solution allows for a scalable deployment of PV

Generator Dominant

PV Inverters → **Fuel Save Controller** → **Battery Inverters**

- Robust design proven in harsh environments
- High tolerance for wide voltage and frequency ranges
- Integrated management functions for weak grid
- Up to 20% PV

- Intelligent and fast interfacing between load, genset and PV inverter
- Several operation modes for maximum compability
- Together with SMA

Spinning Reserve

- Storage integration to substitute spinning reserve/idle genset operation

Inverter Dominant

Grid Manager

- Increased PV penetration of 100–120% to reach economic optimum, including support for diesel off-mode

PV PENETRATION of 20 % means:
For each 1 MW installed Genset capacity you can add 200 kW of PV

PV PENETRATION of 60 % means:
For each 1 MW installed Genset capacity you can add 600 kW of PV

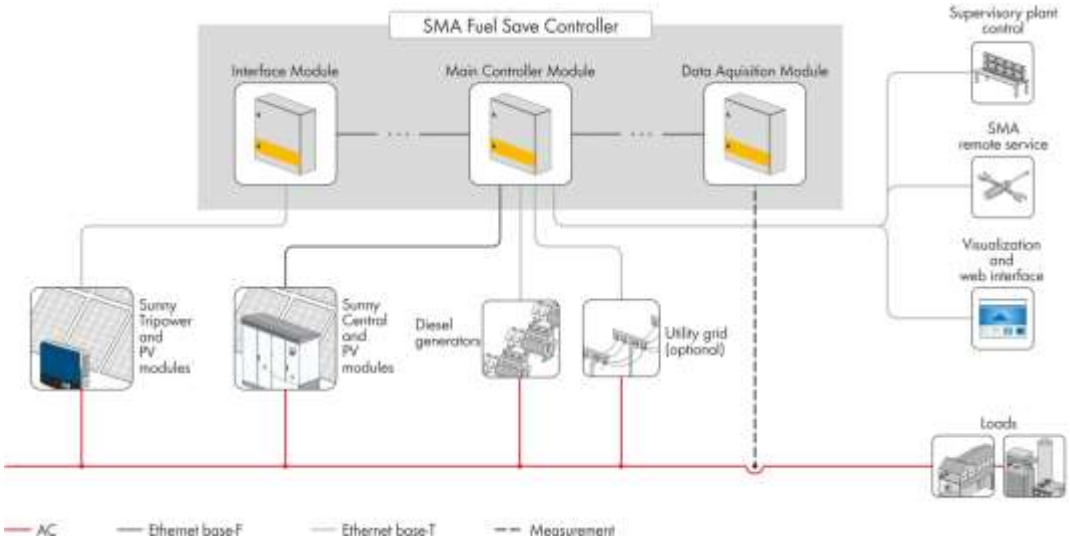
PV Penetration

up to 20 %	up to 60 %	100 % +

1. Ratio between PV peak power and genset nominal power

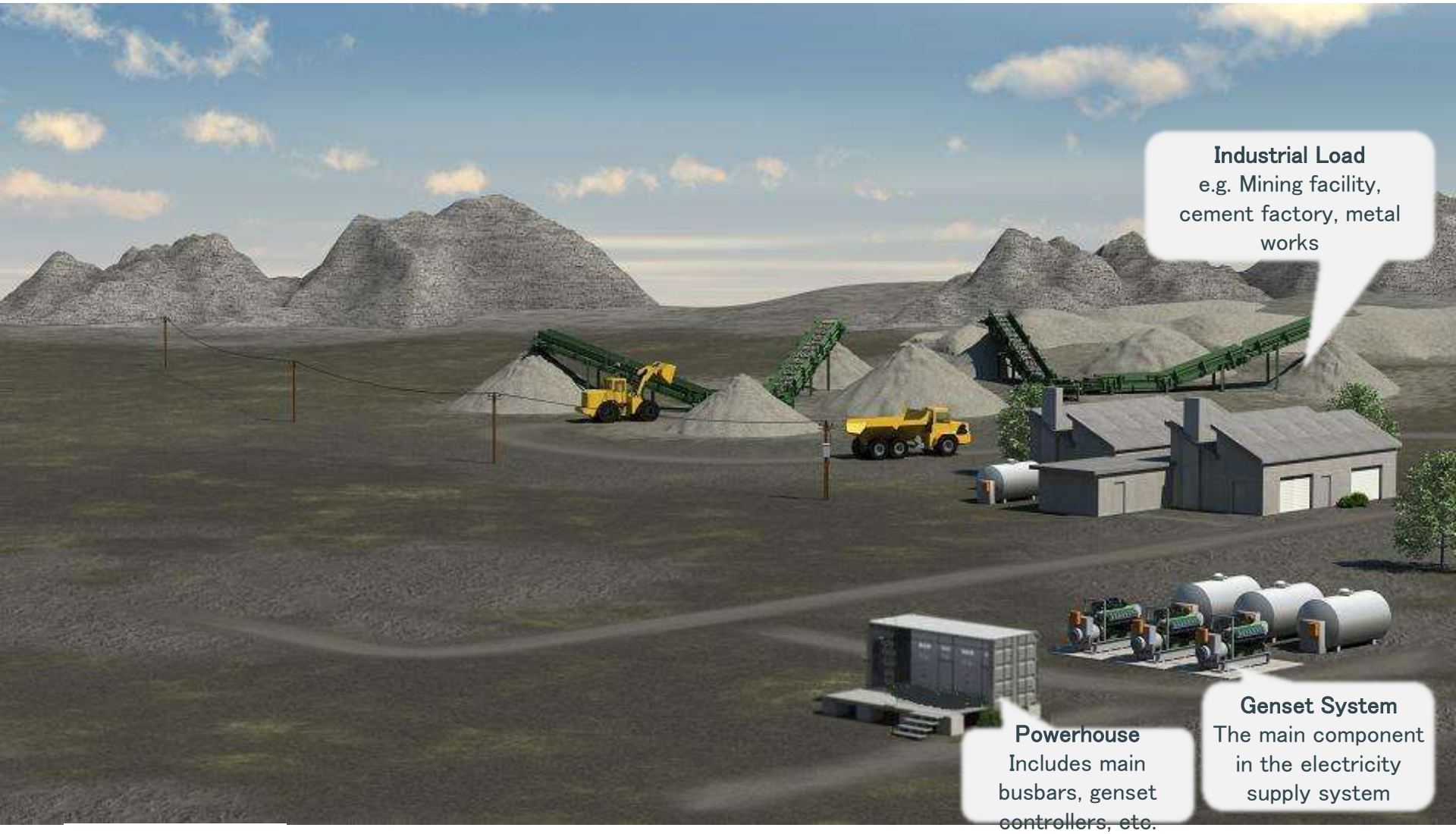
Source: SMA

Reliability of Grid is Prime

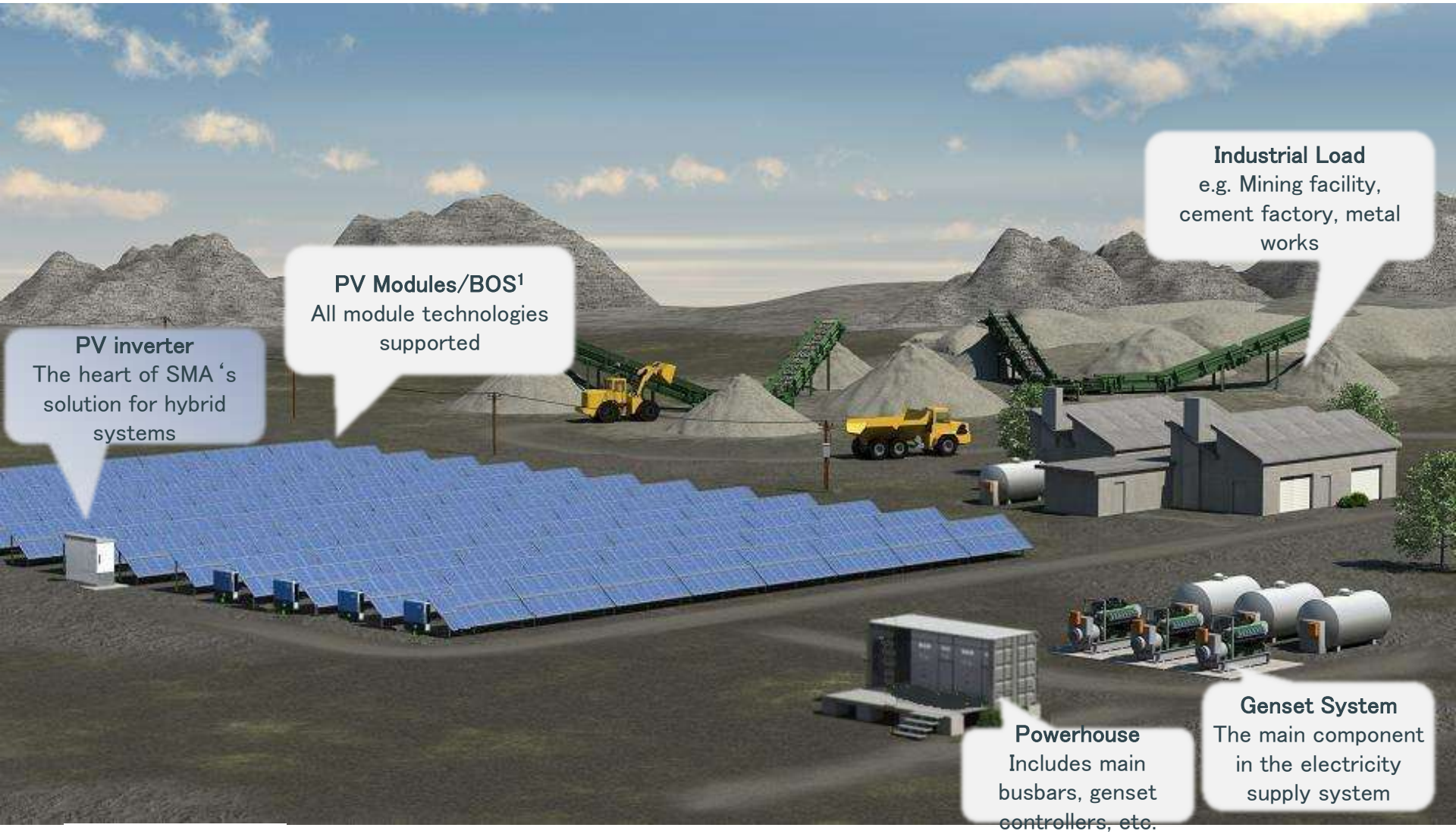


- **Fuel Save Controller**
  - **Generator dominant**
  - simply monitors grid parameters (generator operation, load characteristics)
  - Does not take over Control function of existing Grid
  - Only calculates maximum Safe and Stable PV penetration, curtail PV when limits reached
  - **If PV fails, Grid operation Unaffected**

Industrial loads in remote areas are typically supplied by conventional Genset systems



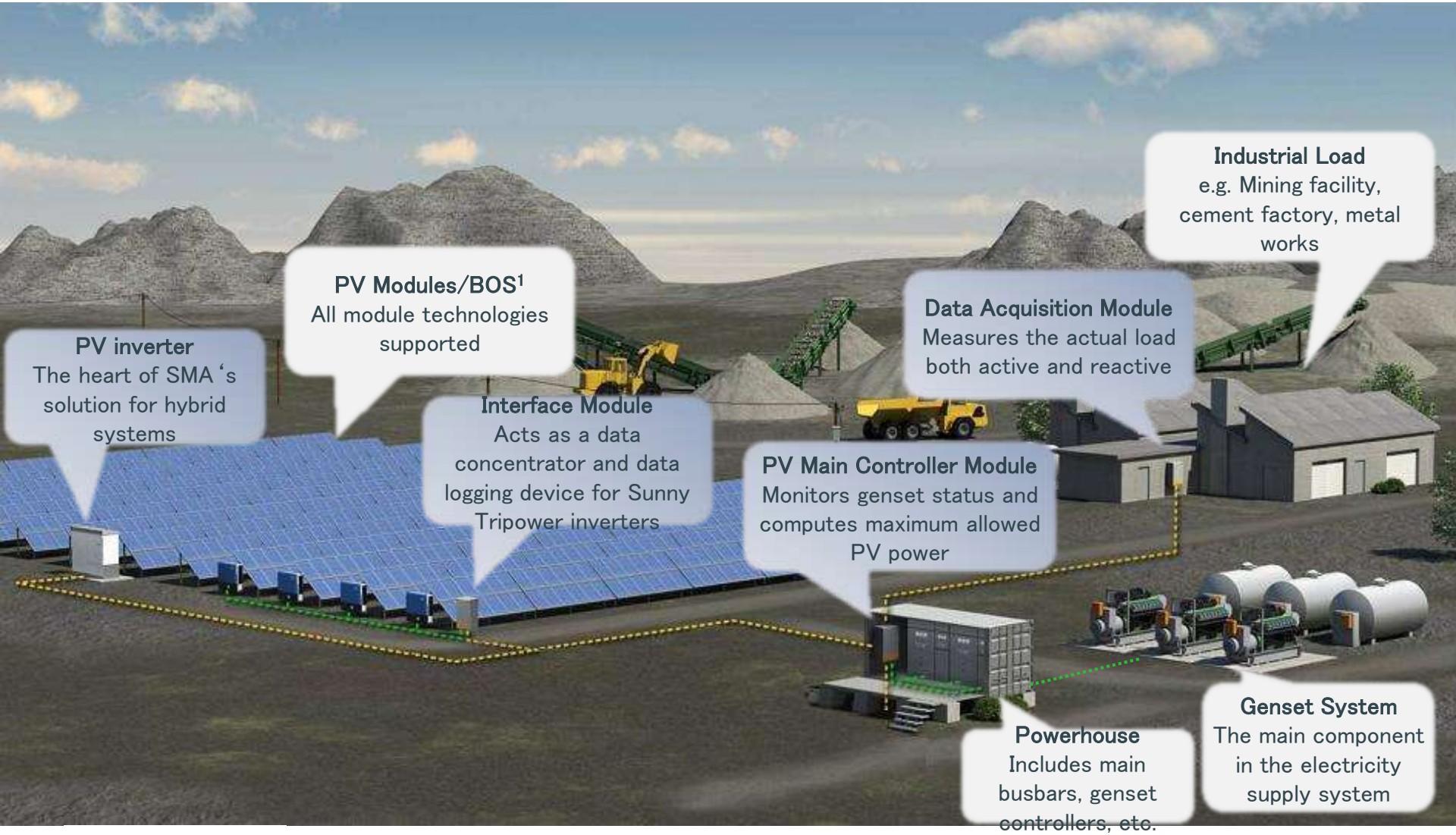
Adding Photovoltaics is the first step towards a future-proof system...Up to 20% PV Penetration



SMA equipment

1. Balance of System (e.g. cabling, module racks, etc)

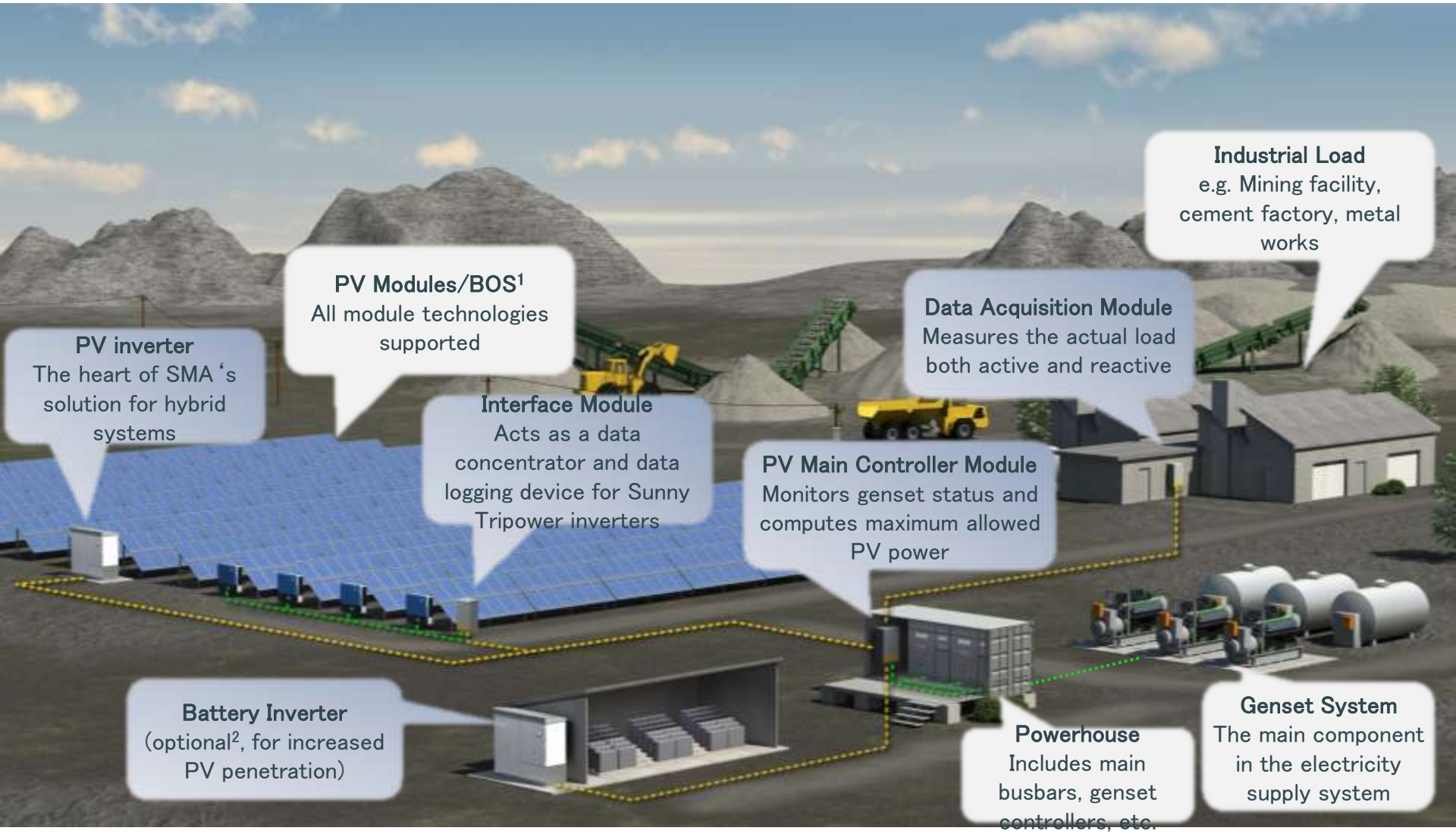
Smart communication between Genset and PV leverages hybrid potential of up to 60%



SMA equipment

1. Balance of System (e.g. cabling, module racks, etc)

Integration of storage is the next step to increase PV penetration.

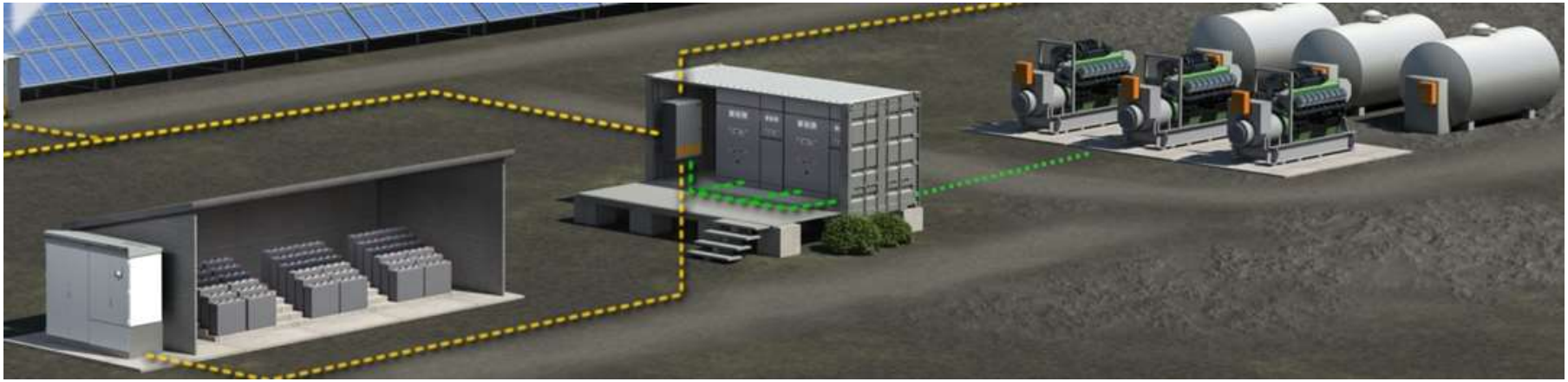


SMA equipment

1. Balance of System (e.g. cabling, module racks, etc)

2. Available by end of 2013

Energy Storage: Phase 1= Reduce Spinning Reserve



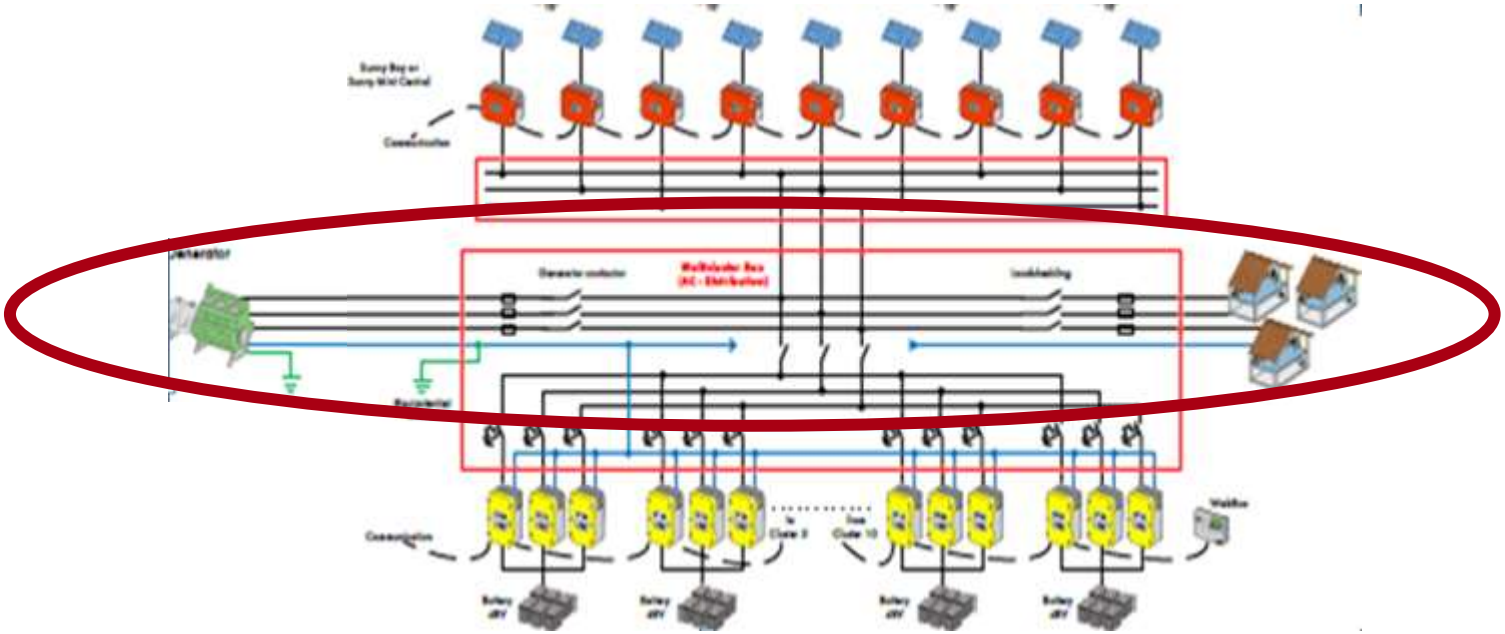
Genset Dominant. Forms Grid.

- Inverter with Battery acts as Dispatchable Load (rather than curtail PV) and Power/Energy Source (Load spike or dip in PV production (clouds etc))
- Modest storage, measured in minutes of load capacity
- Reduce Genset Spinning Reserve requirement, save fuel

Energy Storage Phase 2:
Grid Forming Inverter>100% PV/RE penetration

- Sufficient RE production to meet typical 24 hour Plant Load
- Inverter forms Grid
- Genset powered down completely, brought on as needed when Loads > RE + Storage
- Battery capacity measured in hours or days vs minutes

Reliability of Grid Is Prime



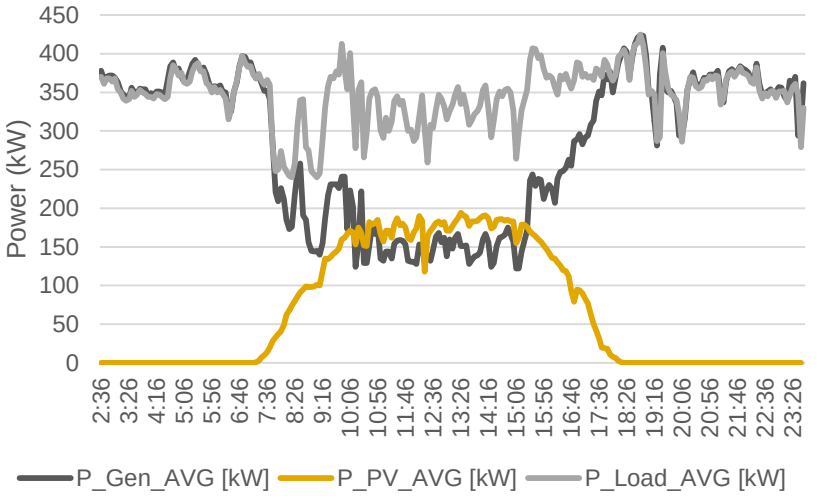
> Sunny Island Multi Cluster Architecture

- Inverter Dominant, Energy Storage Required
- Inverter Controls Grid, Genset Operation, Load management possible.
- **Inverter Fails Transparent: Generator connected to Loads**

Real-life data can be tracked with high resolution to validate the fuel saving effect

Hybrid plant can be monitored exactly

Example: Thabazimbi mining site in South Africa



© Cronimet Mining Power Solutions

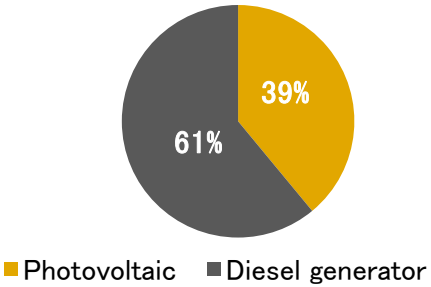
Provided by:

CRONIMET

Performance at a typical day

- Average load 350 kW
- 300 kW PV power activated
- 1440 kWh PV energy produced
- 400 liters of diesel savings
- PV output directly follows load and genset requirements

Energy provided during daytime



Source: Cronimet; SMA project example

Agenda

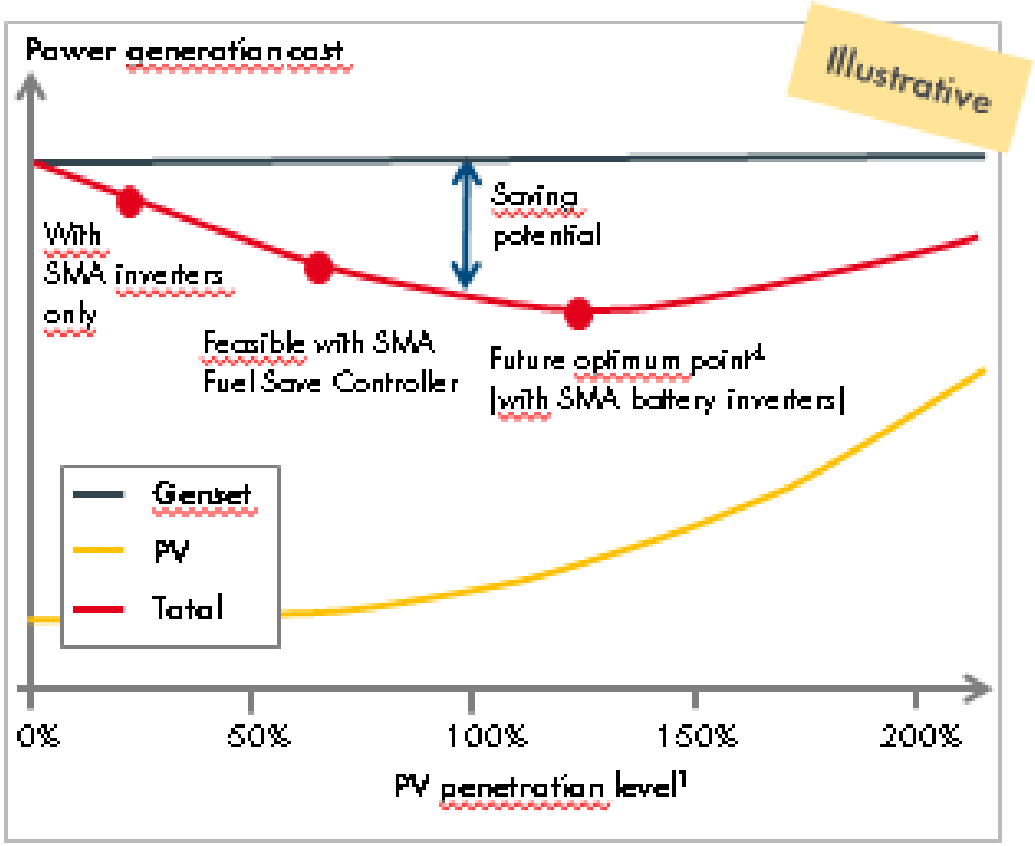
1 Introduction to SMA

2 The business case for Renewables in the Industrial sector

3 A Scalable Approach: Who's the Boss?

4 Lessons learned and example projects

How to choose PV penetration levels



PV generated Electricity is least cost production.

PV (RE) production does not always match load (Intermittent)

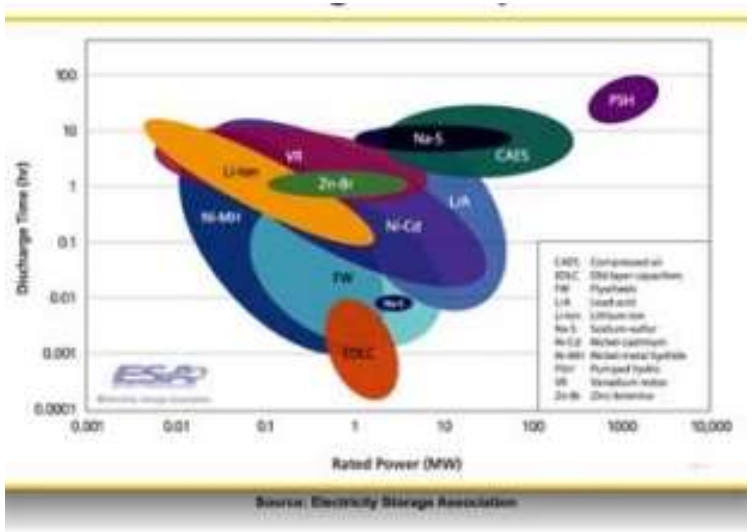
RE + Storage minimizes Intermittency

However, Storage Adds Cost and Complexity

Lessons Learned

- PV/Inverter
  - World Installed PV Capacity reached 100 GW in 2012
  - PV technology is mature and robust (Tier One companies)
  - Costs of Installed PV has fallen by more than 50% within the last 3 years
  - Where PV production matches Load, PV electricity least cost generation (<10 cents/kwh)
  - Choose reliability and service infrastructure for true least cost
  - Distributed v centralized Inverter architecture (pro and con)
    - Centralized = highest efficiency, lowest cost
    - Decentralized = granularity, ease of maintenance, ease of deployment

Lessons Learned



- **Loads**
  - When Off Grid, Loads become the primary design driver. Accurate data is crucial.
  - Load Efficiency nearly always yield high returns
  - Load flexibility reduces impact of Intermittency

    Run planned loads during solar peak

    Flexible loads (water pumping to storage) triggered by RE availability
- **Energy Storage**
  - Next "game-changer" is in Energy Storage technologies.

    (current cost of electrochemical storage >25 cents/kwh)
  - Every fall in cost/kwh of energy storage, window for economic PV production opens.
  - Electro-chemical storage is both a dispatchable load and source of power. 2x value multipli

Conclusion & Outlook

- SMA Fuel Save Controller offers flexibility for diverse applications
- FSC 's sophisticated algorithm which
  - …avoids genset reverse power scenarios
  - …maintains minimum genset loading
  - …ensures that sufficient genset power is onlin
  - … can handle grid connection
- Energy Storage (Battery Inverter)
  - ….lessens spinning reserve
  - ….allows higher PV penetrations

= higher fuel savings

Project Example: 925 kWp hybrid system on Island Nation of Tokelau running successfully since 2012

- 1 MW(925kW) PV system is the biggest standalone power system in the world
- 298 SMA inverters(93 SMA Sunny Islands/205 Sunny Boys), 121 SMA Sunny Island Chargers and 1,344 batteries
- Offset of 200 liters of fuel daily while the country has eliminated it's dependency on fossil fuels

1. Sunny Island system instead of Fuel Save Controller
Source: SMA project example

Project example: Mine in South Africa
Genset dominant, Fuel Save Controller

SMA reference example:

- 2x800 kVA Perkins Gensets + 500 kVA grid connection
- Upgraded with 1 MWp PV
  - Modules: 4170 high-efficiency 240W poly-Si
  - Inverter: 63 STP 17000 + FSC[1]
- PV power production: ca. 1.8 GWh p.a.
- Annual savings: approx. 450,000 liter Diesel fuel

1. Fuel Save Controller
Source: SMA

Project example: Island Vava ʻu in Tonga

- 500 kWp PV plant with 21 x 20 000 TL SMA TriPower Inverters
- Includes 120 x 1000 Ah gel lead acid batteries with 5 SMA Sunny Backup
- Saves 225 000 L of diesel p.a. and 440 tons of CO_2 emissions
- Installed by Ingenero

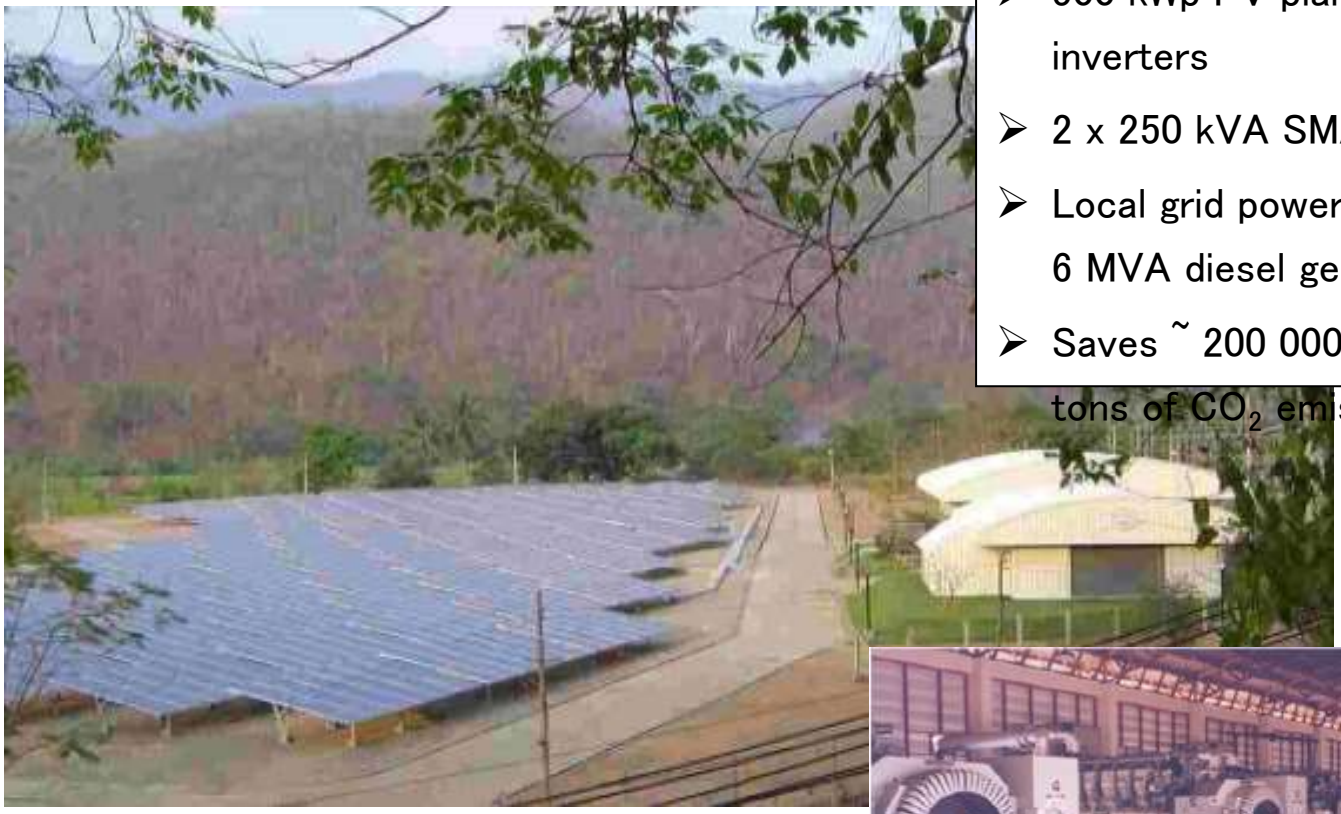
Project example: Cotton Mill in India
Genset dominant, Fuel Save Controller

SMA reference example:

- Cotton Mill in India
- One 1250 kVA Powerica Gensets + grid connection (unreliable grid, several outages per week)
- Upgraded with 1 MWp PV
  - Inverter: 44 STP 20000TLEE
  - FSC: One Interface Module, one PV Main Controller Module, two Data Acquisition Modules
- PV power production: ca. 1.32 GWh p.a. (if the grid is available, a net metering scheme applies)

Source: SMA

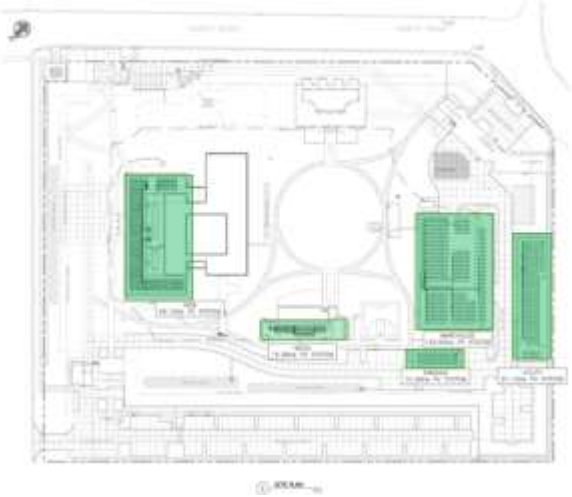
Project example: 500 kWp hybrid system in Thailand
Online since April 2004
Inverter Dominant, custom solution



- 500 kWp PV plant with SMA central inverters
- 2 x 250 kVA SMA battery inverters
- Local grid powered with 5 MVA hydro and 6 MVA diesel gensets
- Saves ~ 200 000 L of diesel p.a. and 483 tons of CO_2 emissions

1. Realized without Fuel Save Controller
Source: SMA project example

Project example: Hybrid system for US-Embassy, Burundi
Grid/Genset dominant, custom solution



- 307 kWp PV system
- Sunny Tower solution
- 5 CAT gensets available
- Only 3h per day of grid availability
- 6 000 USD savings in first 3 months of operation
- Operated in highly unstable seismic zone 3D

1. Realized without Fuel Save Controller
Source: SMA project example

Current reference projects using large scale energy storage

SC-800CP BWR

- Grid-tied battery inverter based on SC-800CP
- Full 4-Quadrant operation (bis 800kVA)
- MODBUS/TCP interface for park or customer control
- Q@Night capable

SOLON-US

- Grid tied based on SC-500U (SOBWR-01)
- MODBUS interface to customer's SCADA
- Part of a Demonstration Project with the University of Arizona
- Funcitonality demonstrated and analysis on battery behaviour ongoing

Each day, over 20 MW of SMA PV inverters are installed worldwide


53 MWp, Germany


85 MWp, Italy


14 MWp, South Korea


44 MWp, Thailand


16 MWp, USA


10 MWp, UAE


10 MWp, Greece


22 MWp, Spain

Why they chose SMA:

- Reliability (Technology & Company)
- Bankability of SMA[1]
- Experience (over 30 GW installed capacity)
- Grid Management Capability
- Financial Performance (SMA Inverters increase yield + reduce TCO[2])

Risk reduction

ROI maximization

1. > 400 Mio. € net liquidity (cash and cash equivalents) as of 30.9.2012 2. Total Cost of Ownership
Source: SMA project example

Thank you for your attention!