Intelligent Integration of PV-Systems into Diesel Grids

Diesel Genset + PV
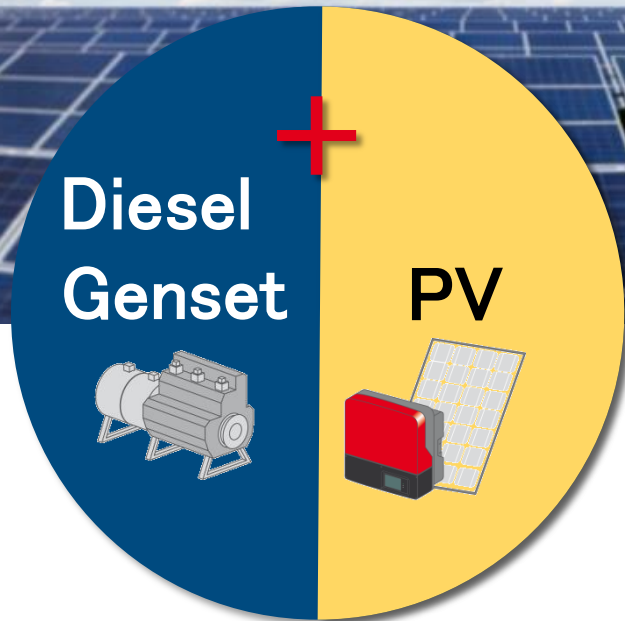
Dipl. Ing. Wilhelm van Butselaar

IRENA–PPA workshop: Assessment of Grid Stability for Increased Renewable Energy Integration

# Agenda

1	Introduction of SMA
2	Technical Approach – 4 Steps Towards the Optimized Solution

SMA is a true growth story – more than 60 % p.a. sales increase in last five years

> WORLDWIDE

>> Founded in 1981

>> Sales 2011 EUR 1.7 billion

>> Shares in exports of 61.2 % (Q1/2012)

>> More than 5,500[1] employees all over the globe

>> 20 foreign subsidiaries in 19 countries on four continents

> Best efficiency worldwide (99 %)

SMA sales and employee development
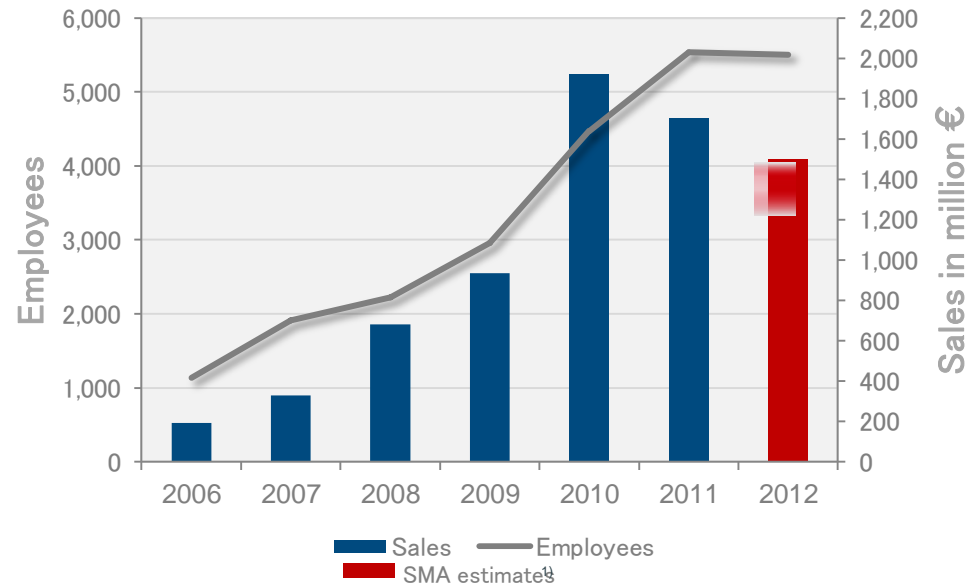
> **SMA was again customers´ first choice in 2011**

SMA is a true growth story – more than 60 % p.a. sales increase in last five years

> LOCALLY in Sydney

>> Present in the AUS, NZ and PIC region since 2007

>> 25 Sales and service staff ensuring energy supply security throughout the region

>> Over 250 systems generating energy in the South Pacific

>> ···and approx 2500 in the whole region
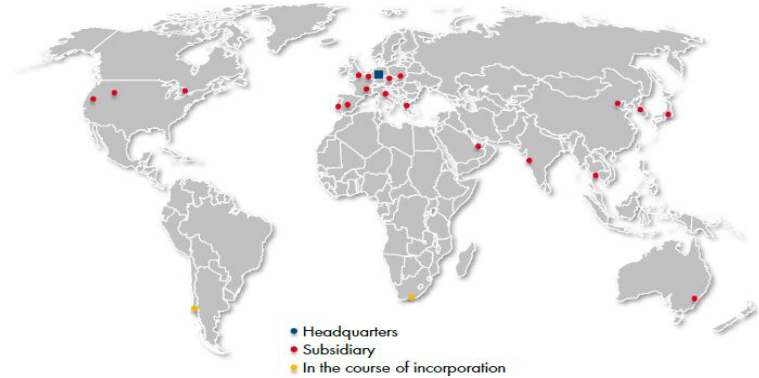
SMA sales and employee development
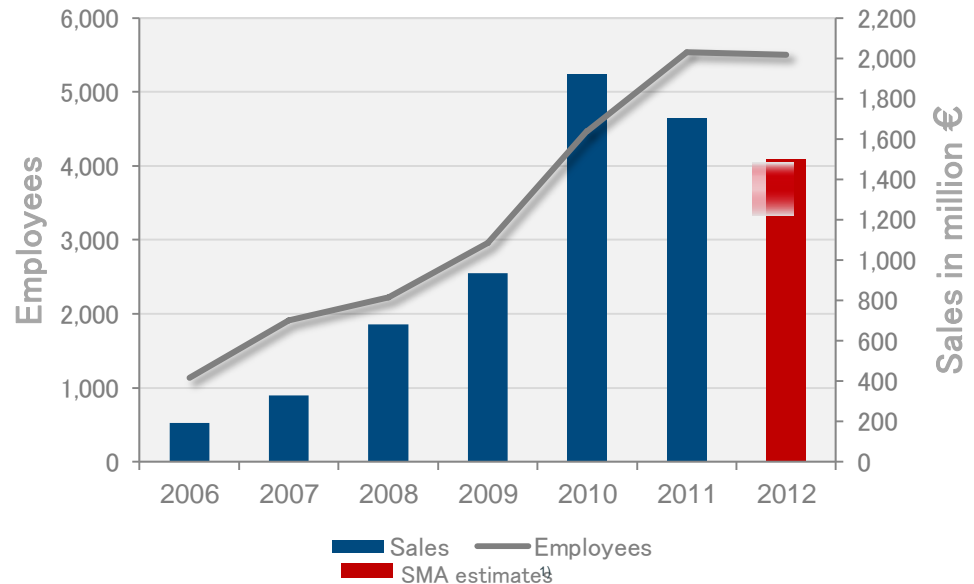
> **SMA was again customers´ first choice in 2011**
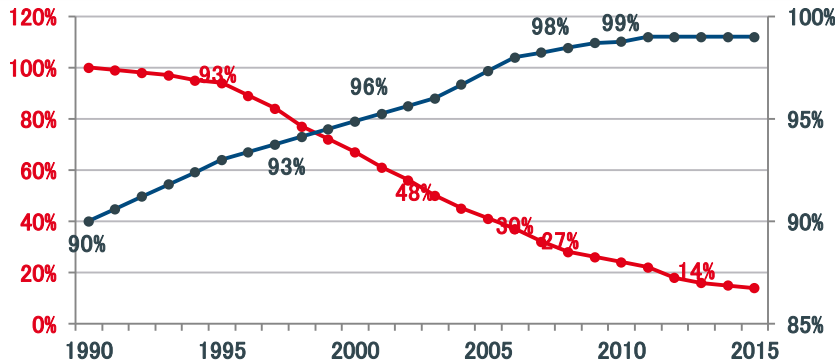
SMA is the global technology leader

Complete product portfolio

Sunny Home Manager   Sunny Boy   Sunny Boy HF   Sunny Tripower   Sunny Central CP

Present all over the world

- ● Headquarters
- ● Subsidiary
- ● In the course of incorporation

Clear cost reduction strategy

93%
96%
98%   99%
93%
48%
30% 27%
90%
14%

1990   1995   2000   2005   2010   2015

—●— Price per Watt (based on 100%)   —●— Maximum inverter efficiency

Well prepared for the future

> Global service organization

> Strong focus on R&D and quality control

> 20 foreign subsidiaries in 19 countries on 4 continents
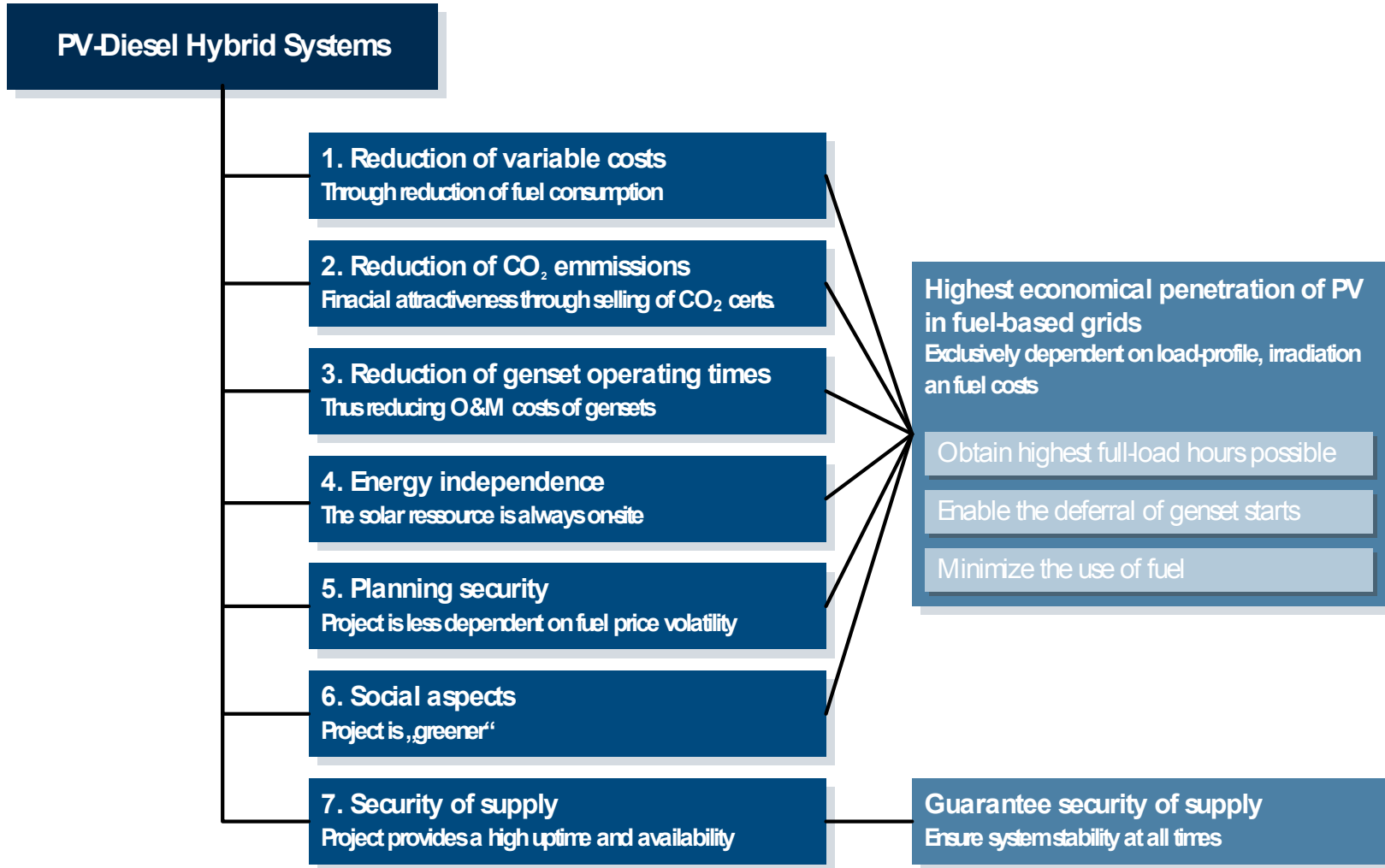
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Agenda

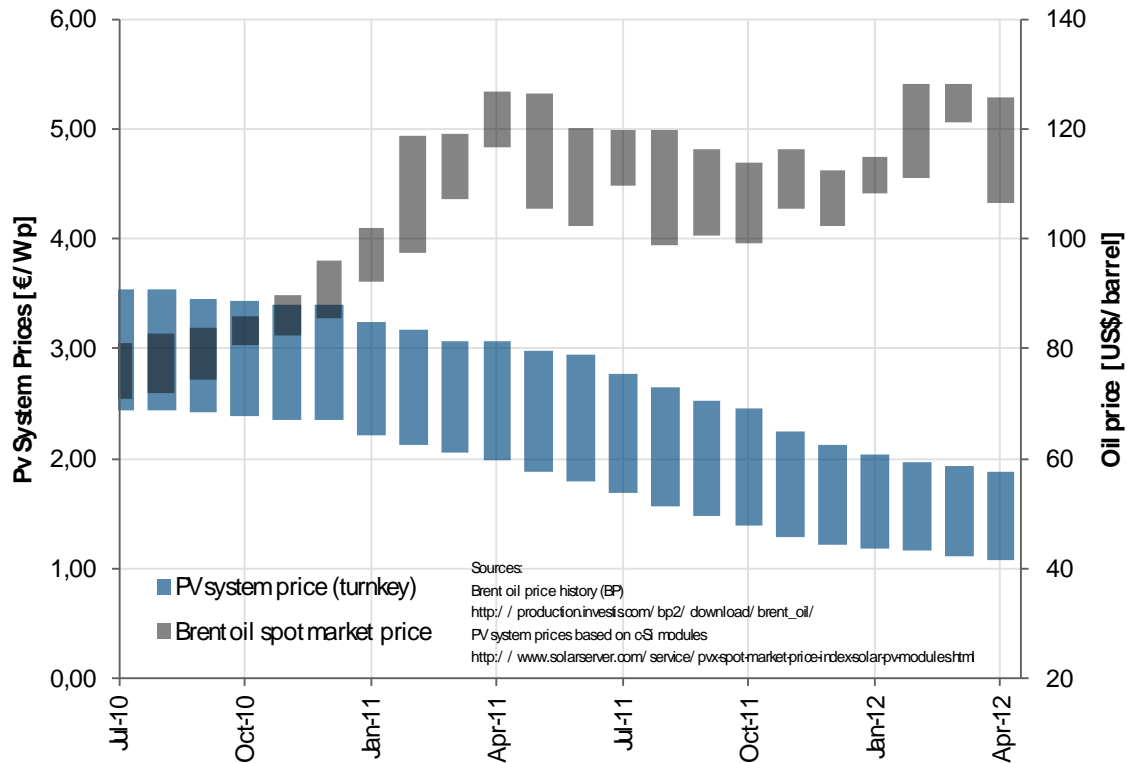|	
1	Introduction of SMA
2	Technical Approach – 4 Steps Towards the Optimized Solution

Why PV-Diesel Hybrid Systems?

PV-Diesel Hybrid Systems

1. Reduction of variable costs
Through reduction of fuel consumption

2. Reduction of CO_2 emmissions
Finacial attractiveness through selling of CO_2 certs.

3. Reduction of genset operating times
Thus reducing O&M costs of gensets

4. Energy independence
The solar ressource is always onsite

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

6. Social aspects
Project is „greener"

7. Security of supply
Project provides a high uptime and availability

Highest economical penetration of PV in fuel-based grids
Exclusively dependent on load-profile, irradiation an fuel costs

Obtain highest full-load hours possible

Enable the deferral of genset starts

Minimize the use of fuel

Guarantee security of supply
Ensure system stability at all times

Price developments give a clear advantage to PV

PV System Prices [€/Wp] / Oil price [US$/barrel]

Legend:
- PV system price (turnkey)
- Brent oil spot market price

Sources:
Brent oil price history (BP)
http://production.investis.com/bp2/download/brent_oil/
PV system prices based on cSi modules
http://www.solarserver.com/service/pvx-spot-market-price-index-solar-pv-modules.html

> **PV module prices** have **drastically reduced** in the last years

> **PV system prices** have continuously decreased

> **PV reached grid parity in the PIC years ago!**

Diesel Systems and Large–Scale Stand–Alone Grids

Traditional
Diesel System

Fuel saver
- Diesel-PV-hybrid systems
- Standard PV inverter

1

2

Fuel saver+
- Diesel—PV-hybrid systems
- Standard PV inverter
- **Battery inverter (non autonomous)**

Diesel-dominated stand-alone Grid
- Diesel + PV + wind
- Standard PV inv.
- **Battery inverter (voltage controlled)**
- Diesel generator as system manager
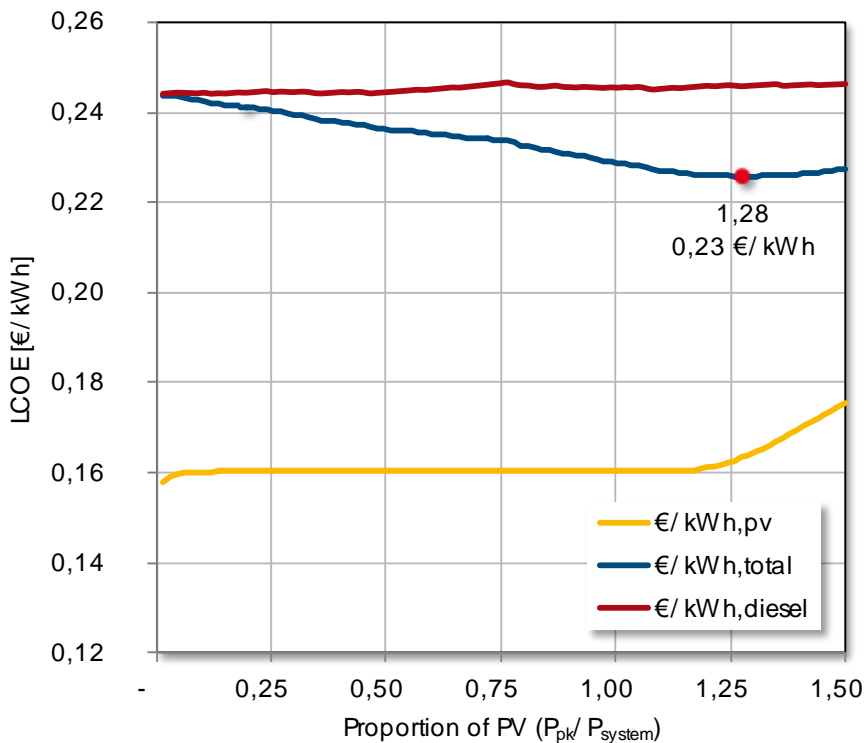
3

4

Inverter-dominated Stand-alone Grid
- Diesel + PV + wind
- Standard PV inverter
- Battery inverter (voltage controlled)
- **Battery inverter as system manager**
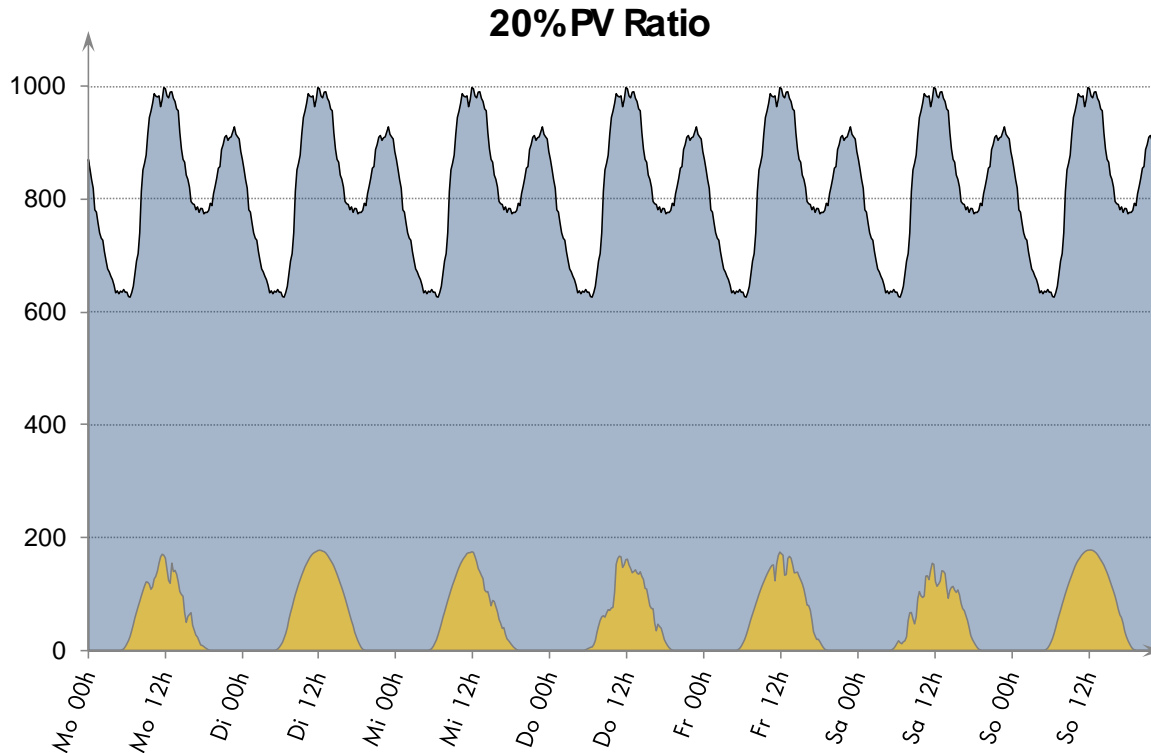
Example of a diesel-based island system

> Pure PV integration (no batteries) is
> able to reduce costs but causes
> challenges when it exceeds a certain
> penetration level

Optimum PV
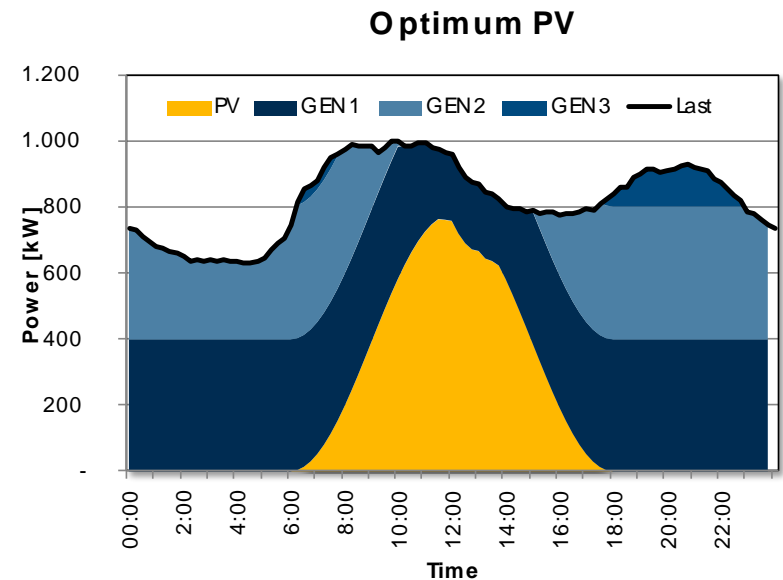
Assumptions
Diesel price of 130 US ct/L disregarding Maintenance costs
LCOE for PV based on study from the EPIA for the Sunbelt countrie

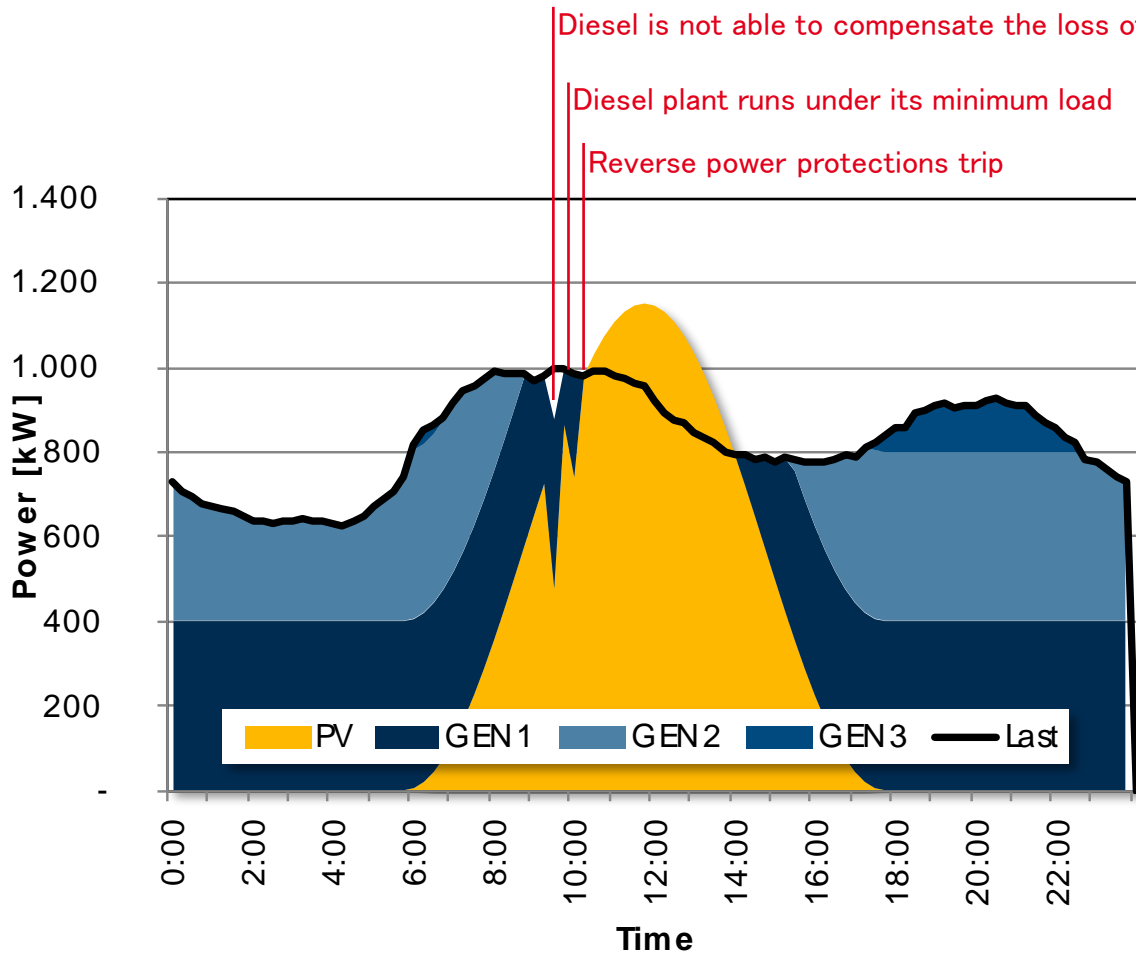# 10–20% P_{sys} is feasible without problems

20% PV Ratio

Conditions

- PV loss can be managed by the genset at any time (typically Genset systems can cope with up to 20% load steps)

- The minimum base load during the high irradiance hours is at least 40% P_{sys}

- The base load gensets are at least as large as the PV field.

The main challenge: Grid and Energy Management

Diesel is not able to compensate the loss of PV power

Diesel plant runs under its minimum load
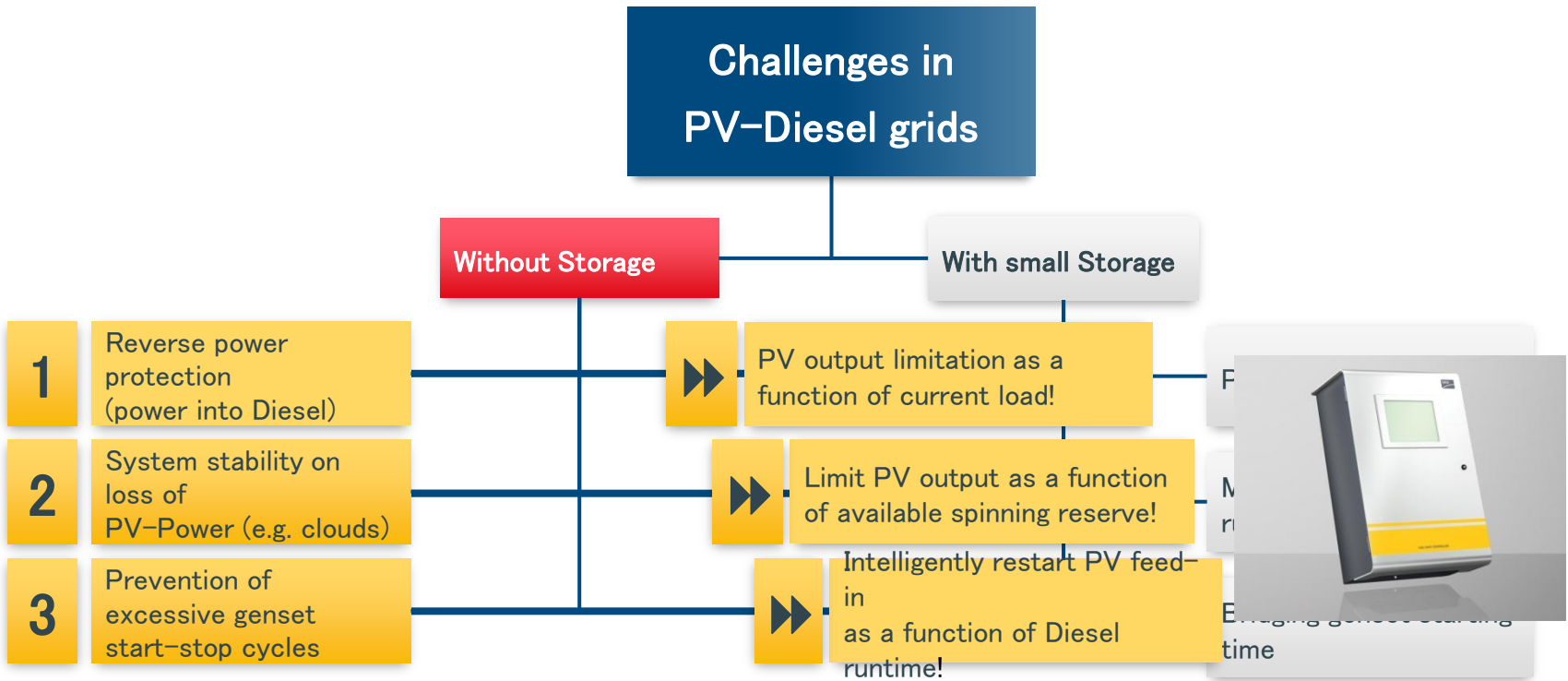
Reverse power protections trip

Challenges

- Management of overproduction

- Compensation for large steps in irradiation (spinning reserve).

Overview of Challenges

> First priority is to tackle challenges without installing any storage

Grid Management with solar inverters

> Passive Anti-Islanding function (V,f)

> Active Anti-Islanding functions (frequency shift)

> Reactive Power Supply (Q)

> Low Voltage Ride-Through (LVR)

> Short Circuit Current Supply (Isc)

> Tertiary Control (Active Power depending on frequency)

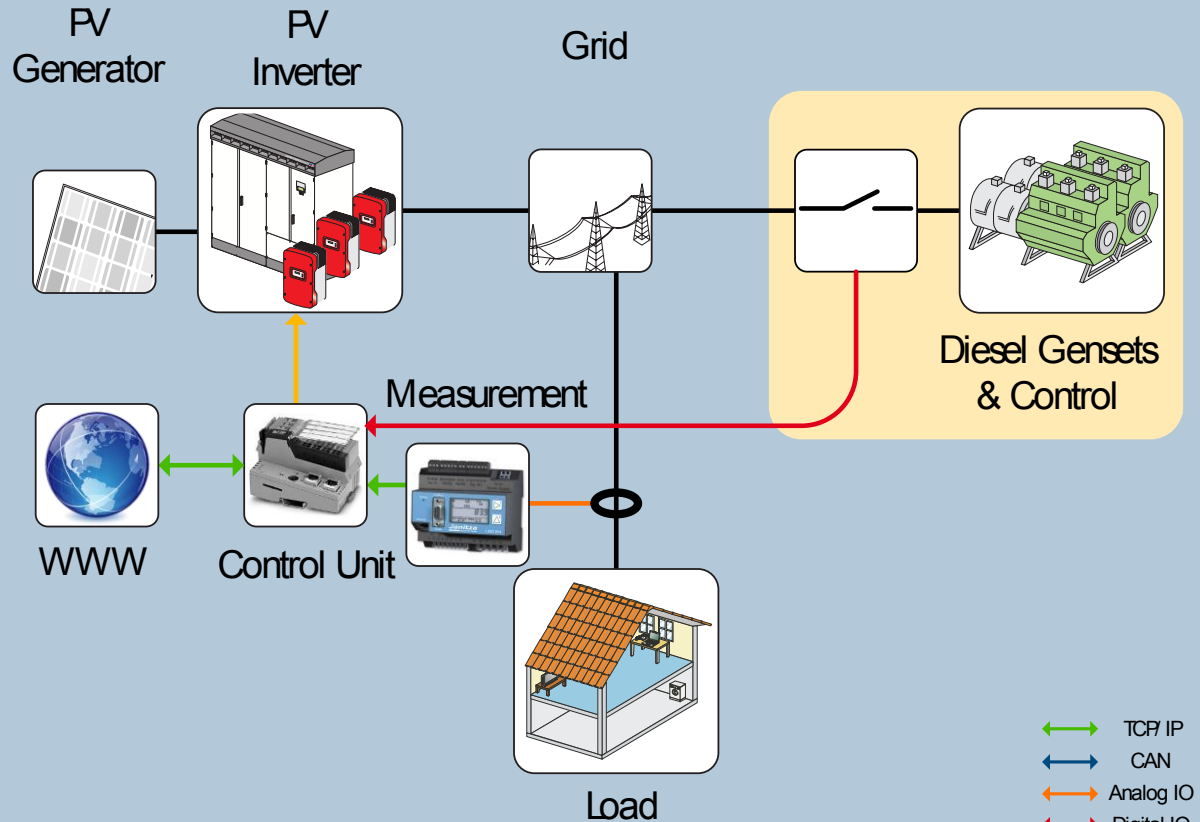> Remote Control Functions to set Power Output and Power Factor

Overview of Concept (Without Storage)

If:
- Diesel minimum load is known
- PV installed power is known

Then:
- the inverter will be limited to the measured load – minimum diesel load

Exceptions:
- Secondary diesel units are running under shut-off conditions
- There is not enough spinning reserve

PV Generator   PV Inverter   Grid

Diesel Gensets & Control

Measurement

WWW   Control Unit

Load

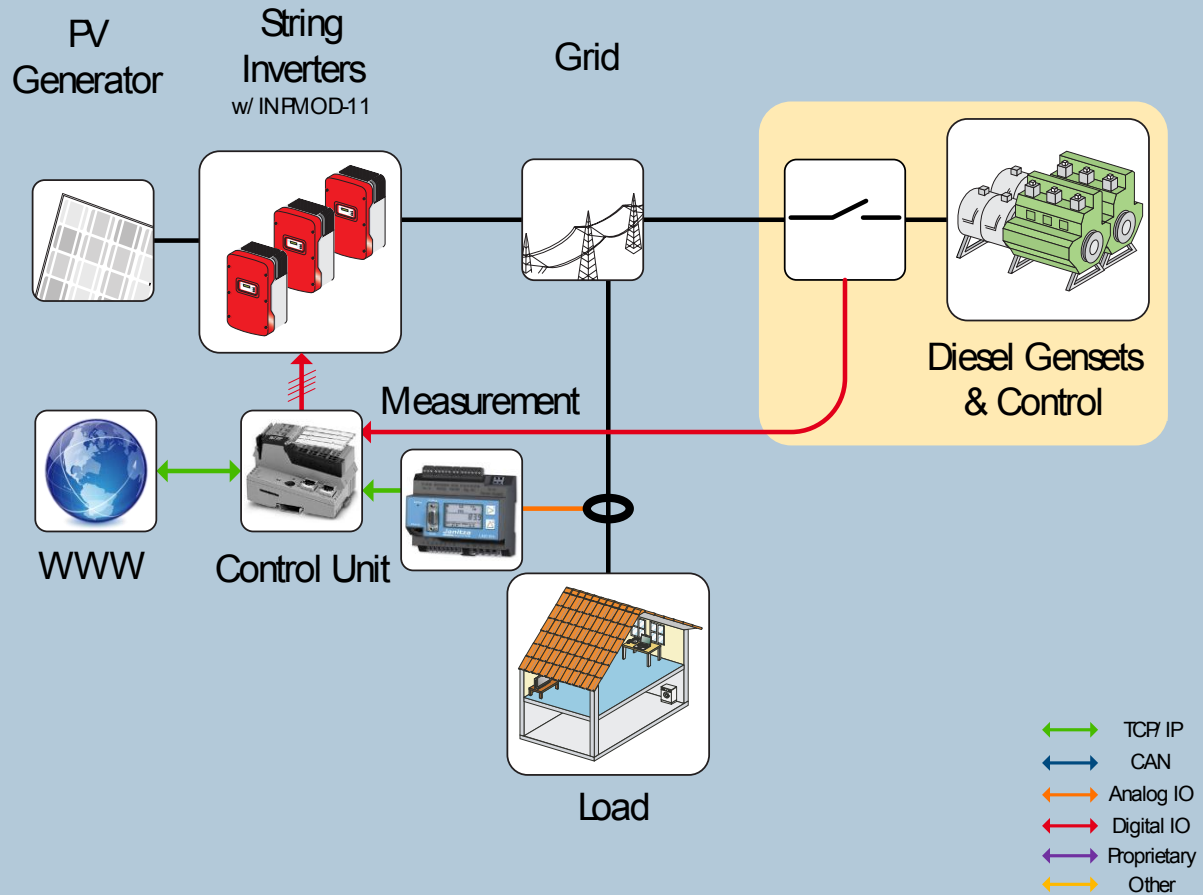|	TCP/ IP
	CAN
	Analog IO
	Digital IO
	Proprietary
	Other

Concept for String Inverters

Control unit sends one of 15 power reduction levels to the inverters

Communication interface:
- Digital / 5 Wire

Reaction time:
- Less than 2 seconds

PV Generator

String Inverters
w/ INPMOD-11

Grid

Diesel Gensets & Control

Measurement

WWW

Control Unit

Load

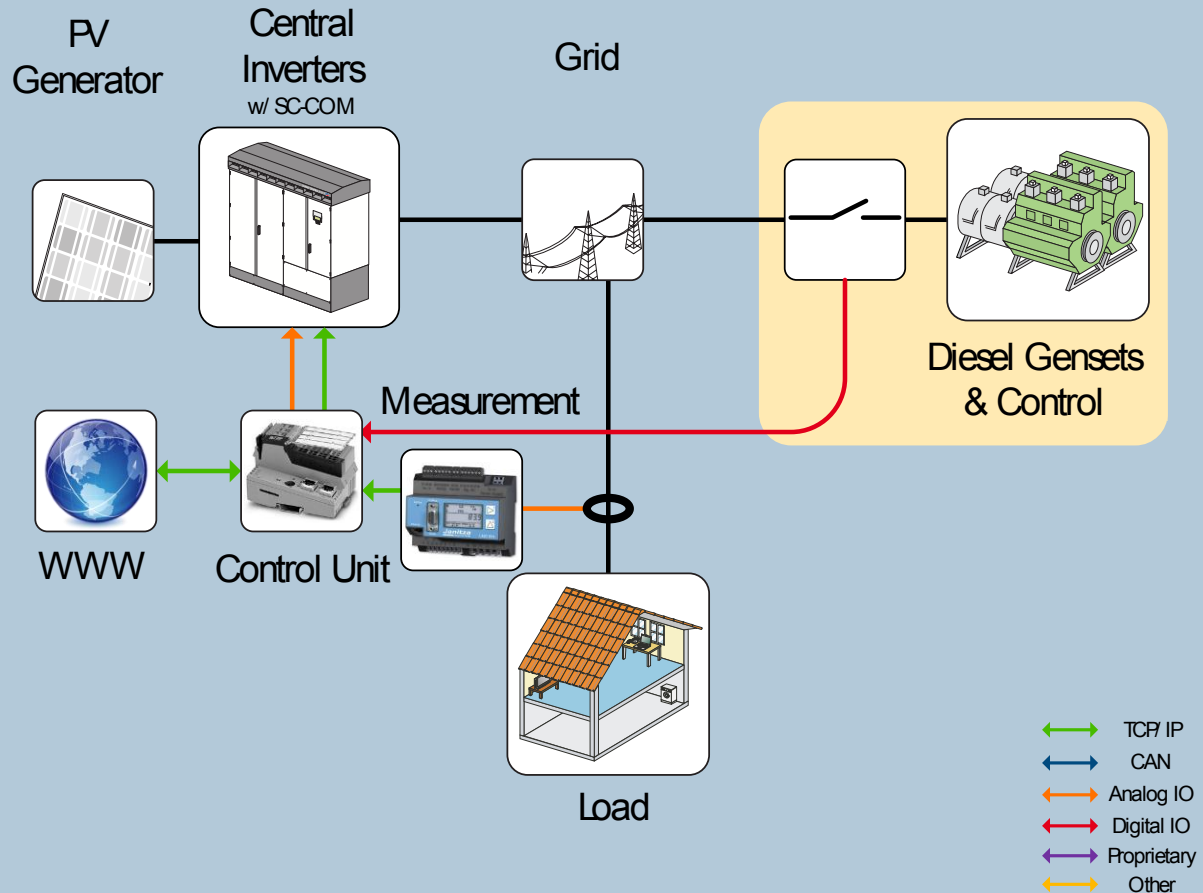|	
TCP/ IP	
CAN	
Analog IO	
Digital IO	
Proprietary	
Other	

Concept for Central Inverters

Control unit reduction setpoint through analog or ip communication. Through MODBUS, reactive power also possible

Communication interface:
- 4−20mA Analogue signal

Reaction time:
- Less than 200ms

PV Generator

Central Inverters
w/ SC-COM

Grid

Diesel Gensets & Control

Measurement

WWW

Control Unit

Load

	TCP/ IP
	CAN
	Analog IO
	Digital IO
	Proprietary
	Other

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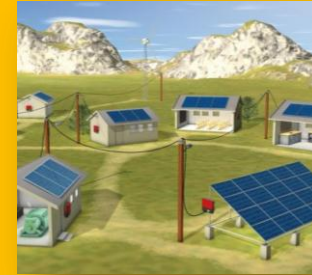
Traditional Diesel System

1   **2**   **3**   **4**

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Thank you for your attention!