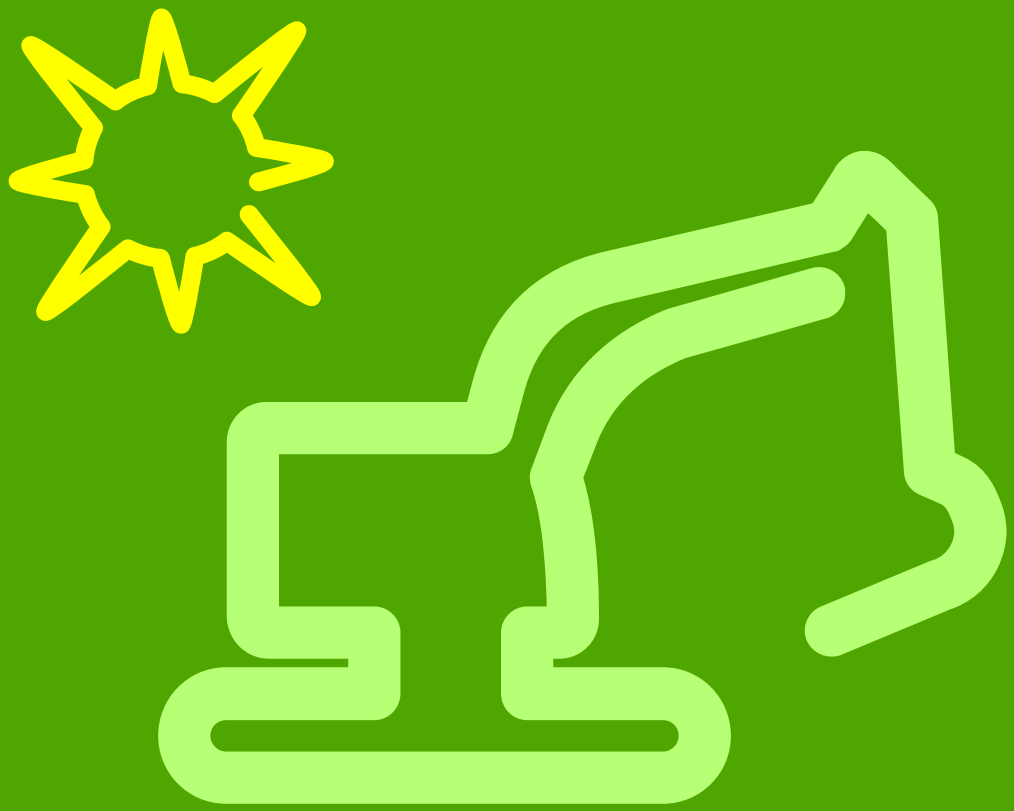
Hybrid Solutions for Mines
Save Fuel & Keep Digging



Schneider Electric

Schneider Electric at a glance

The global specialist in energy management

Large company

24

billion € of sales in 2012

41%

of sales in new economies

140 000+

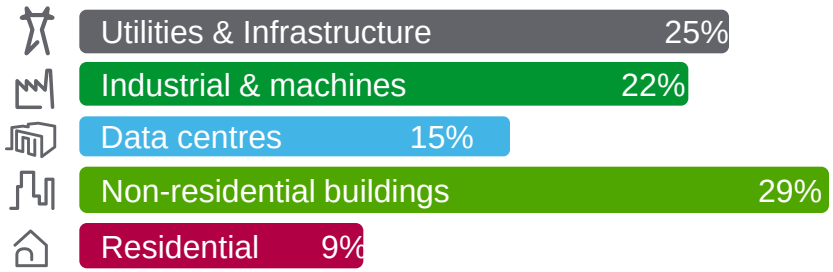
employees in 100+ countries

4–5%

of sales devoted to R&D

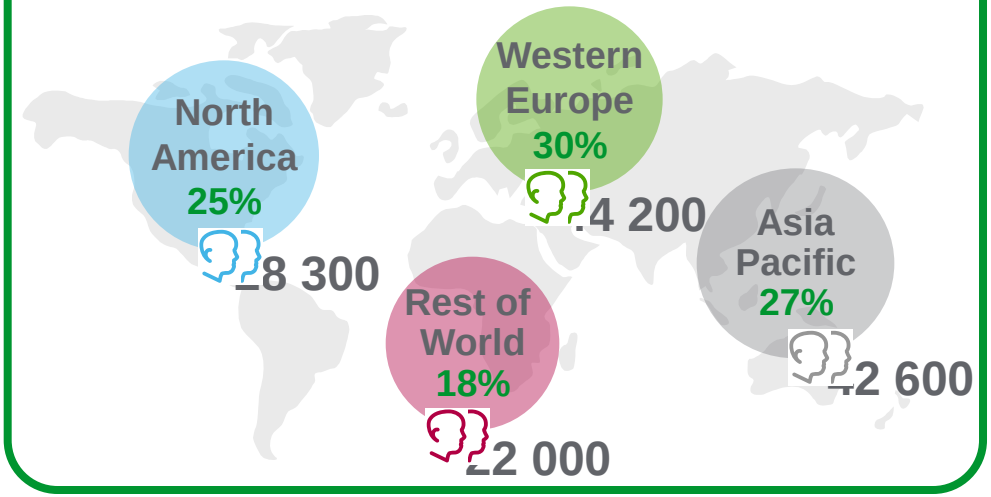
Diversified end markets

FY 2012 Sales (billion €)

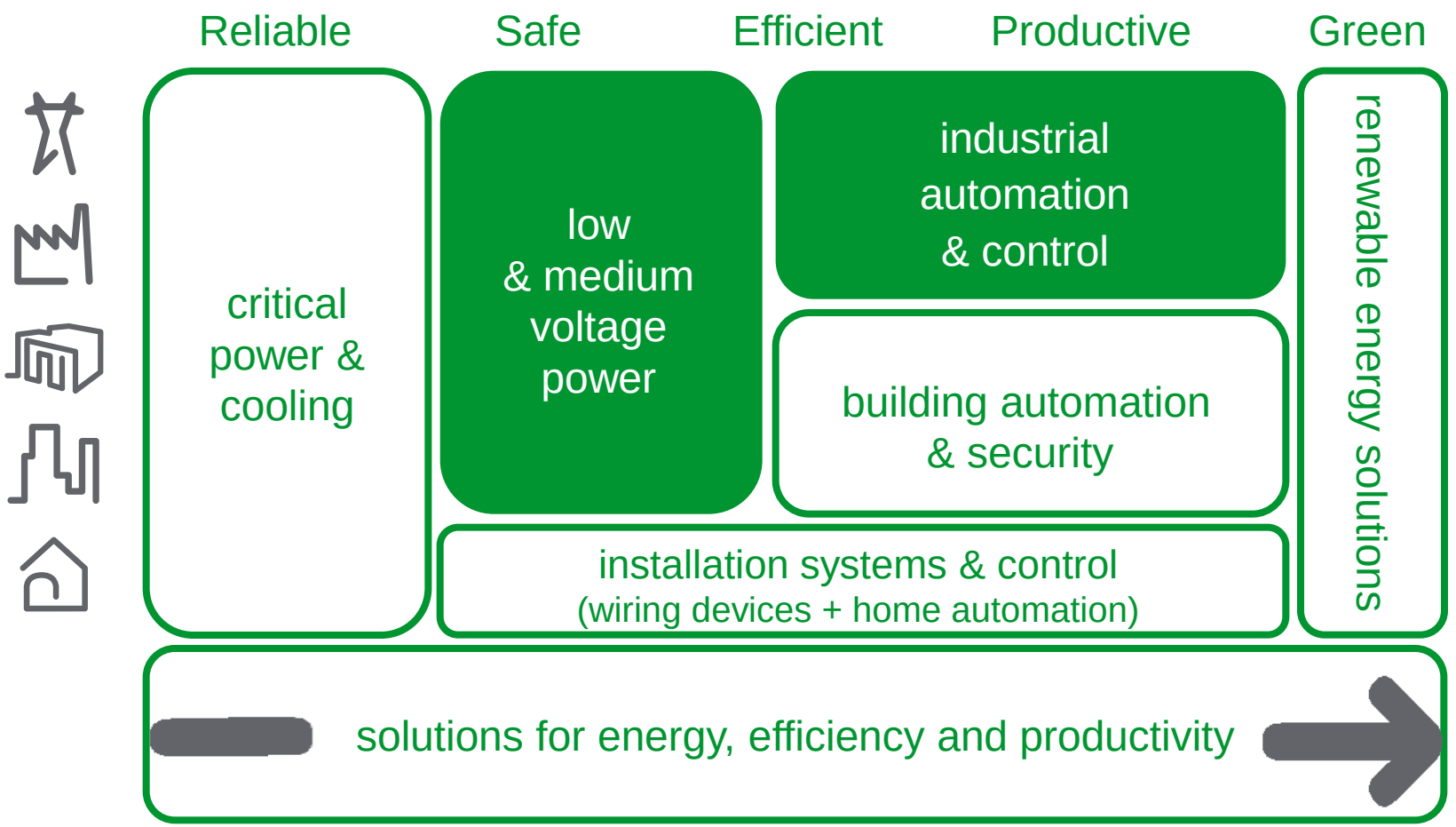


Balanced Geographies

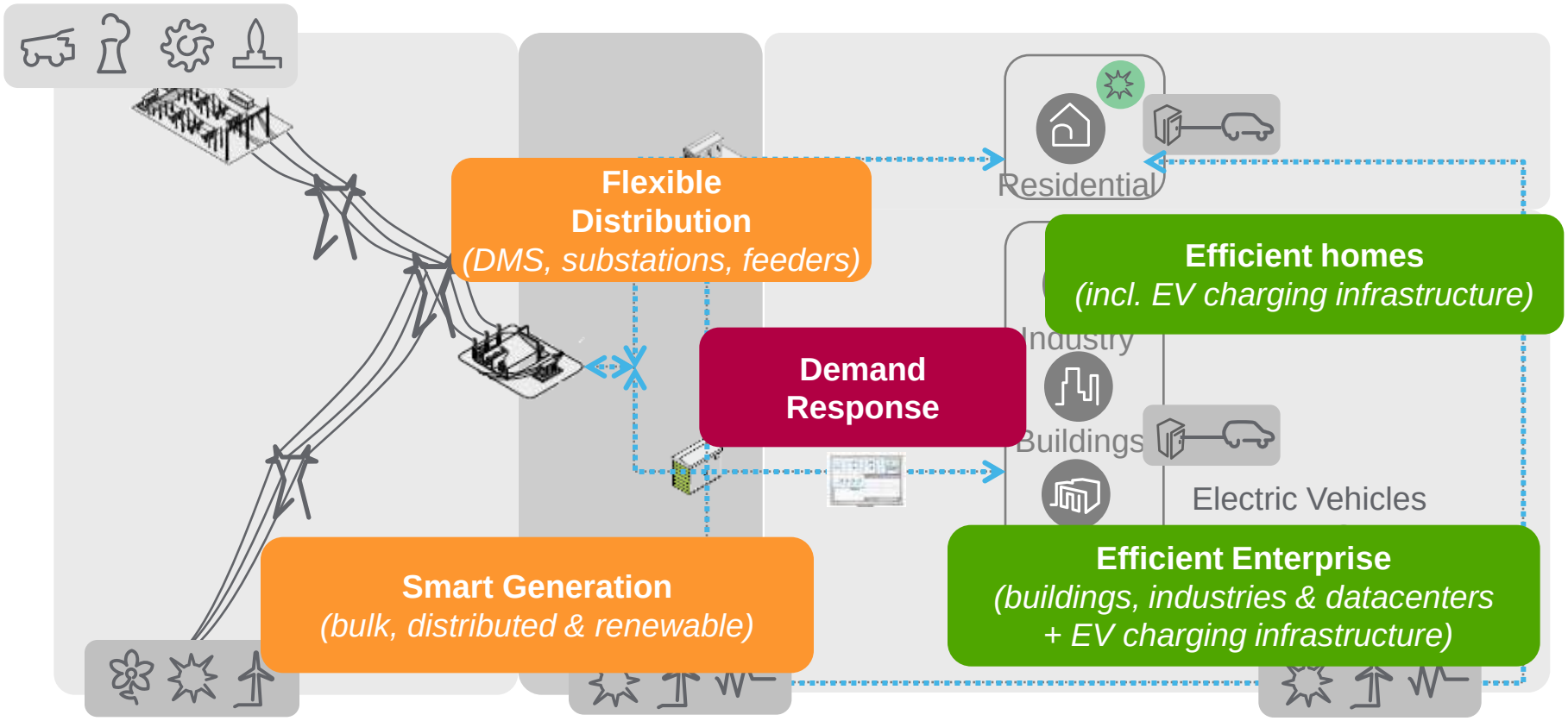
FY 2012 sales
Year-end 2012



The most comprehensive and integrated portfolio in energy management



Leading the development of the Smart Grid



Smarter Demand + **Smarter Supply** + **Demand Response** = **the Smart Grid**

Hybrid Generation for Mines

Schneider Electric Winning Formula

Save Fuel & Keep Digging

Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

+ ? + ?

=

Save Fuel & Keep Digging

We are a global technology player from pit to port, from mine production to enterprise

EcoStruxure™

Products, solutions & services from the mine site to the enterprise level

Sustainability
Energy Management and Sustainability Services. People's Safety Solutions

Supply Chain Integrated Planning and Optimization
Integration to production (OT)

Energy Optimization Systems
Water, Air, Gas, Electricity and Steam Use Optimization Solutions.

Process Management
Process monitoring & control; Process Expert Systems

Electrical Distribution
Energy monitoring and control
MV, LV, Motor Protection and Control

Secure Power Solutions
Traditional and Mobile Data Centers for Mining Sites; Secure Power; UPS

Access Control and Security
Access control, Security Video
Cyber security, CCTV

Business Management
Integration with ERP, CRM and Asset Mgt. Energy procurement ; Demand Response

You deserve a smart mine

Method and integrated systems + Right information, right user, right time = Up to 30% savings on OpEx & CapEx

Recent Large Mining References

AMBATOVY - MADAGASCAR

Engineering:
SNC-Lavalin Group Inc

End user:
Sherritt International Corporation,

Annual production:
60 000 t of nickel, 5 600 t of cobalt

Contract: EPC
Turnkey execution of the complete electrical distribution network

Scope of Supply: 20x E-Houses including MV/LV power distribution, MCC's and drives

Global amount: 50+ M€

Execution: 2007-2011

GUELB II - MAURITANIA

Engineering:
SNC-Lavalin Group Inc

End user:
SNIM Mauritania

Annual production:
+ 4 000 000 t of high quality concentrate

Contract: EPC
Turnkey execution of the electrical distribution & the process control

Scope of Supply: 23x E-Houses including MV/LV power distribution, MCC's and drives, process control system with 9000 I/O

Global amount: 30+ M€

Execution: 2011-2014

Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

\+ ? \+ ?

=

Save Fuel & Keep Digging

Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

+

Bankable Solar Systems

+

?

=

Save Fuel & Keep Digging

A Bankable Leader in Solar Solutions

Leveraging our global strength to support your business

More than
€ 24 billions

The sales for Schneider Electric in 2012

More than
3 GW

The amount of large three-phase inverters Schneider Electric has installed worldwide.

More than
100

The number of countries in which Schneider Electric is present, offering global support

More than
400 MW

The total power of PV Plants delivered by Schneider Electric as Main Electrical Vendor or Contractor.

More than
50 years

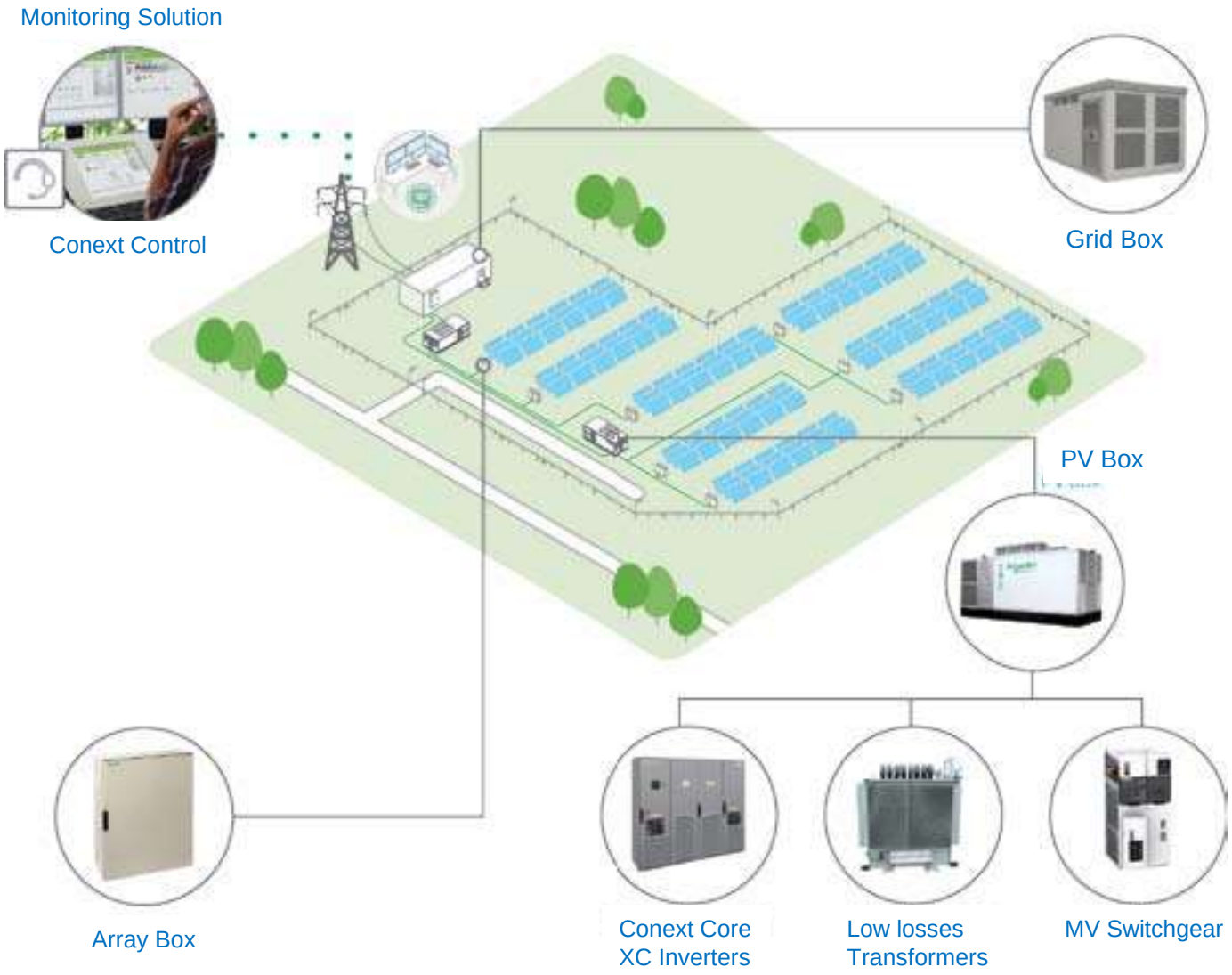
Our experience in Projects & Engineering

98.9 %

The peak efficiency of our Conext Core XC Inverters

Utility-Scale Solar Power Plants

Comprehensive solutions from modules DC output to MV or HV grid connection



O&M – a strong field proven experience

O&M Contracts in operation

France	153 MW
Reunion Island	7,6 MW
Italy	160 MW
Bulgaria	43 MW
Germany	300MW (maintenance)
Spain	50 MW (maintenance)
Slovakia	11 MW
Thailand	36 MW
Czech republic	17, 7 MW

Over 400 MWp of projects grid connected executed as main electrical vendor/contractor or BOS supplier in Europe ....

24MWp - Les Mées
Solaire Direct
Electrical EPC / O&M

4MWp - Vinon
Solaire Direct
Electrical EPC / O&M

22MWp - Gabardan
EDF-EN / Exosun
Elec. Solution / O&M

9MWp – Ste Clar
Solarezo
Elec. Solution / O&M

4.5MWp – Truck Etape
JMB / Car Park
Electrical EPC

7.4MWp – Callian
Eneryo
EPC / O&M

39MWp Letnitsa/Vratsa
Samsung
EPC / O&M

7.5MWp Rodhnikovoye
Activ Solar
Electrical Solution

43MWp - Celino
AES
EPC / O&M

23MWp - Lanuvio
SunPower
Electrical Solution

15MWp - Solare Roma
SunPower
EPC

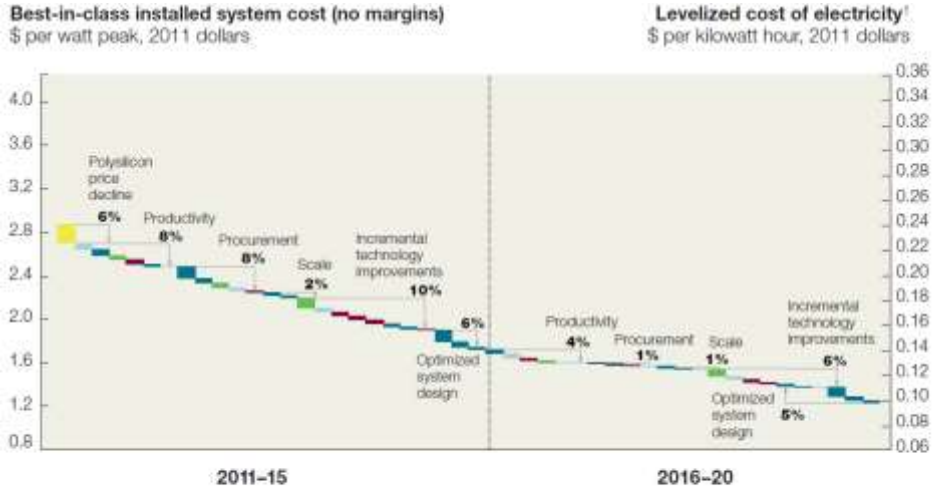
17MWp - GreenYellow
Casino group / Roof
Electrical EPC / O&M

Hybrid Systems: Why Solar PV ?

Economics

- World Diesel Costs ~$1 per Litre and is steadily rising
- Gensets Consume ~ 0.25 L Fuel per kWh Produced ($0.25 per kWh)
- Cost of Grid Connected PV Technology is steadily declining

  (>50% Reduction Since 2009) with a Levelized Cost of Energy < $0.15 per kWh



[1]Levelized cost of energy; assumptions: 7% weighted average cost of capital, annual operations and maintenance equivalent to 1% of system cost, 0.9% degradation per year, constant 2011 dollars, 15% margin at module level (engineering, procurement, and construction margin included in BOS costs).

Source: Industry experts; Photon; GTM Research; National Renewable Energy Laboratory; US Energy Information Administration; Enerdata; press search; company Web sites; McKinsey analysis

Today, Hybrid Generation based on PV Systems is a reality
Considering that up to 40% of the Operation Cost of mines are Diesel, the potential of savings is huge

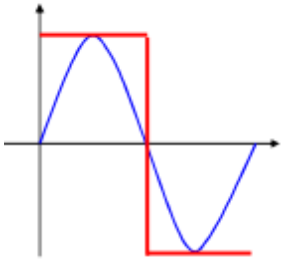
Hybrid Systems: Why Solar PV ?

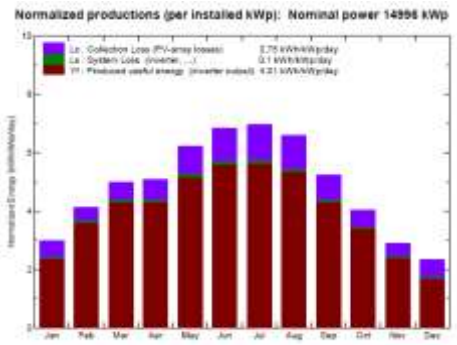
Benefits

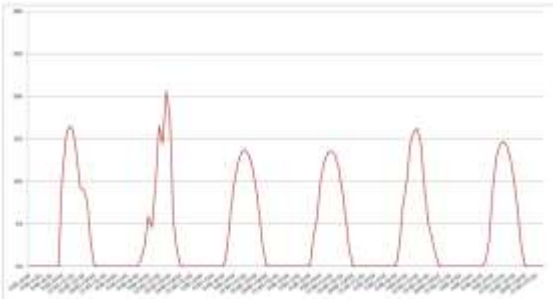
- In high irradiation areas, low LCOE achieved by Solar PV makes it already **affordable**
- Solar PV is **scalable** – Plants are designed and built through standardized building blocks
- Solar Systems can be **built quickly** even in hard climatic conditions
- Power can be produced where it is needed, **no transmission line losses**
- Can be combined with **Diesel Gensets and Battery Systems** to form a **Micro-Grid** with increased **Energy Efficiency** and no reliance on the grid

Solar PV Generation

Reminding the basics







SOLAR is day time only!

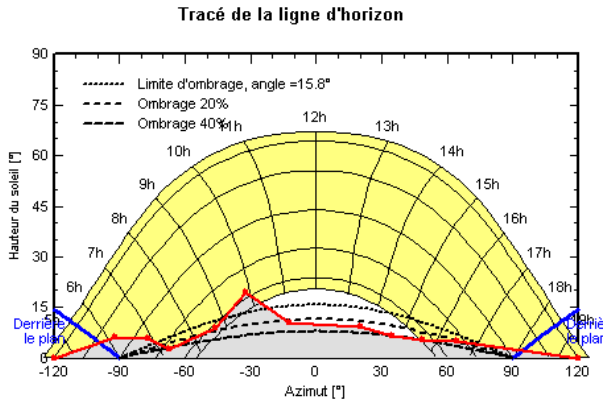
PV Design

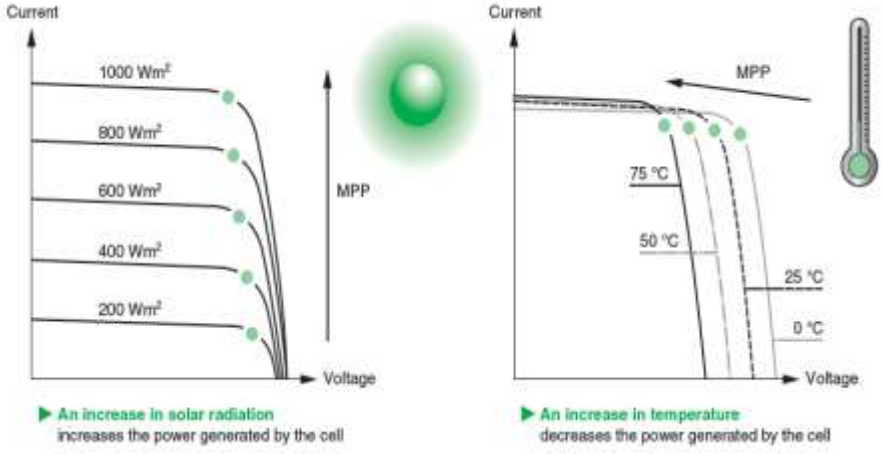
Electrical Design

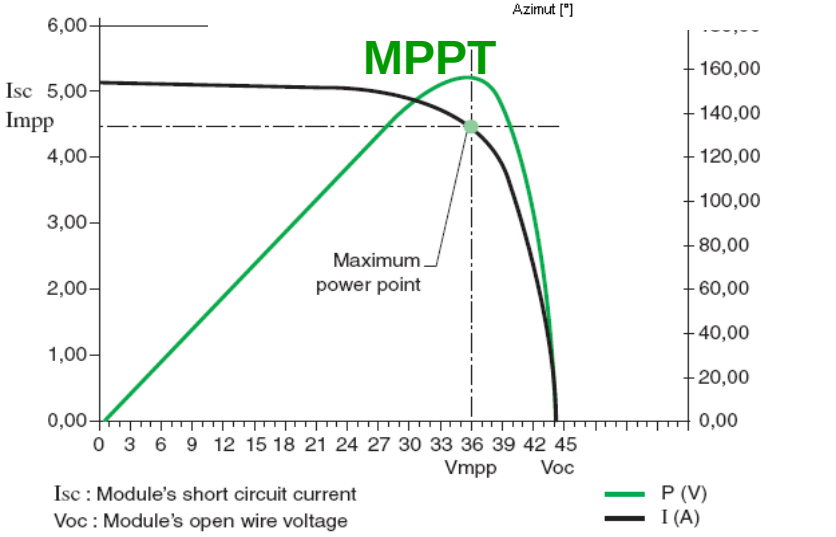
- $Voc(T°min)_{PVplant}$ < Inverter Vmax
- $Vmpp(T°max)_{PVplant}$ > Inverter Vmin
- $Isc_{PVplant}$ < Inverter Imax

Mechanical Design

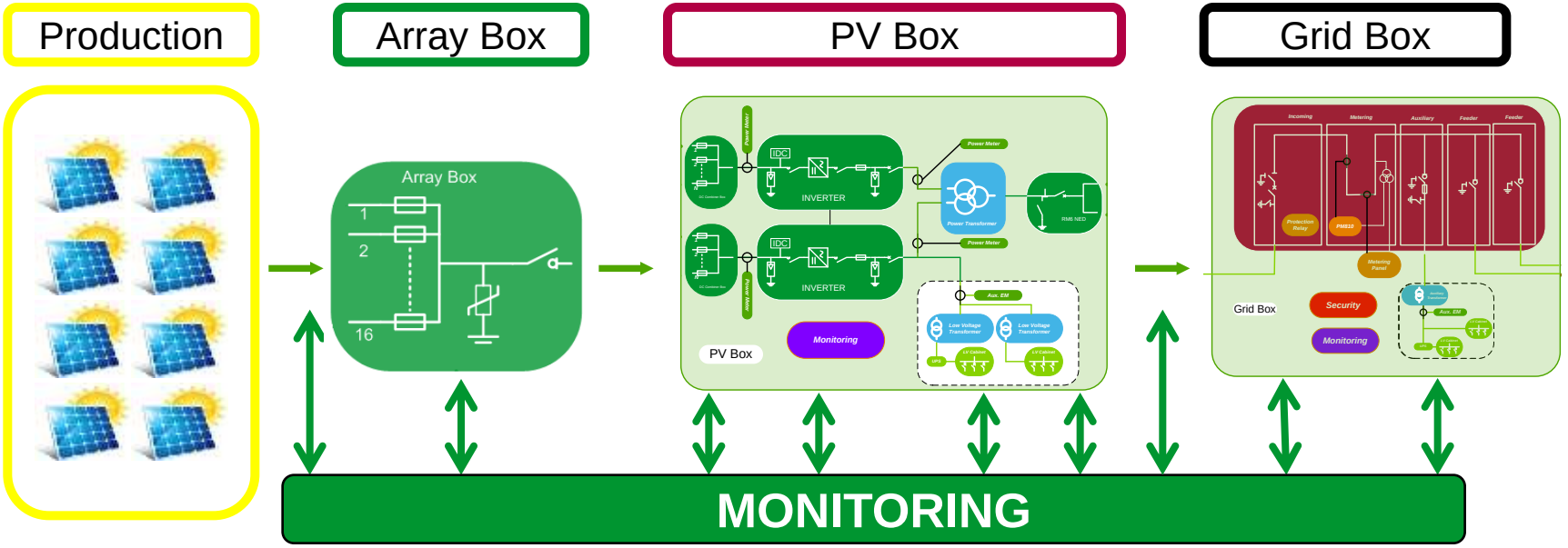
- Pitch
- Tilt
- Azimut



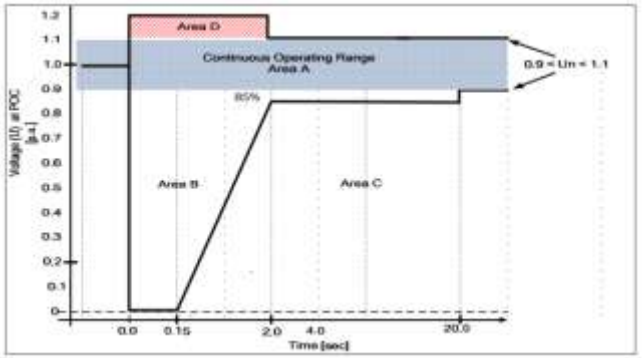




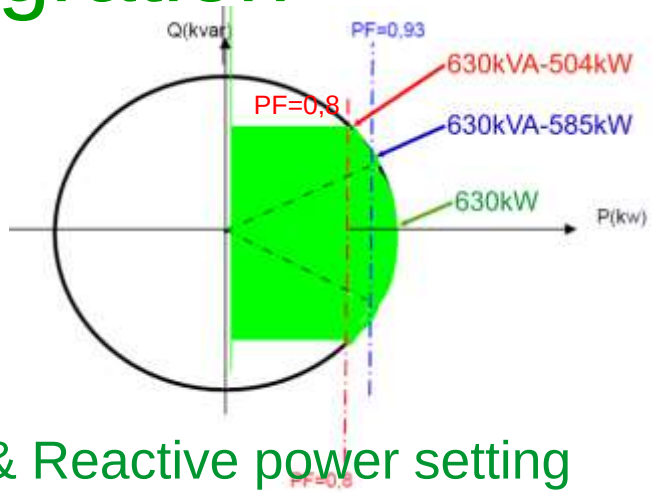
Fully monitored DC-AC conversion



+ network constraints integration



- Voltage Ride Through



- Active & Reactive power setting

Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

+

Bankable Solar Systems

+

?

=

Save Fuel & Keep Digging

Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

+

Bankable Solar Systems

+

Micro Grid Expertise

=

Save Fuel & Keep Digging

Main Renewable Integration Issues

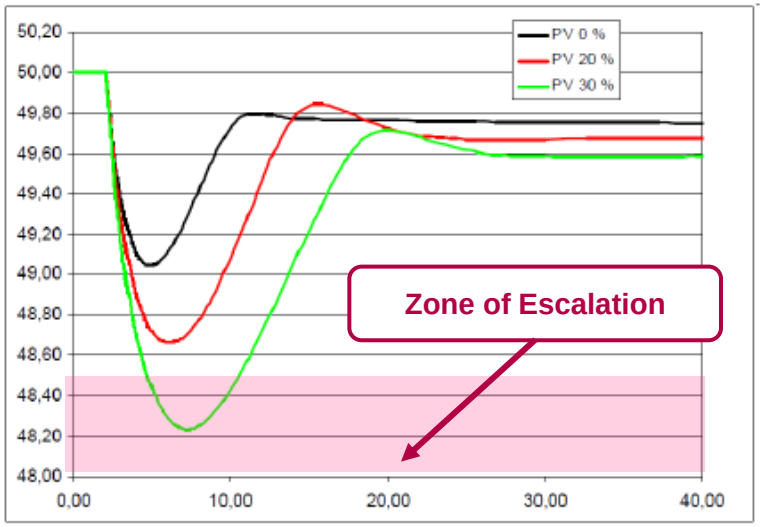
The more the system integrates renewable generation, the more is sensitive to production intermittence

- → Frequency zags du to lack of spinning reserve
- → Voltage variation outside equipment withstand

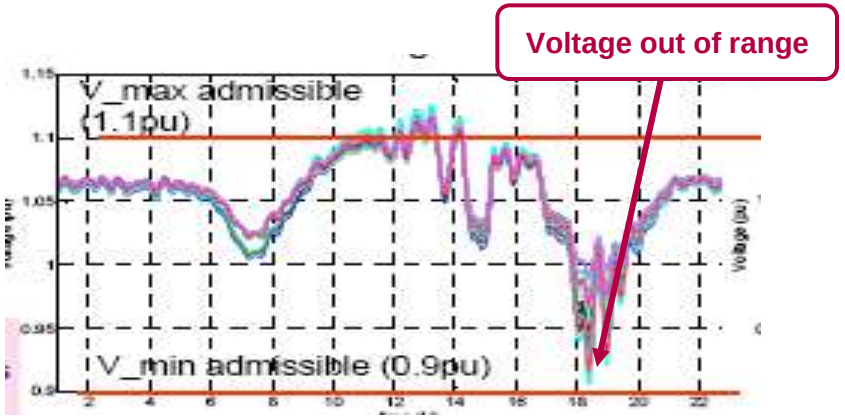
To increase renewable integration those 2 issues need to be solved technically and commercially depending of the different Grid Codes.

Schneider Electric Micro Grid Solution help to:

- ➢ Balance locally Production & Consumption
- ➢ Share the load between both generation
- ➢ Offer new means to manage power flows



Example of frequency variation du to 20% loss of production on an off-grid system depending on Renewable integration (EdF source)

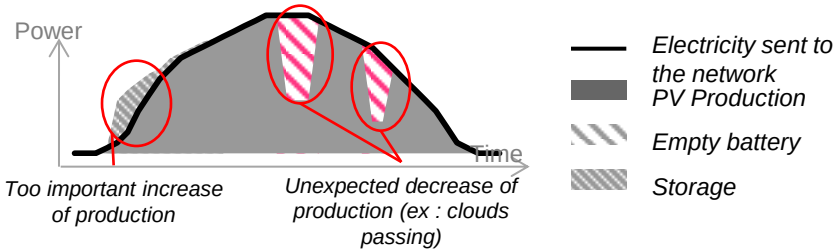


Example of voltage variation du to Solar intermittent production (IDEA source)

Main usage of a storage system is to transform intermittent energy in dispatchable energy

Power storage

Objective is to
- deliver to the grid all the available power in a few seconds with a typical duration of 15 to 30 minutes (frequency ancillary service)
- to **Smooth the Renewable** intermittency sent over the network

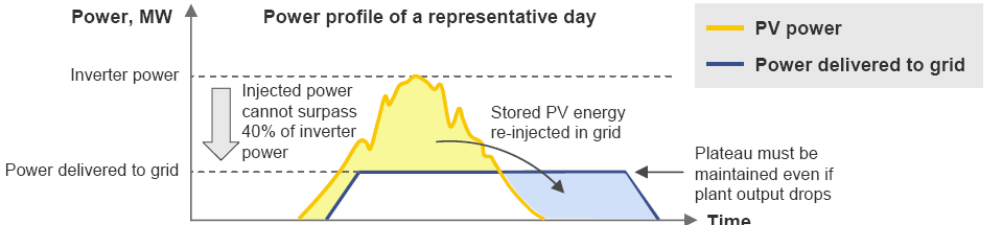


(Source: Millener Project)

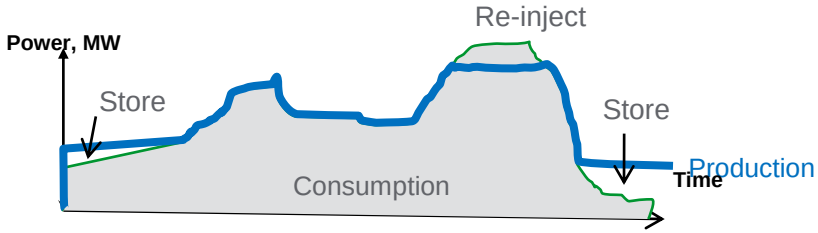
Energy storage

Objective is to
- store all the extra available energy above a settable threshold and to deliver a **constant active and reactive** power to the grid, or to the user (self consumption).

-Hoist assets by filling the valley to continue to produce base production (e.g. nuclear, gaz) and **reducing peak-load** demand

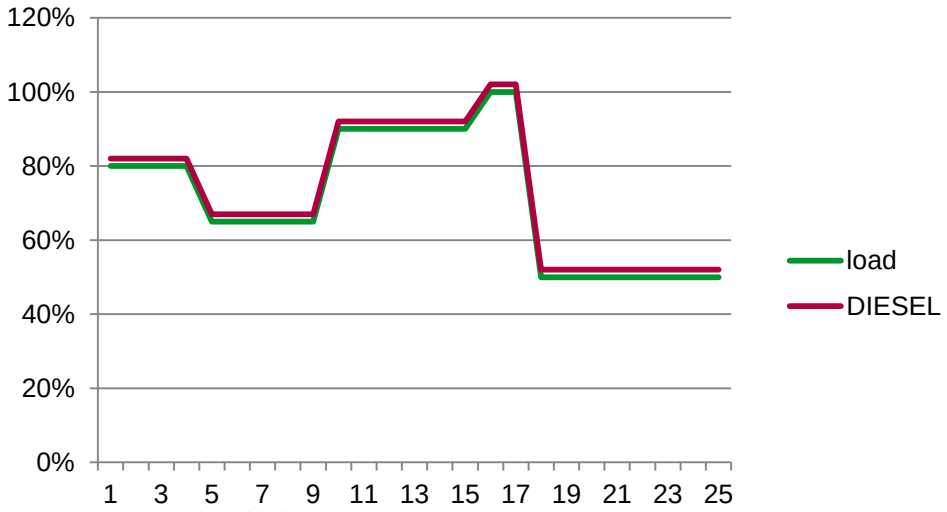


(Source: Request for Performance from CRE)

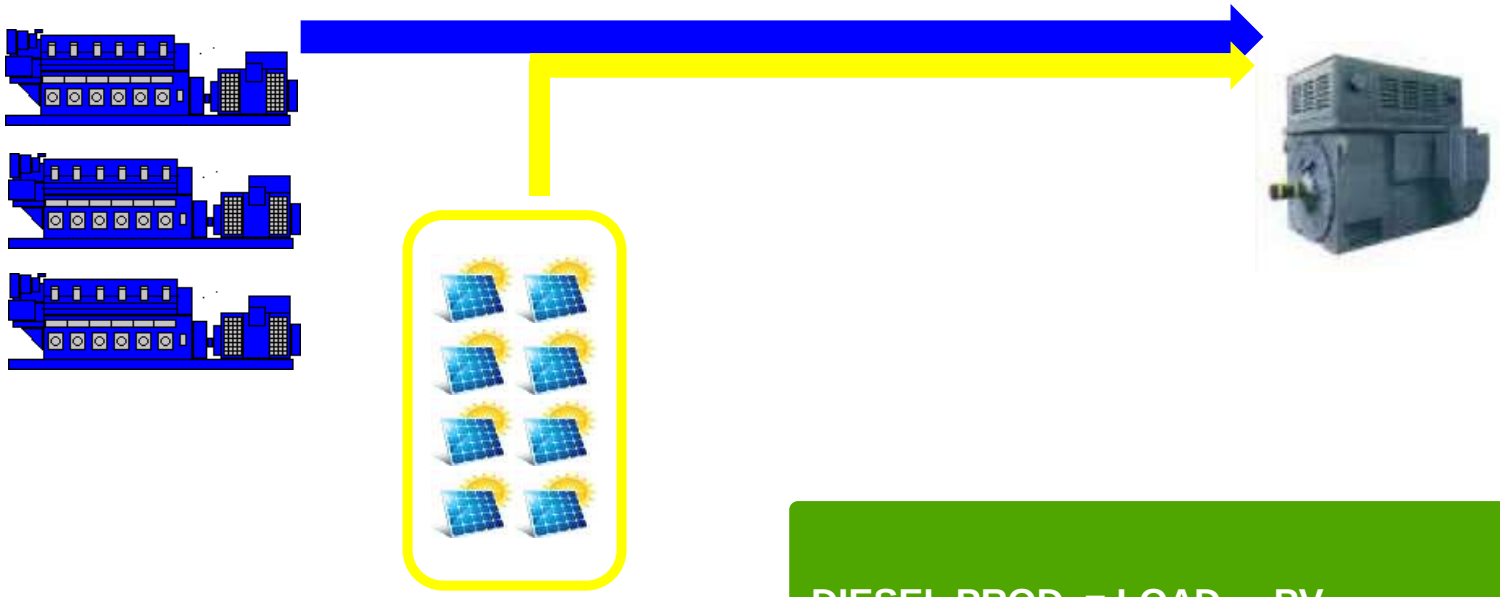


Typical daily curve

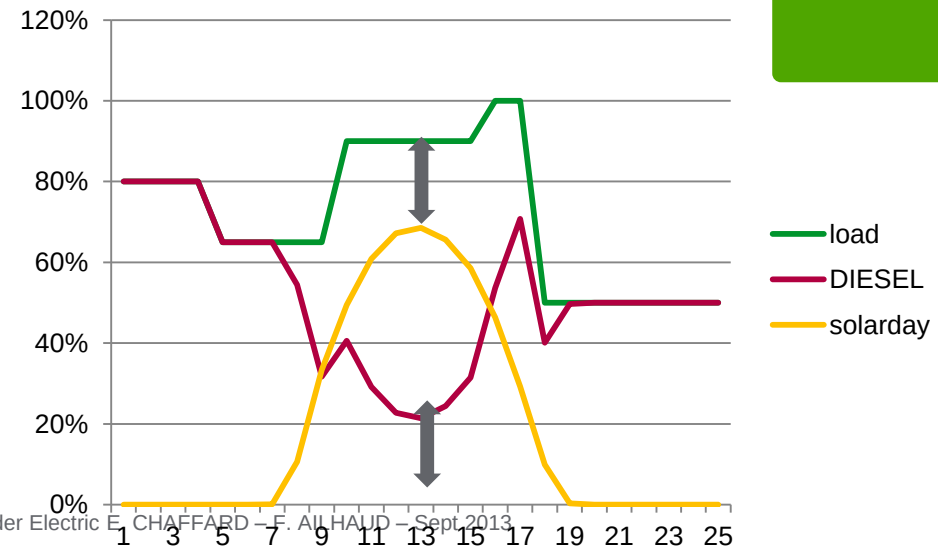
DIESEL PROD. = LOAD CONSUMPTION



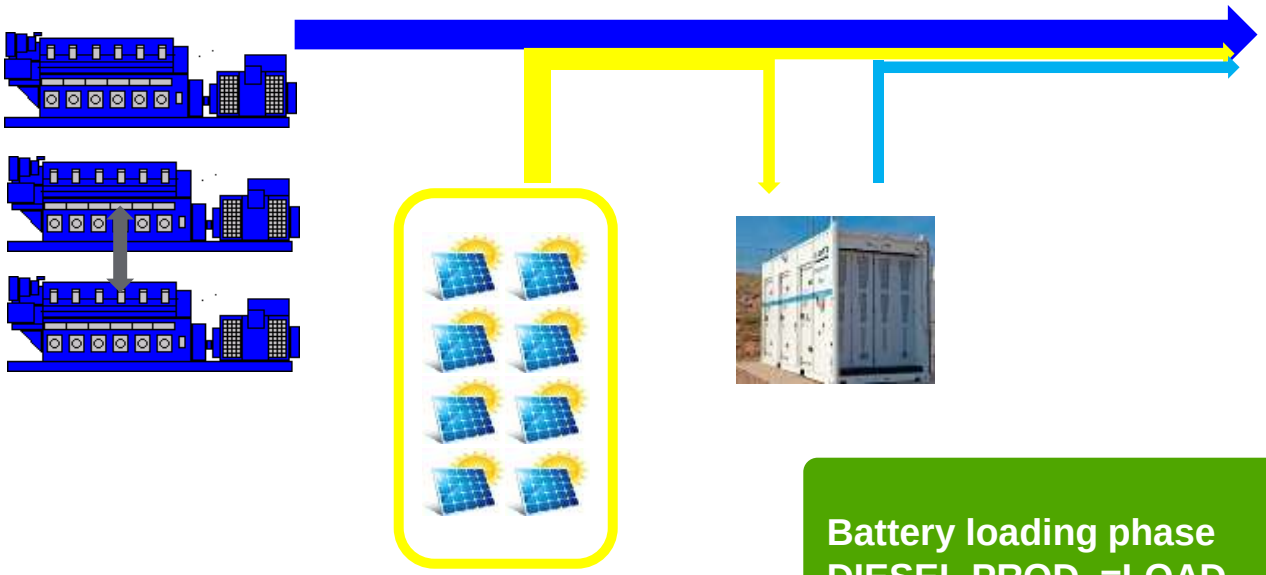
Typical daily curve

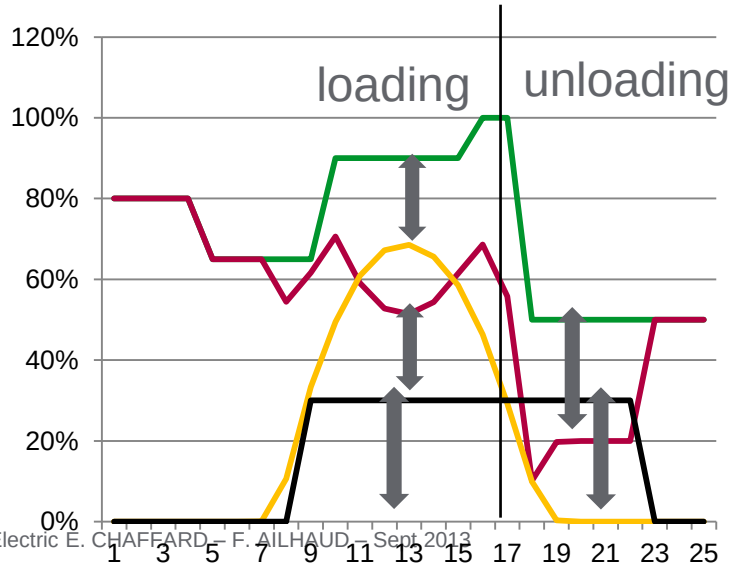


DIESEL PROD. = LOAD – PV



Typical daily curve

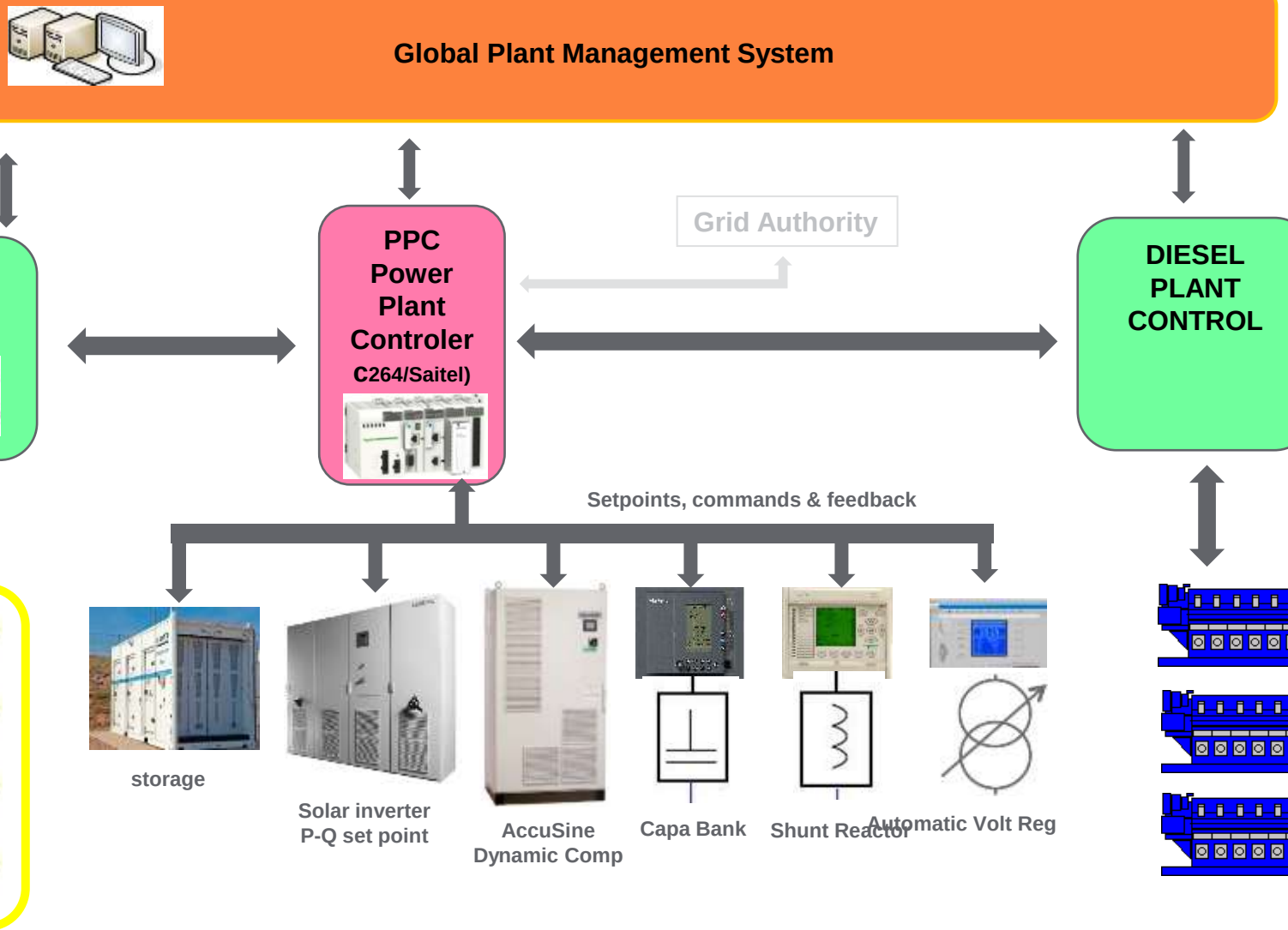




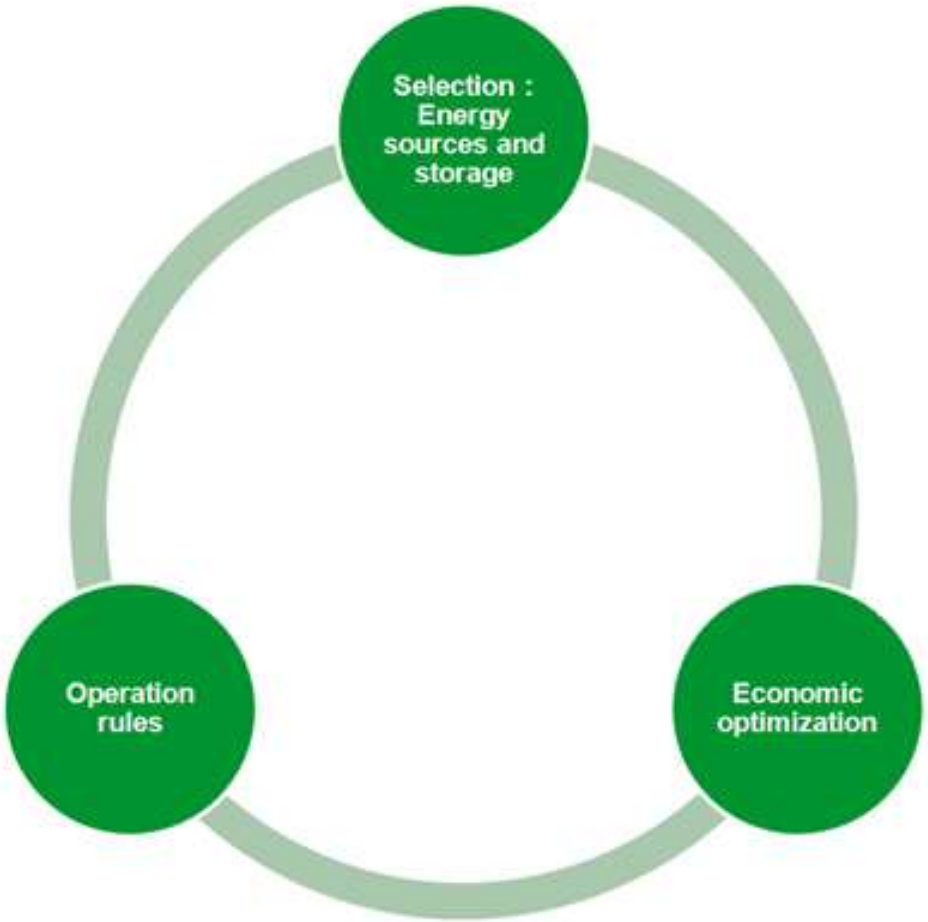
Battery loading phase
DIESEL PROD. =LOAD - PV + BATTERY

Battery unloading phase
DIESEL PROD. = LOAD –PV - BATTERY

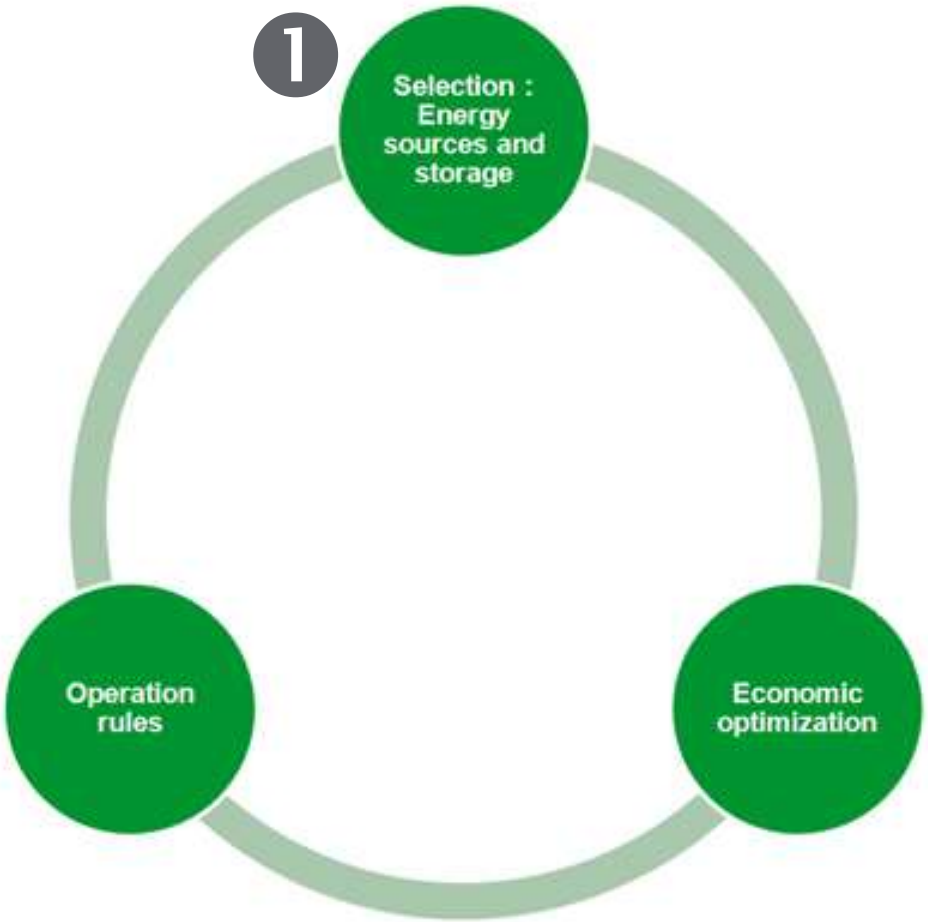
SCHNEIDER applies same rules than for large scale grid connected plant controler



From Diesel to Hybrid Generation: A 3-step methodology



From Diesel to Hybrid Generation: A 3-step methodology



1- Energy Mix Selection

Electrical Energy needs

Load Profile

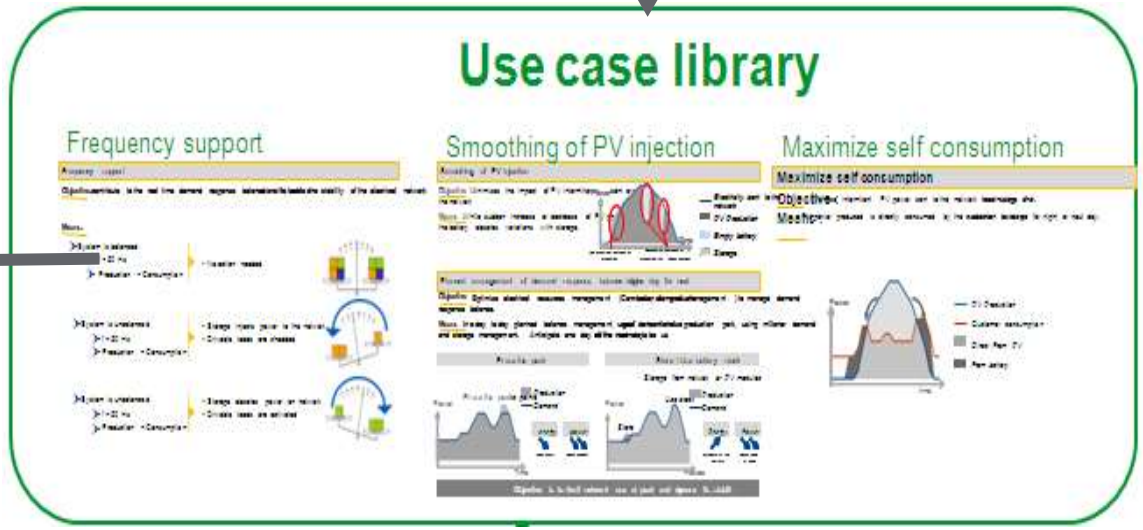
Electrical availability needs

Spinning Reserve
Motor startings
Grid Quality and stability
Weather constraints

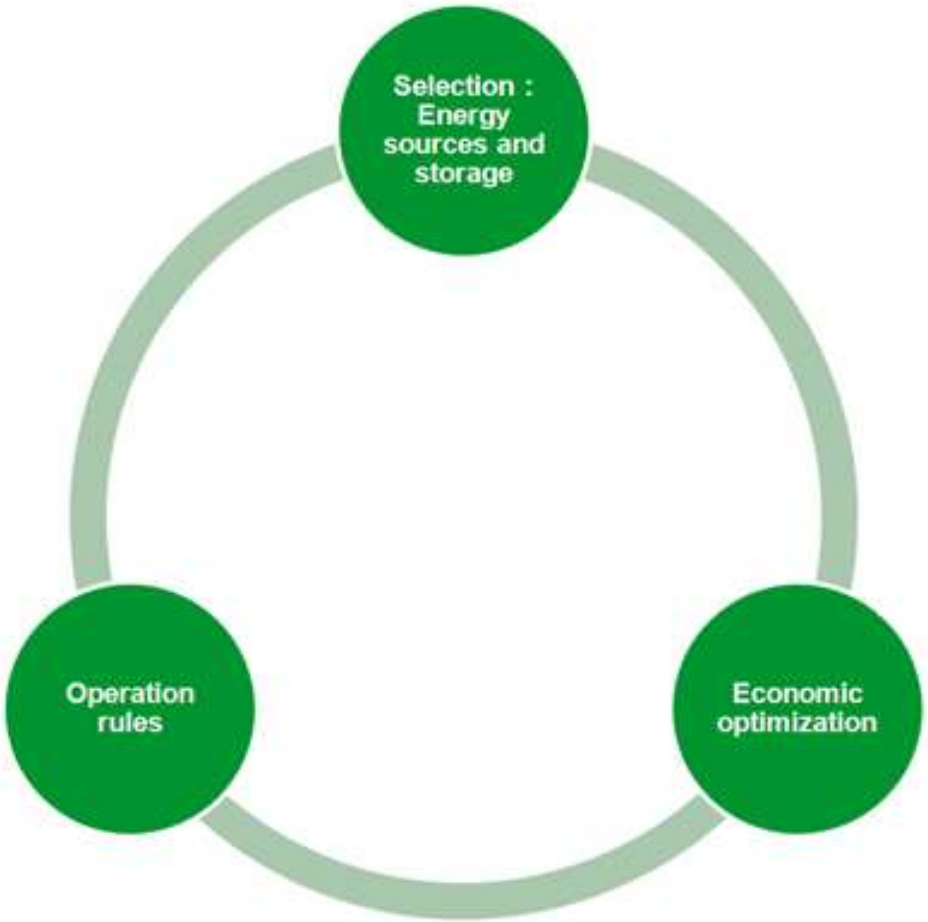
TIP on site audit

FUNCTIONNAL ANALYSIS

Selection of Energy Sources & Storage needs

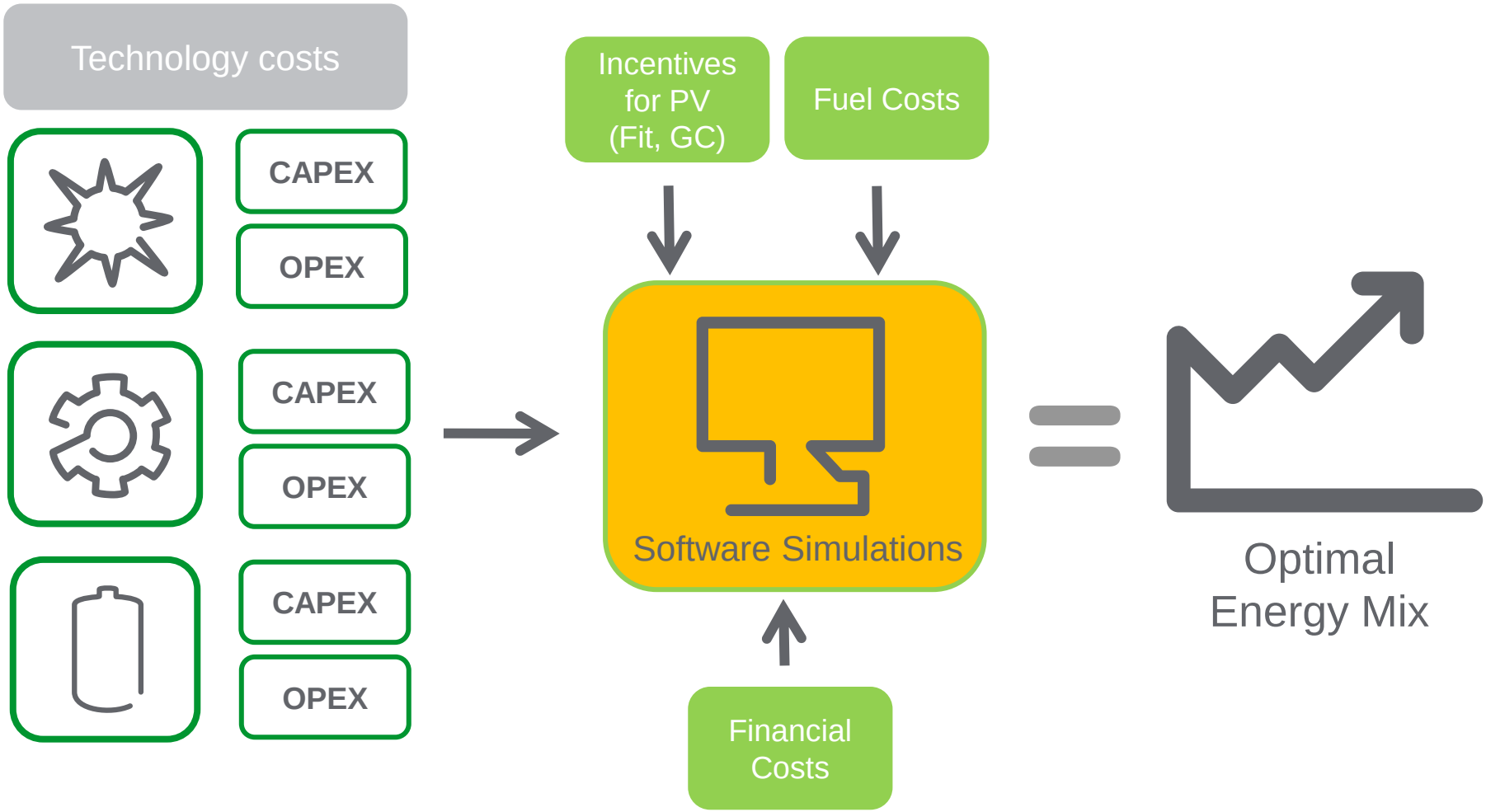


From Diesel to Hybrid Generation: A 3-step methodology



2

2- Economic Optimization

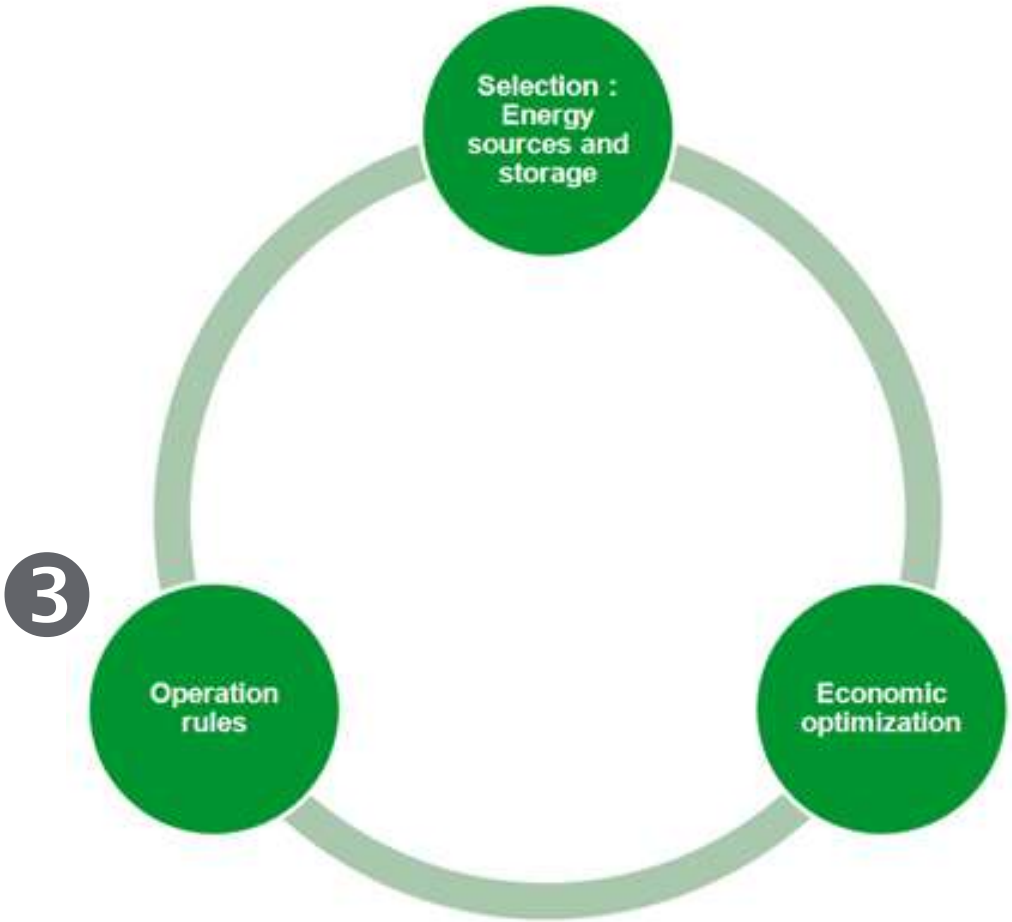


2- Result of Economic Optimization (example)

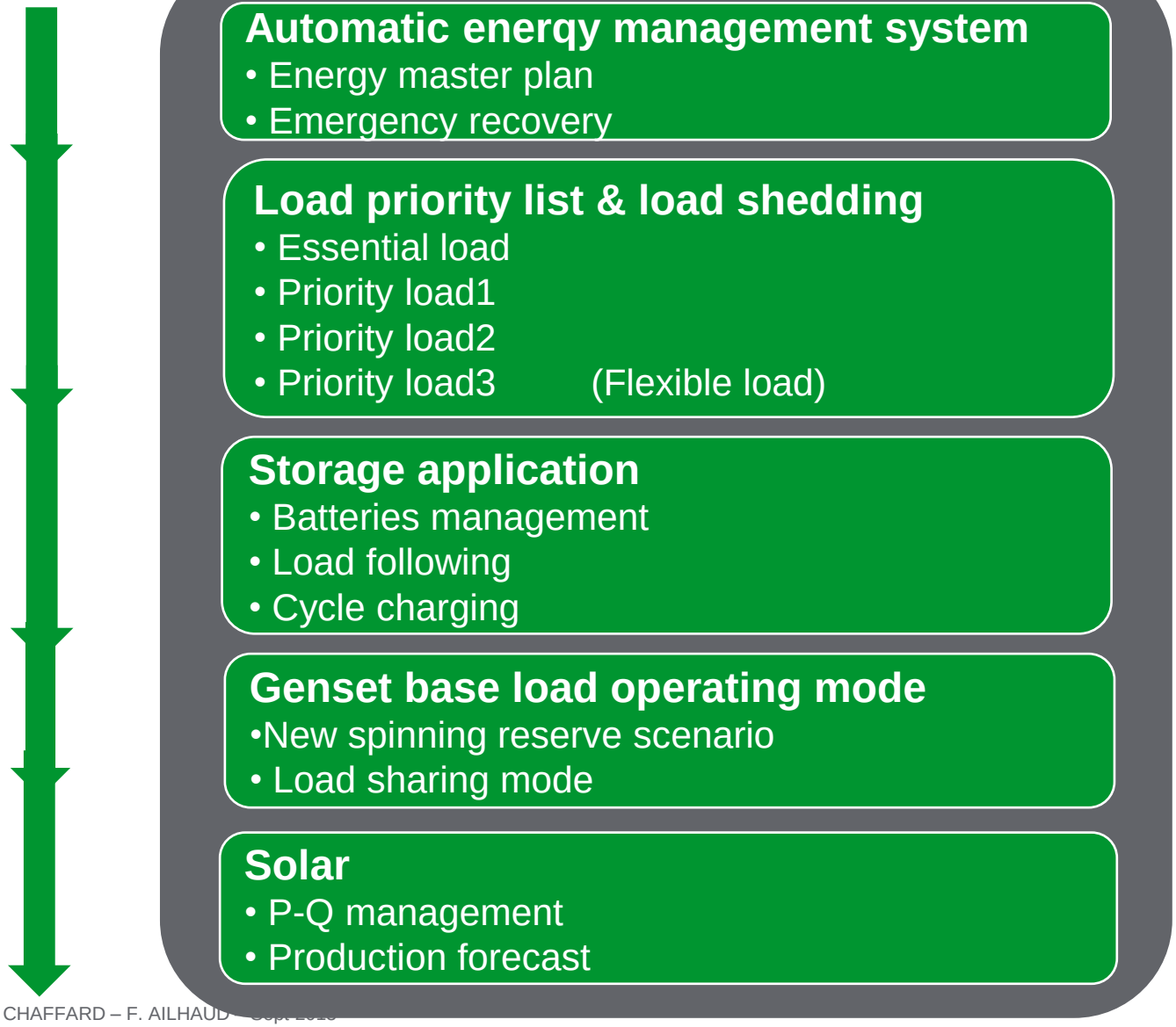
Scenario	Generator (kW)	PV (kW)	Storage (kW)	First cost ($1000)	Diesel use (mill. liters/yr)	Levelised elec. cost (¢/kWh)	Re-newables fraction
Gen Only	3,500	0	0	875	4.0	53.9	0
Gen+Strg	3,500	0	1,000	2,875	3.0	42.6	0
Gen+PV	3,500	500	0	3,375	3.9	55.0	0.10
Gen+PV+Strg	3,500	2,000	2,000	14,875	2.0	42.4	0.28
PV+Strg	0	7,000	12,000	59,000	0.0	68.4	1.00

IRENA – Electricity Storage and renewables for Island Power – May 2012

From Diesel to Hybrid Generation: A 3-step methodology



❸ Operation rules = final specifications



Hybrid Generation for Mines

Schneider Electric Winning Formula

Solid Mining Experience

+

Bankable Solar Systems

+

Micro Grid Expertise

=

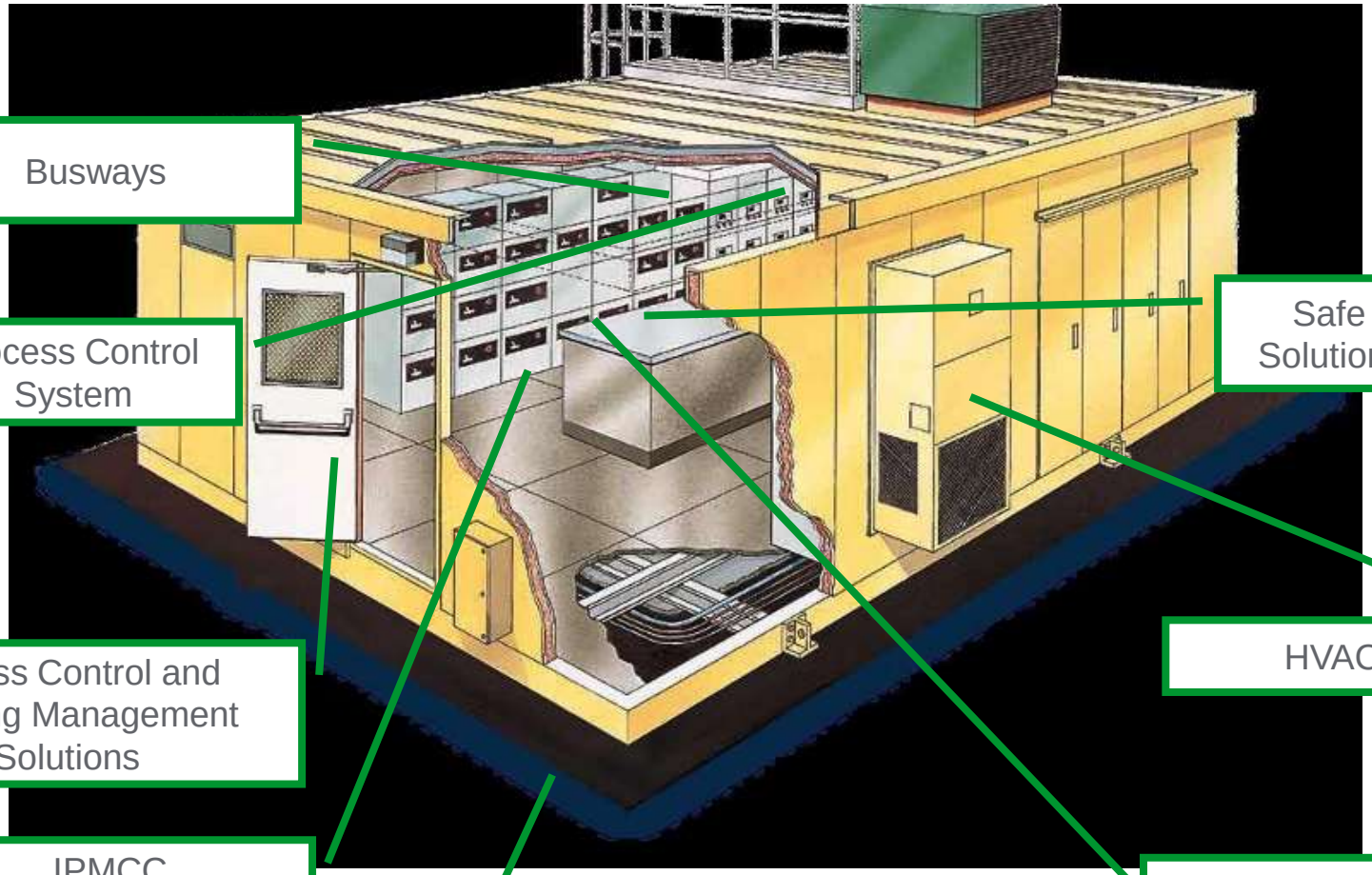
Best-in-class Hybrid Generation Solutions maximizing YOUR ROI keeping high availability of YOUR assets

Make the most of your energy™

Schneider Electric

Back up

Mining Solutions Schneider Electric E-Houses

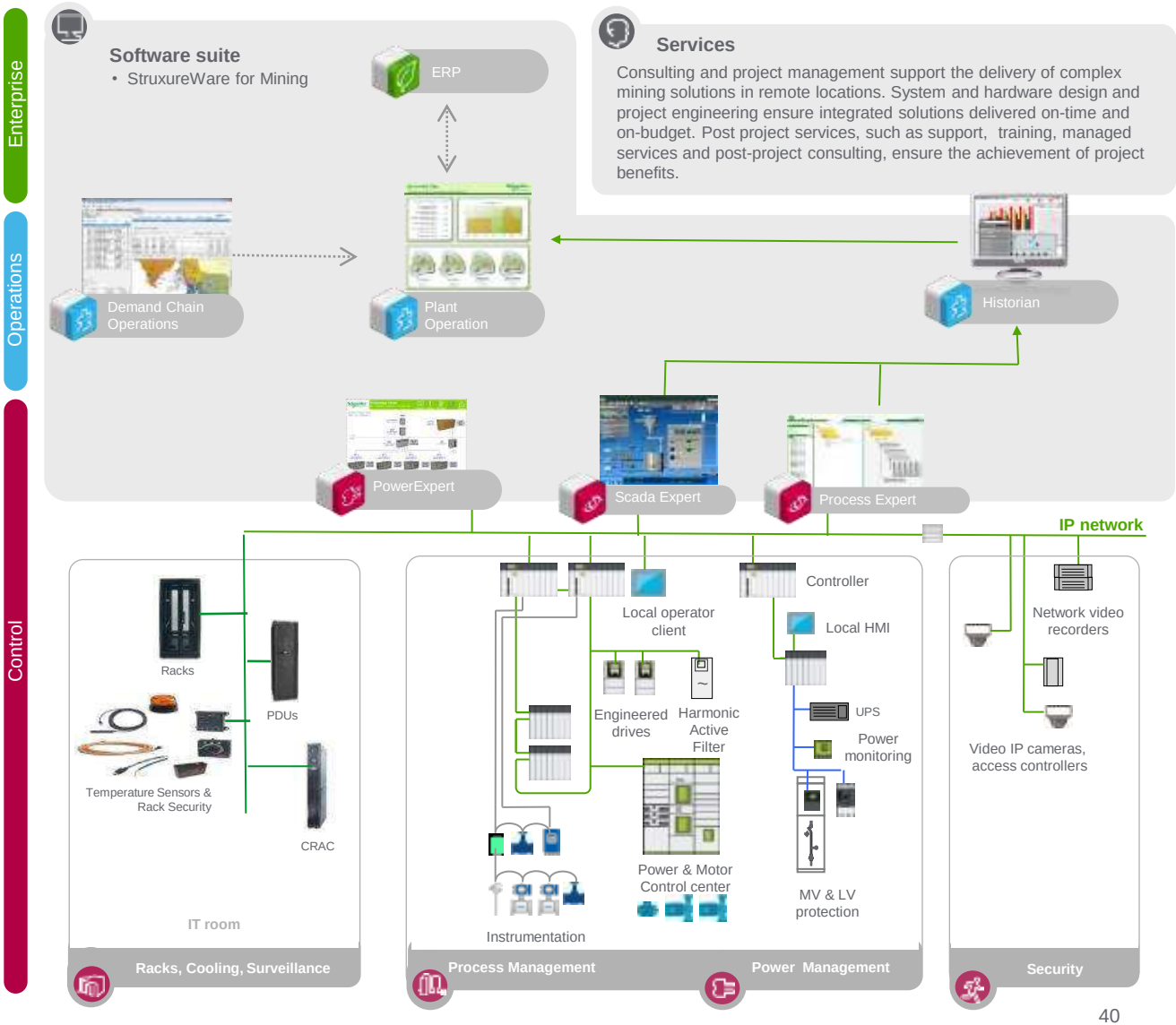


Mining Solutions Supply Chain Integrated Planning & Optimization

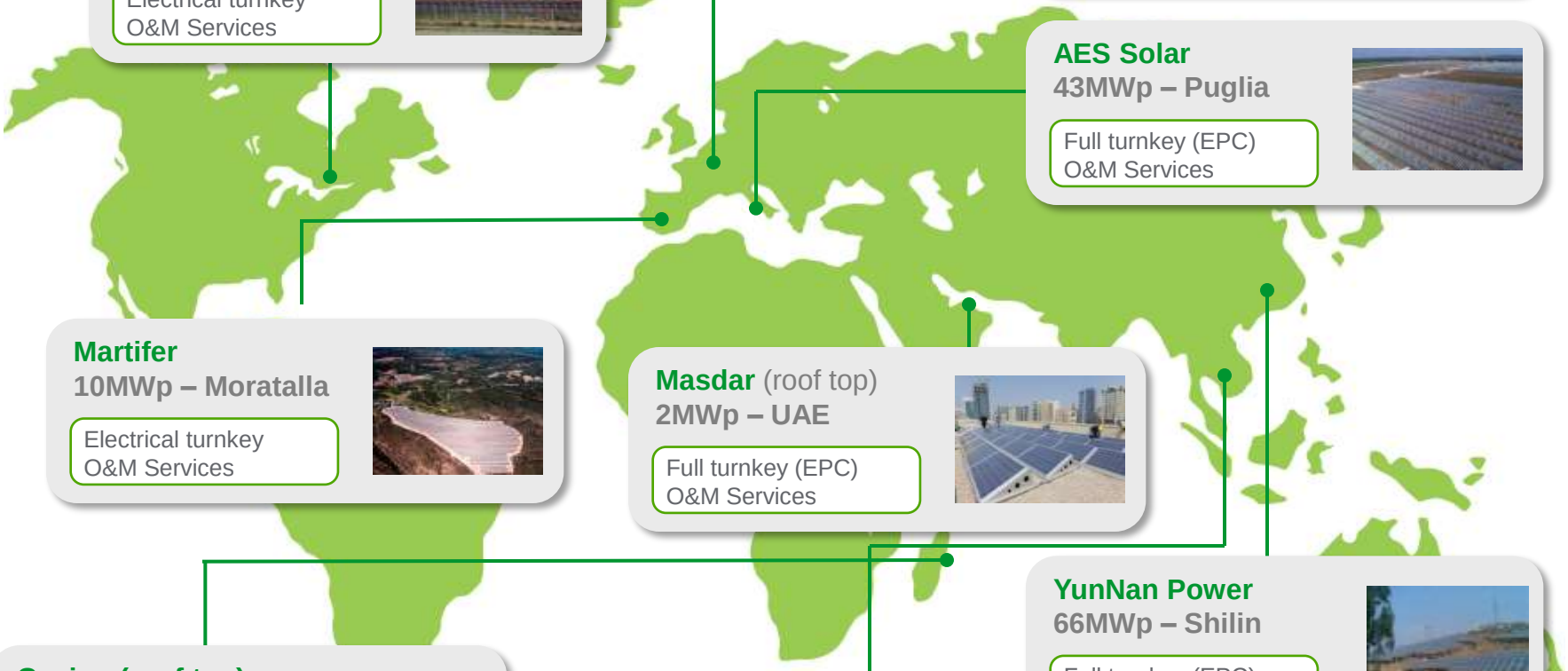
Optimize the mine value chain performance

→ Integrated Planning and Optimization

- Enable optimization across the mining operations chain by integrating near real time information from resource development, fleet operations, plant operations, and inventory systems.
- Advanced planning and scheduling functionality allows you to globally optimize operational plans and optimally plan the work.
- Integration through web services of:
  - Planning, scheduling and operations
  - Scheduling and dispatching
  - Dispatching and plant operations



.. and worldwide



enXco
19MWp – Ottawa
Electrical turnkey
O&M Services

Solaire Direct
24MWp – Les Mées
Electrical turnkey
O&M Services

AES Solar
43MWp – Puglia
Full turnkey (EPC)
O&M Services

Martifer
10MWp – Moratalla
Electrical turnkey
O&M Services

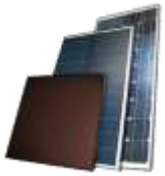
Masdar (roof top)
2MWp – UAE
Full turnkey (EPC)
O&M Services

YunNan Power
66MWp – Shilin
Full turnkey (EPC)
O&M Services

Casino (roof top)
17MWp – Reunion
Electrical turnkey
O&M Services

Gunkul Powergen
3.3MWp – Phetchabun
Full turnkey (EPC)
O&M Services

Electrical Design: Conversion & Losses



Sun Light

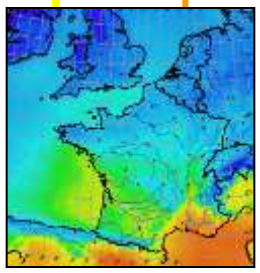
Optical
- Tilted Plane
- Shading
- Soiling
- Reflections

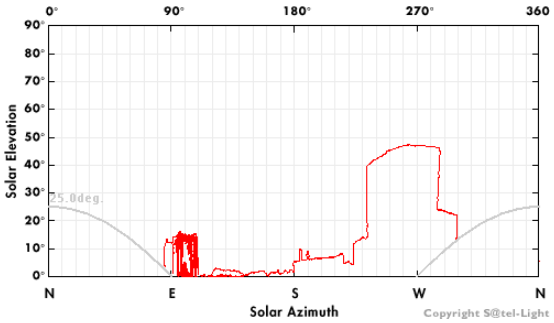
Photovoltaic
- Technology
- Temp. effect
- Low rad.

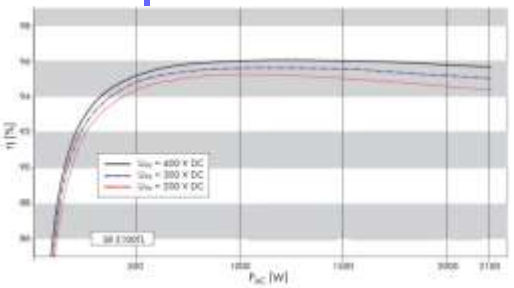
Electrical
- DC losses
- AC Losses
- Inverter
- Transformer

Other
- Availability
- Grid Avail.
-

Electricity







Schneider Electric' Smart Micro Grid definition

- **SIZE**: **few MW** to **100MW systems**

  Typical voltage levels: **Medium Voltage (4,16kV to 33kV)**

- **MANAGING MULTIPLE Power Generation**

  From **kW** to **MW generation** : reciprocating engines , Mini to small-size combustion turbines, Micro-turbines, Fuel cells, Photovoltaic systems, Wind turbines, …

- Managing **loads and demand**

- Increasing power quality, reliability and maximise assets with **storage contribution**

- Managing the **use of energy**

  CO2 emission reduction, Price optimisation, Process optimisation

PV Diesel – Technology Study

Nemiah, British Columbia, Canada

- 30kVA Genset + 28kW PV Weekends
- 90kVA Genset + 28kW PV Weekdays
- 10% Fuel Savings Achieved

IEEE Paper:

Nemiah Valley Photovoltaic-Diesel Mini-Grid: System Performance and Fuel Saving Based on One Year of Monitored Data