



Energy AG



station for Africa

**Outstanding 2G Technology for Hybrid Solutions with
2G Gas Generator Technology in Abuja**

Yield and Cost Analysis of Pv-Gas Applications



The 2G Group

- Founded 1995 as factory for biogas gensets
- Headquarters in Heek / North West of Germany
- Manufacturing and distribution of gas generators for **biogas, natural gas and landfill gas** applications between 20kW – 4,500 kW electrical capacity each
- Biggest independent gas generator manufacturer in Europe
- Solution provider: development, project engineering, production, service and after sales support
- Since 2007 listed at the German stock market
- **Over 5,500 power plants in more than 45 countries worldwide** (about two per day since 2016)
- **More than 1,000 of them are operated as hybrid with wind or solar already today**





The 2G Group

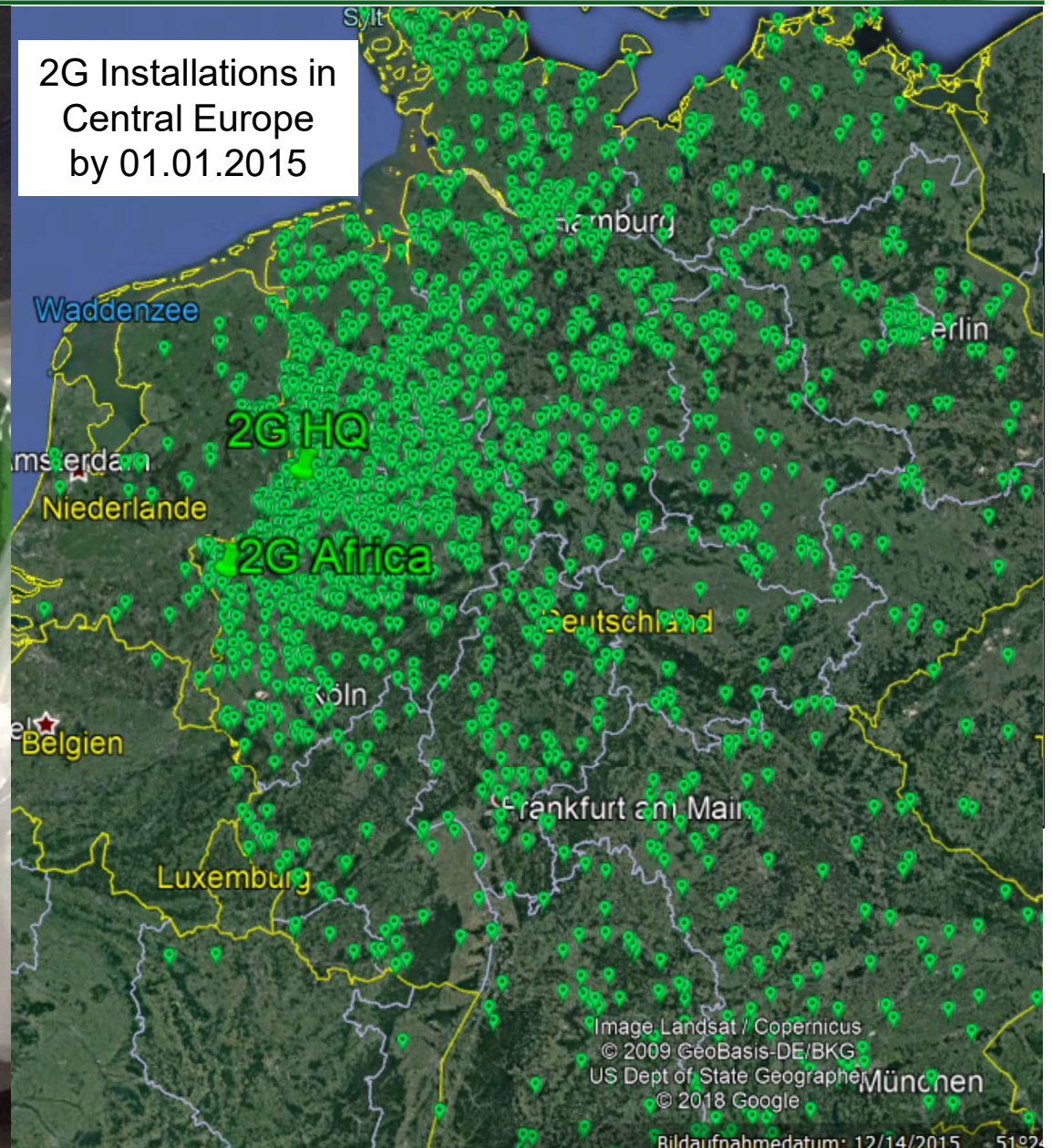
Gas Generator Portfolio

Product Group	Power Range	Type of fuel	Basic Engine
G-Box	20 to 50 kW	Natural Gas	MAN / Toyota
<i>filius</i> [®]	50 to 150 kW	Biogas	MAN / 2G
2G-KWK-Series	100 to 400 kW	Natural Gas / Biogas	MAN
<i>agenitor</i> [®]	200 to 450 kW	Natural Gas / Biogas	MAN / 2G
<i>avus</i> [®]	500 to 4,500 kW	Natural Gas / Biogas	Jenbacher / MWM / MTU / 2G

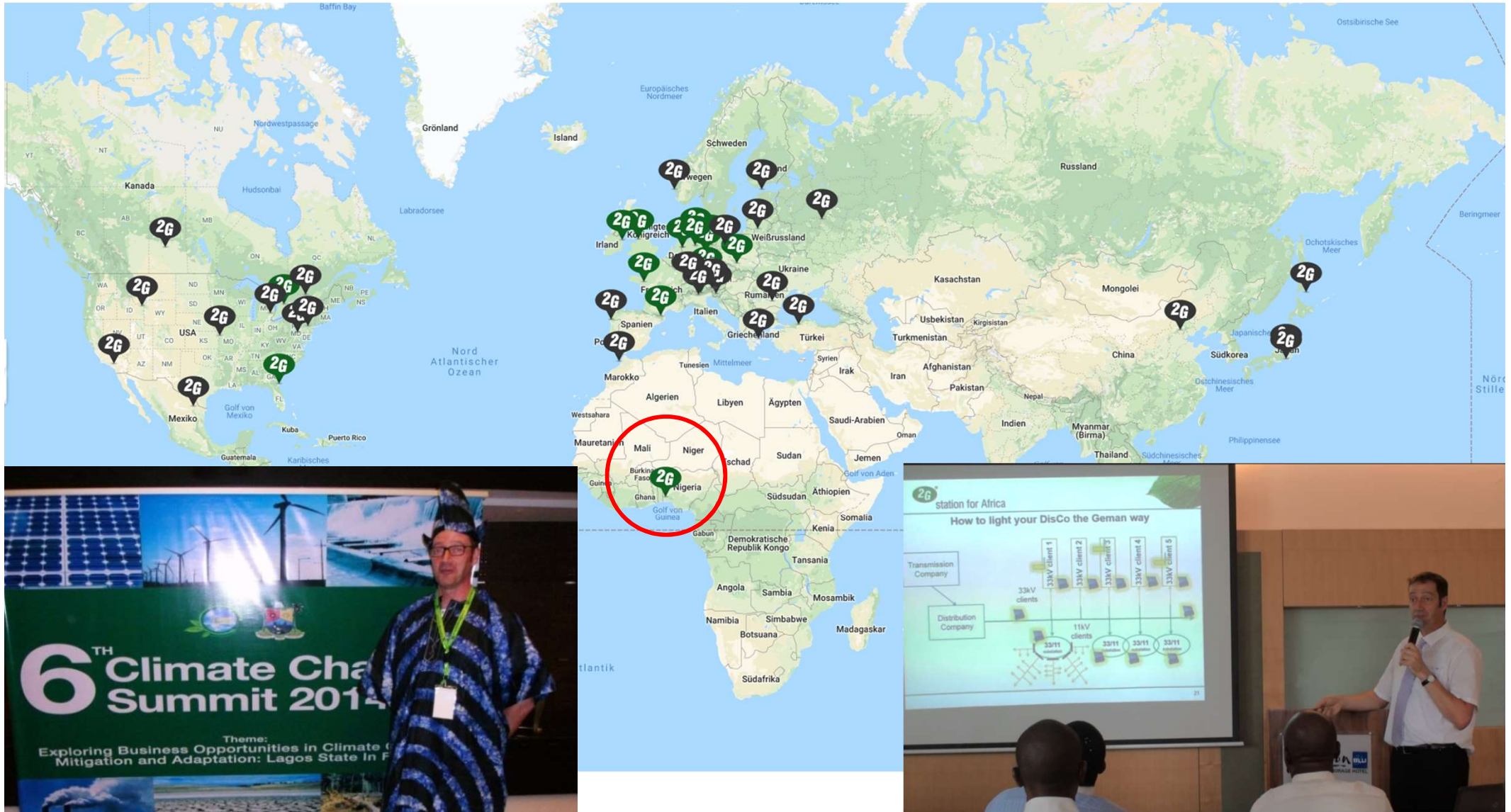




3.3 MW Jenbacher
containerized



The 2G Group



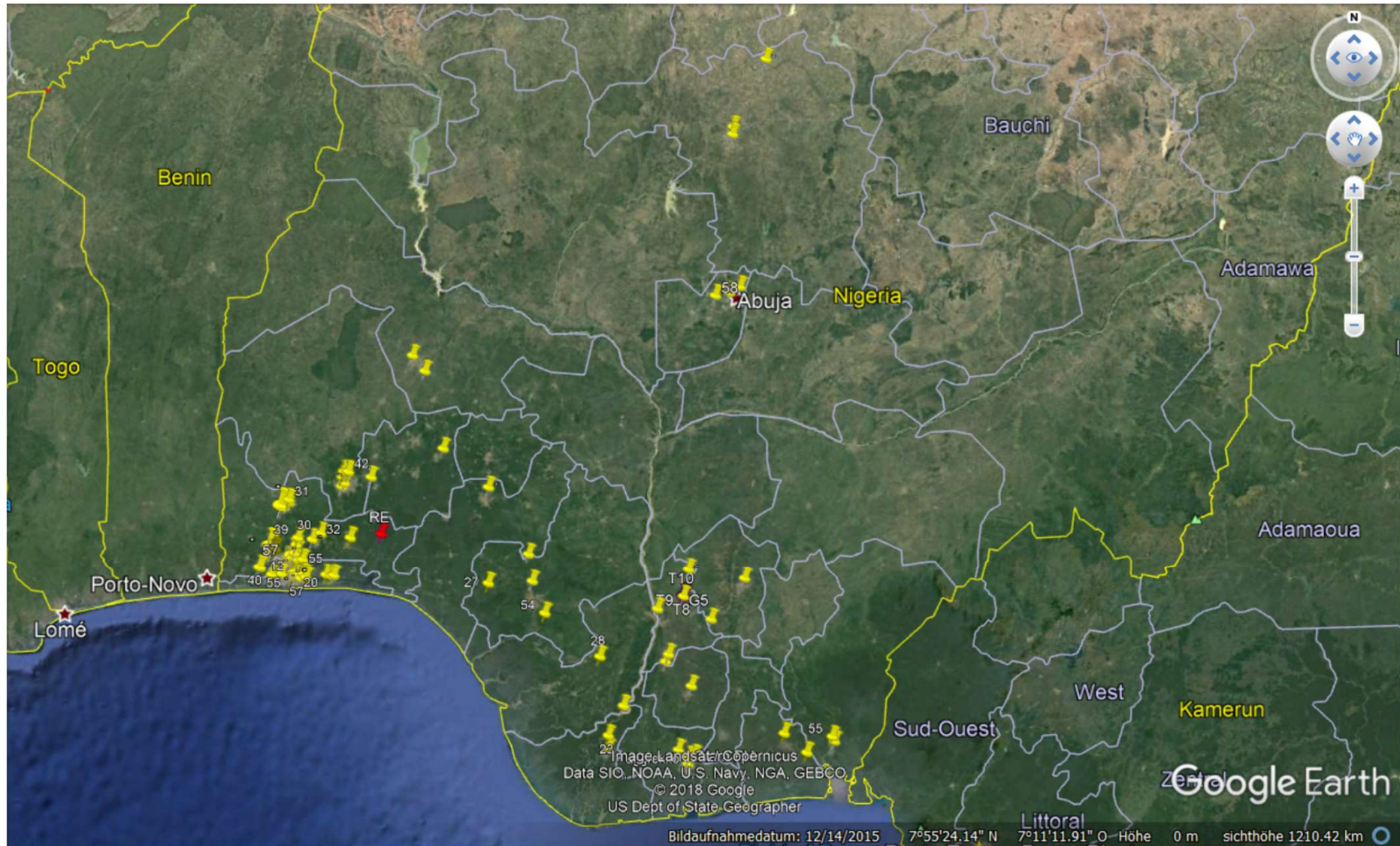
Sales and Service Network: >5,500 gas generator plants in more than 45 countries



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Design demand and our local content



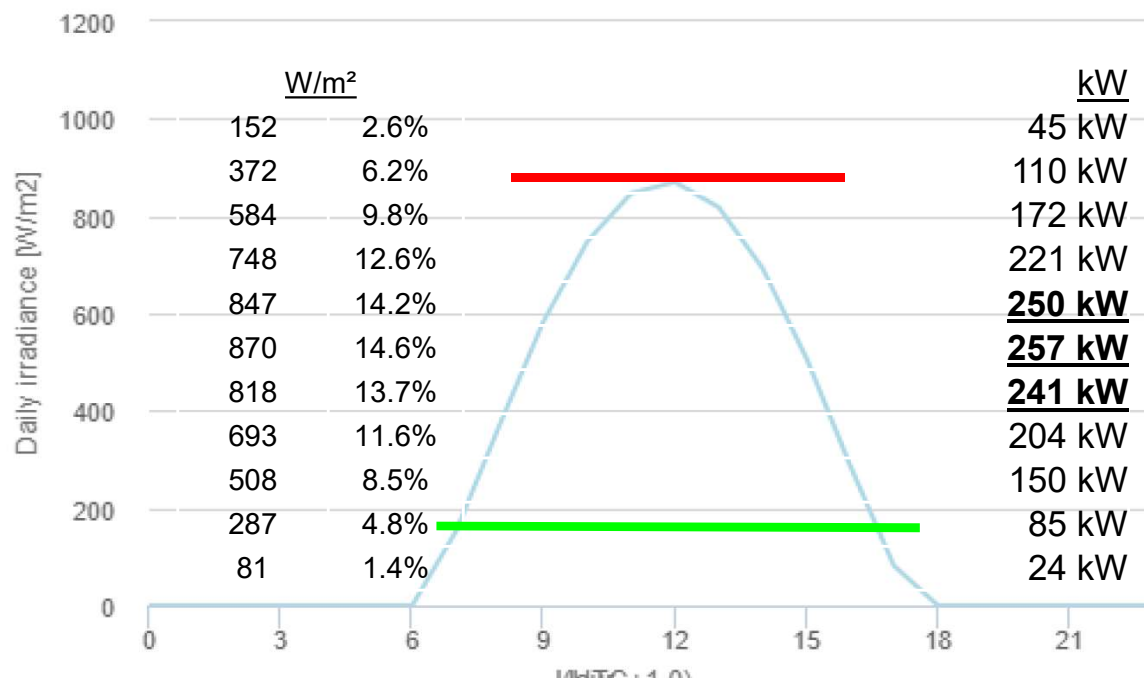
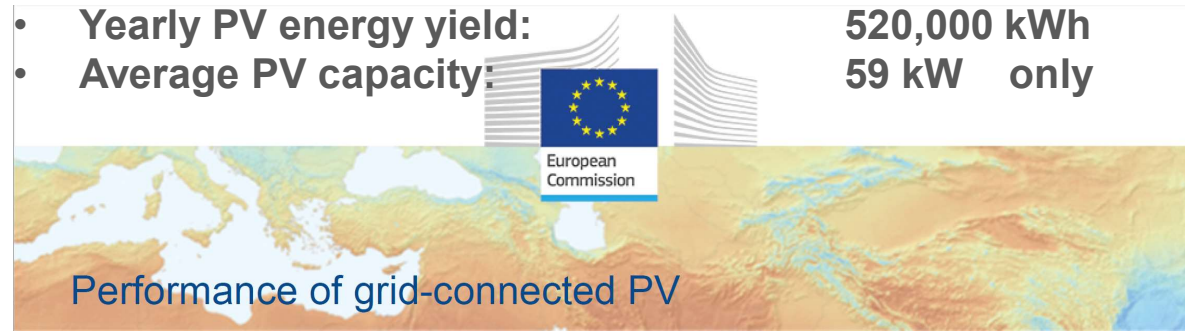


Basic PV „fuel“ data for Abuja

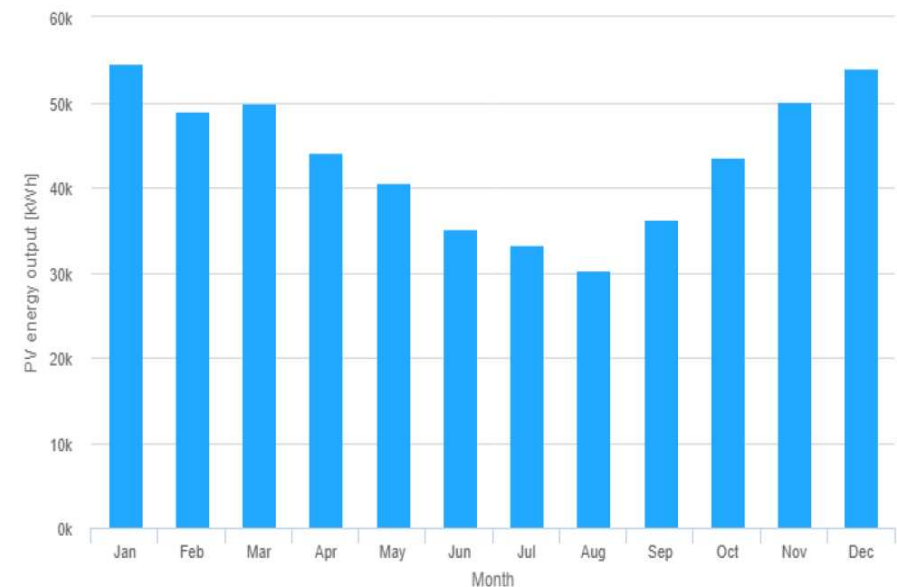
Example: Installation

350 kWp

- Yearly PV energy yield: **520,000 kWh**
- Average PV capacity: **59 kW only**



Monthly energy output from fix-angle PV system:



- Max monthly PV energy: **54,500 kWh/M**
- Max daily PV energy (/31): **1,758 kWh/d**
- **Peak capacity risk 257 kW**
- **Average energy yield 59 kW**



Basic PV data commercial analysis for Abuja

Installation with following assumptions:

- Location: Abuja
- All power usable
- No service expenses
- No damages
- No replacements
- Optimized power management, thus, no batteries needed

	350 kWp	Invest	1,200 \$/kWp	420,000 \$	360 NGN/\$
	Solar Installation commercials				Solar
	Invest	Interest	payback over	total capex	CAPEX / kWh
	151.2 M NGN	20%	5 years		520,000 kWh/y
	rem value				"fuel" cost
year 1	151.2 M NGN	30.2 M NGN	30.2 M NGN	60.5 M NGN	116 NGN/kWh
year 2	121.0 M NGN	24.2 M NGN	30.2 M NGN	54.4 M NGN	105 NGN/kWh
year 3	90.7 M NGN	18.1 M NGN	30.2 M NGN	48.4 M NGN	93 NGN/kWh
year 4	60.5 M NGN	12.1 M NGN	30.2 M NGN	42.3 M NGN	81 NGN/kWh
year 5	30.2 M NGN	6.0 M NGN	30.2 M NGN	36.3 M NGN	70 NGN/kWh
year 6	0.0 M NGN	0.0 M NGN	0.0 M NGN	0.0 M NGN	0 NGN/kWh
year 7					

- These „best case“ commercials hardly provide a viable and bankable business case;
- Gensets will mitigate in efficiency due to lower load during PV productivity additionally;

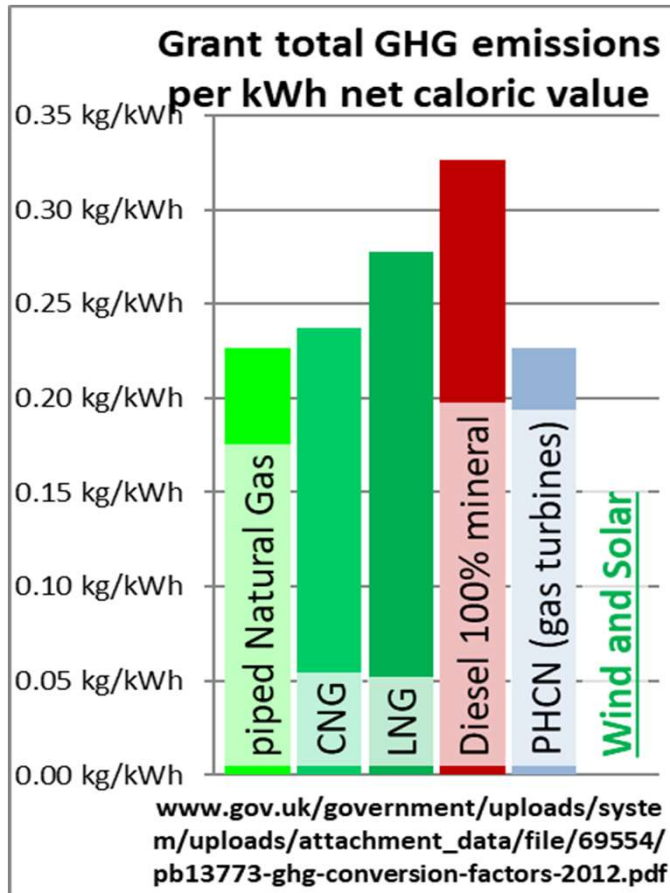
The apparent risk of load fluctuations has to be compensated by

- Spinning reserve of underlying generators
- Energy buffer like batteries, boosting capex
- Optimized load analysis



Why changing to hybrid solutions

environmentally?



Hybrid solutions enable

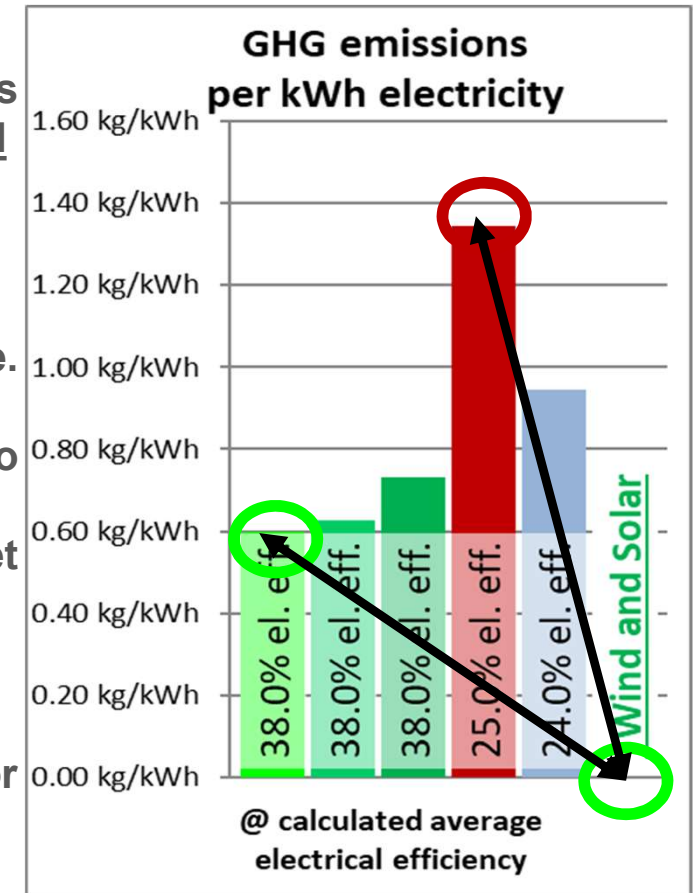
- Benefitting from renewables without battery storage demand
- substituting fossil fuels,
- Reducing fuel dependency

Hybrid solutions demand

- a stable and reliable local, i.e. captive grid
- large load spike capability to cope with cloud covering
- Full Redundancy with genset capacity

Hybrid solutions depend on

- Client load profile
- Available and suitable space for installation



Overall Hybrid solutions provide CO2 savings as combination

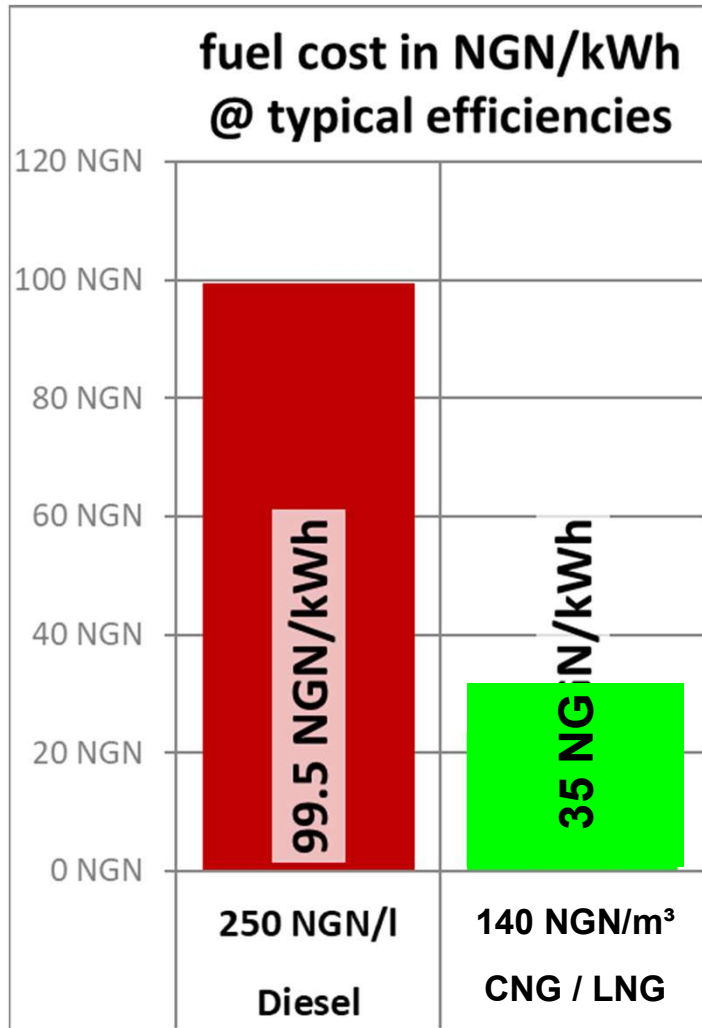
- of the achievable value of CO2 neutral renewables and
- the GHG emissions of underlying power generation technology



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Why changing to hybrid solutions commercially?



In Nigeria, just fuel expenses per kWh with

- commonly used diesel gens are about 100 NGN,
- 2G gas generator technology just
 - With piped gas about 24 NGN,
 - With CNG or LNG about 35 NGN

Solar hybrid installations

- are CAPEX intensive in relation to generation,
- cannot substitute generator capacity;
- Most hybrids still run > 85% on fossil fuel.

Solar hybrid with diesel gensets

- generate power today at a very high price mix;
- don't provide any remarkable commercial savings.

Solar hybrid with 2G gas generator technology

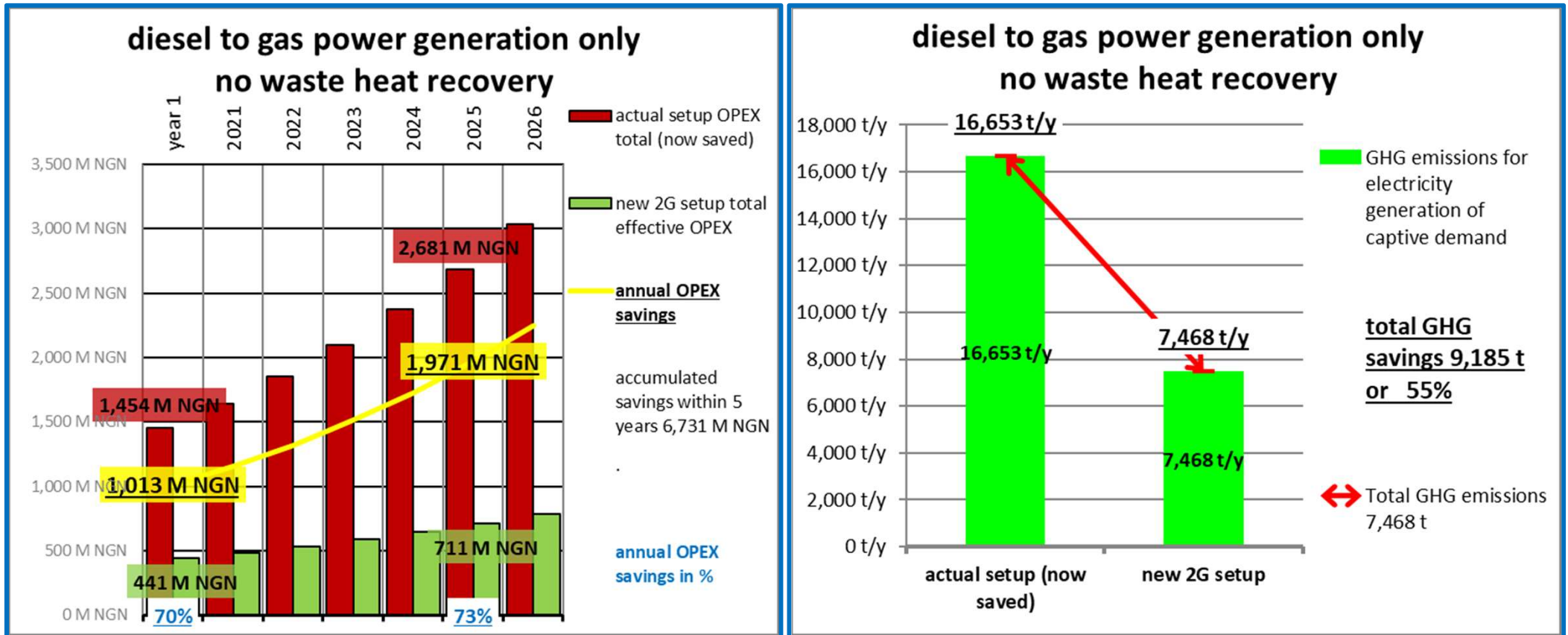
- Save about 75% fuel cost (piped gas vs. Diesel)
- Waste heat recovery provides additional savings
- Gas generator CAPEX is recouped after 1 year
- Solar CAPEX can be covered with cash flow gains

Hybrids with 2G technology provide valid business cases.



How to change from diesel to gas power generation?

Based on a case study for a 3MW gas generator installation



This technology can only be utilized,

- If the gas generator technology is tailor-made for your individual local application and
- If you benefit from a proper after sales service including a prolonged equipment warranty;

Investment is „recouped“ after 1 year; annual savings will „last for ever“.



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Basic PV data commercial analysis for Lagos

	350 kWp	Invest	1,200 \$/kWp	420,000 \$	360 NGN/\$
	Solar Installation commercials				Solar
	Invest	Interest	payback over	total capex	CAPEX / kWh
	151.2 M NGN	20%	5 years		476,000 kWh/y
	rem value				"fuel" cost
year 1	151.2 M NGN	30.2 M NGN	30.2 M NGN	60.5 M NGN	127 NGN/kWh
year 2	121.0 M NGN	24.2 M NGN	30.2 M NGN	54.4 M NGN	114 NGN/kWh
year 3	90.7 M NGN	18.1 M NGN	30.2 M NGN	48.4 M NGN	102 NGN/kWh
year 4	60.5 M NGN	12.1 M NGN	30.2 M NGN	42.3 M NGN	89 NGN/kWh
year 5	30.2 M NGN	6.0 M NGN	30.2 M NGN	36.3 M NGN	76 NGN/kWh
year 6	0.0 M NGN	0.0 M NGN	0.0 M NGN	0.0 M NGN	0 NGN/kWh
year 7					

100 NGN/kWh diesel gensets @ inflation of 5% fuel cost	Diesel and Solar average cost @ solar share of 10% mixed cost
100 NGN/kWh	103 NGN/kWh
105 NGN/kWh	106 NGN/kWh
110 NGN/kWh	109 NGN/kWh
116 NGN/kWh	113 NGN/kWh
122 NGN/kWh	117 NGN/kWh
128 NGN/kWh	115 NGN/kWh

35 NGN/kWh 2G Generators @ inflation of 5% fuel cost	Gas and Solar average cost @ solar share of 10% mixed cost
35 NGN/kWh	43 NGN/kWh
37 NGN/kWh	44 NGN/kWh
39 NGN/kWh	44 NGN/kWh
41 NGN/kWh	45 NGN/kWh
43 NGN/kWh	45 NGN/kWh
45 NGN/kWh	40 NGN/kWh

- Solar starts to improve overall cost once solar „fuel“ cost is below genset fuel cost
- Solar can contribute to the overall energy solution



Core Competences

Engine Periphery

Control and regulation of

- Cooling / combustion air flow at choosen design temperature to
- avoid any deratings

24/7 telemonitoring
from Germany

Fully automatic
operations



The chosen periphery defines the overall technical reliability



Core Competences

High-end engines

**Standardized design to
optimize / maximize**

- **Manufacturing**
- **Reliability**
- **Longterm quality**
- **Service and
maintenance**
- **Compatibility**
- **Spare parts logistic**



However, any chain is only as strong as it's weakest part.



Core Competences

Installation:

- **Adjusted to space availabilities**
- **on top of a hospital**
- **Noise proven down to 45 dB(A) only**
- **Vibration free**
- **Assembly and commissioning in less than 10 hours**
- **Flexible and removable**



Very often, commercial savings generate space availability.



Core Competences

Waste Heat Recovery: „steam for free“ to substitute fuel expenses

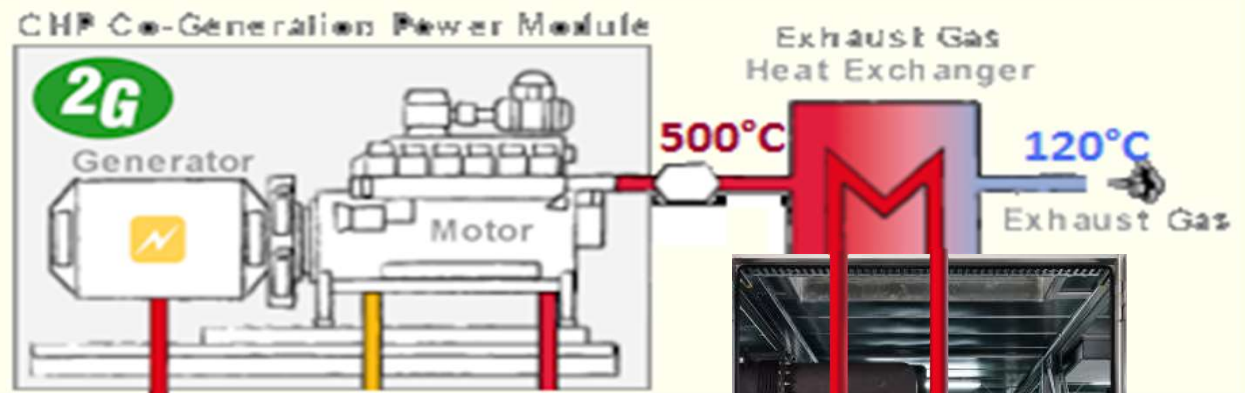
Due to the combustion process in all combustion engines like cars, diesel or gas engines etc., plenty of energy dissipates as heat, mainly in form of

- hot exhaust gas (up to about 500°C), normally lost through the chimney and
- hot jacket water (about 90 – 93°C), normally dumped within heat dumpers.

This „co-generated heat“ 2G can utilize to boost the overall efficiency.

The exhaust gas energy, i.e.

- exhaust mass and
- exhaust gas temperature, is utilized to generate steam.



A 2G gas generator of 1 MW can generate

- about 600 kg steam @ 10 bar per hour, thus
- substituting about 1,500 l diesel each day you need today to operate the same steam within your fossil fueled boiler.

This can save $(1,500 \times 365 =)$ 550,000 l/y diesel





Core Competences



3.3 MW gas generator
during commissioning

The steam generator substitutes about 2 mio l diesel p.a.

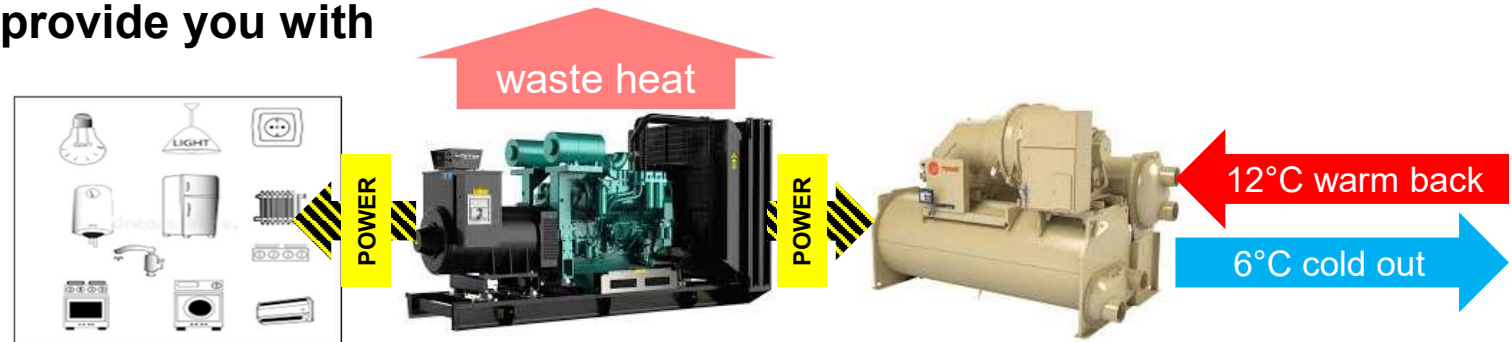


Core Competences

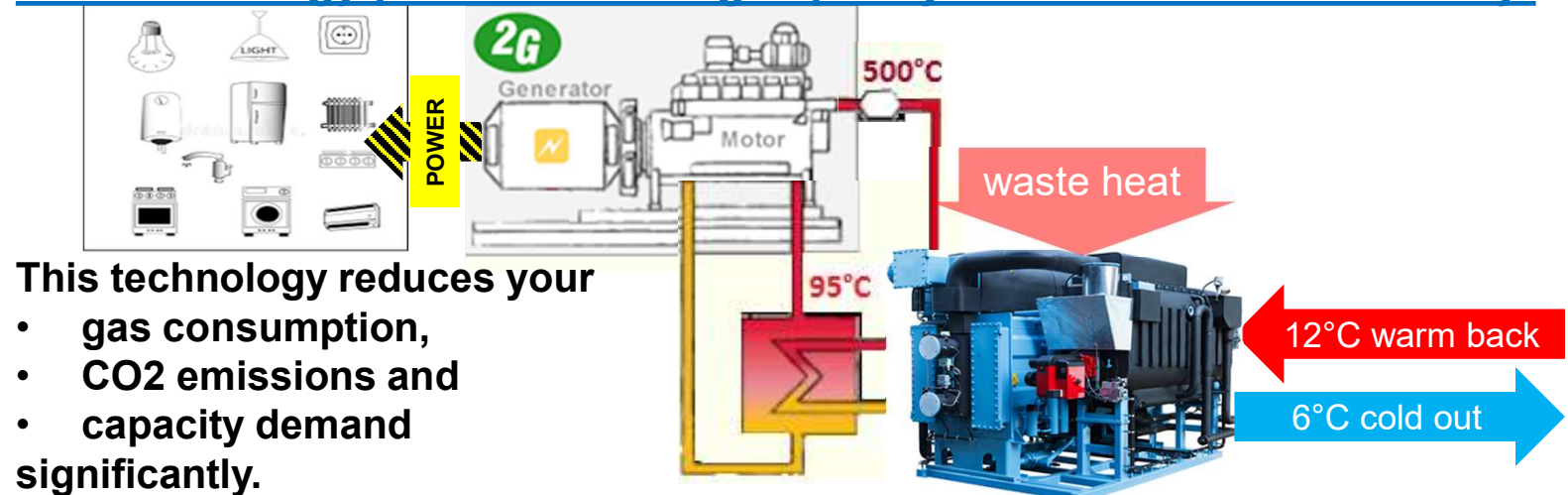
Waste Heat Recovery: Chilling water to substitute electrical chiller demand

Today, your generators provide you with power for

- normal consumers and
- large electrical chillers.



Our technology provides chilling capacity from waste heat recovery:



This technology reduces your

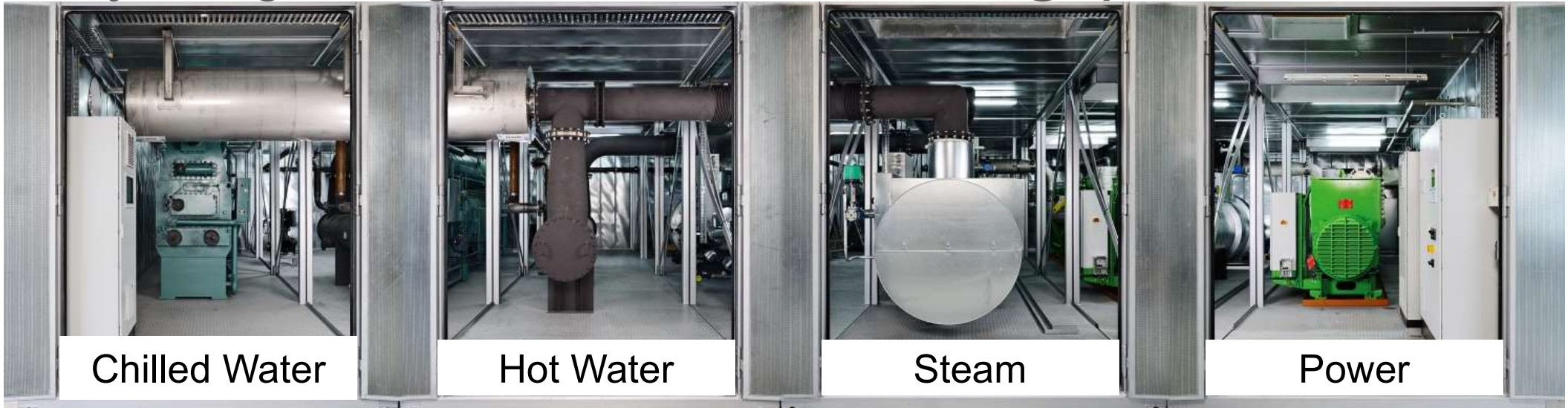
- gas consumption,
- CO2 emissions and
- capacity demand significantly.

Our technology can reduce energy and installation demand by 30%.



Core Competences

Project Engineering – customized installations @ optimized conditions:



manufactured and tested



trucked to site



assembly on site

Our „plug & play“ technology can be tested before shipment.



station Nigeria Services



2G Carefree Maintenance

2G station Nigeria Services Ltd. with its operational base in Ikeja structures and conducts our carefree maintenance services in cooperation with

- 2G certified local „2G Partners“ and
- 2G technicians from Germany



CARE BEFORE REPAIR

Instant Trouble Shooting

24/7 telemonitoring

Operational supplies

Preventive Maintenance

Based on daily operation by your operator on-site

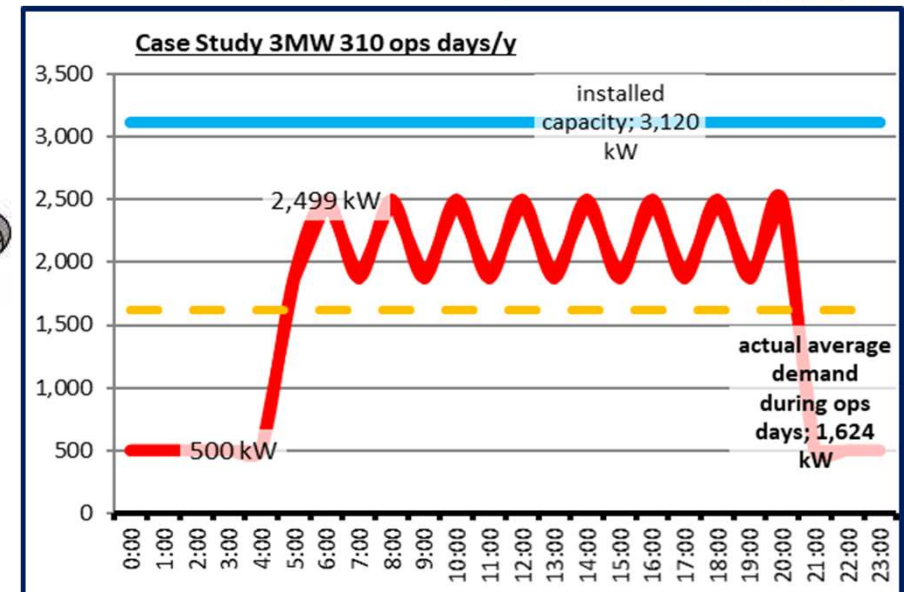
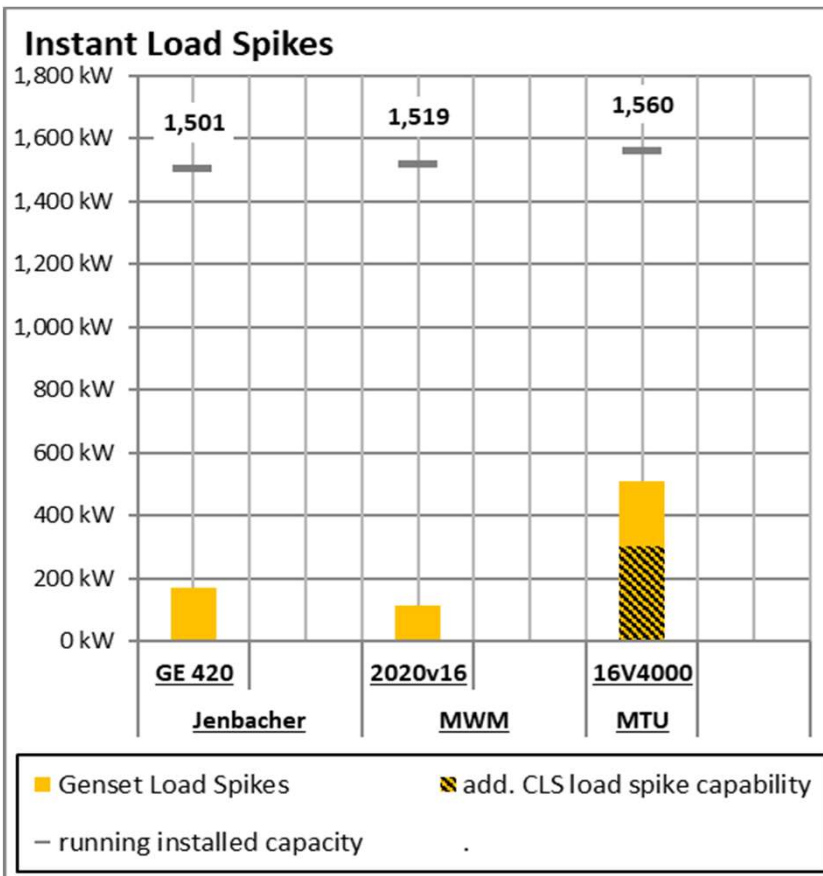
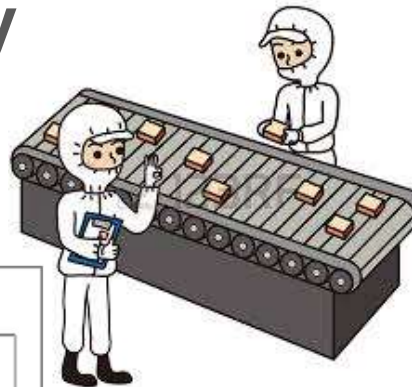


Results in prolongation and upgrade of initial warranty
and Technical availability of more than 95%



Load Spike Capability

High quality gas engines
can cope with load spikes
of about 10 – 15% only



Hybrid Capability

Whenever clouds cover a solar installation,

- the pv power disappears immediately,
- causing a significant load spike,
- your generators have to cover instantly

The load spike capability of the grid stabilizing equipment defines the usable hybrid capacity.

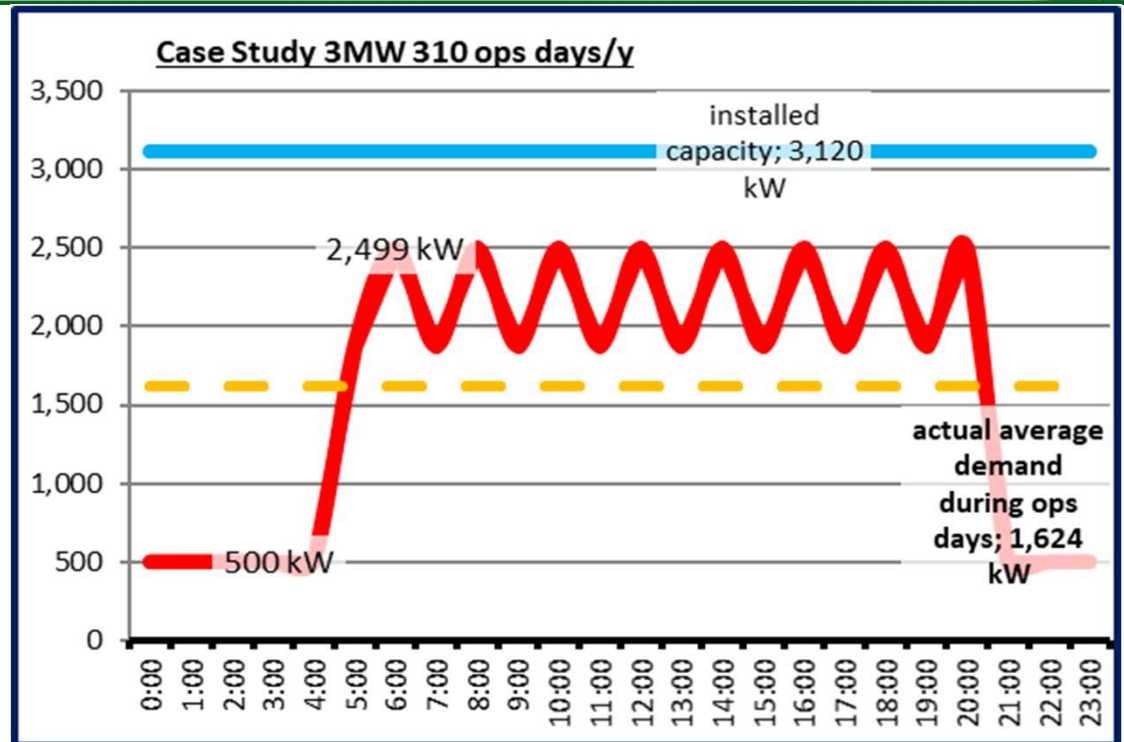
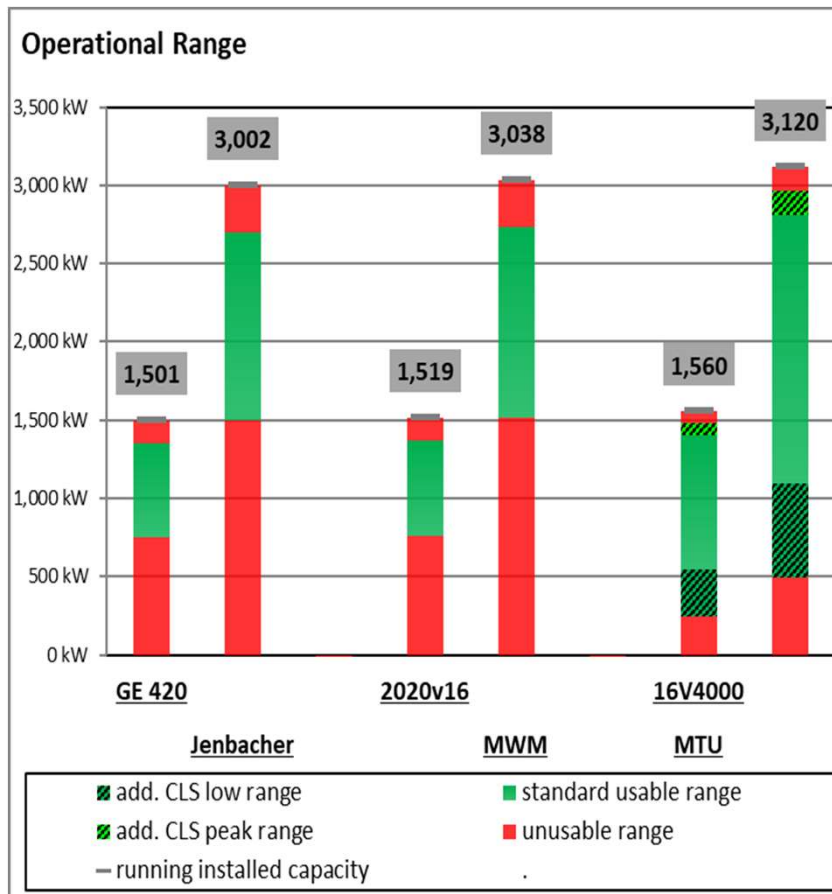
Our Central Load Stabilizer can provide much more.



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Operational Range

High quality gas engines
cannot be operated continuously
below about 40 – 50%.



Expenses to run 15% diesel „just overnight“:

coverage:

15% diesel
85% Gas

Fuel expenses:

@ 100 NGN/kWh = 15 NGN
 @ 24 NGN/kWh = 20 NGN
 mixed fuel cost of 35 NGN

35 NGN instead of 24 NGN = 145% fuel cost

2G technology boosts the operational range.

A Flexible Operational Range supports Hybrid applications.



Nigeria Gas Price Regulations Overview



Gas Pricing

- „DSO“ reg. gas price **95NGN/m³**
- Linked to piped gas usage

Gas Flare capturing

- Trucking without pipeline usage
- Not linked to DSO
- Demands larger trucking distance
- Demands higher logistical cost
- Feasible with large volume gas capacities
 - As LNG
 - As CNG with composite trailers
- And for energy efficient technologies
 - High electrical yield
 - Waste heat recovery



Logistics Example

Energy demand today

- Average 1 MW power
- Steam boiler demand

3,500,000 l diesel / year
500,000 l diesel / year
4,000,000 l diesel / year
11,000 l diesel / day

Energy demand with 2G generator solution:

- Average 1 MW power
- Steam demand, covered with waste heat recovery

2,190,000 m³ natural gas / year
0 m³
2,190,000 m³ gas / year
6,000 m³ gas / day

Thank you for
your attention!

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