BayWa r.e.

r.e.think energy

Carbon-free sites
Self supplying solar construction sites

Dipl.-Ing Peter Hussinger
BayWa r.e.

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1

Introduction

and situation on the ground

2

Working

towards a mobile battery solution

3

Learnings

+ cost comparison and way forward

Why carbon free sites?

Renewable energy solutions

should avoid fossil power, wherever possible

CO_2, NO_x Emissions

first countries have introduced stricter regulations for the building sector

Low efficiency of diesel gensets

especially on low loading, as low as 15% or less

Assure constant fuel supply

requires constant effort and cost over months **- the sun shines for free and sends no bill**

O&M Cost

for gensets is high - especially for 24h operation on site

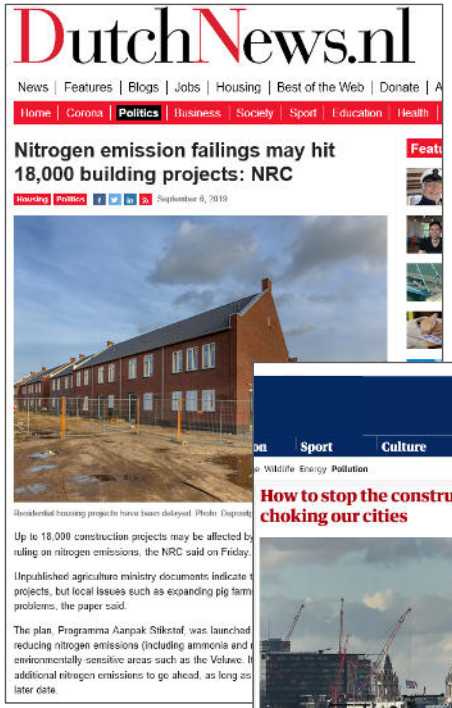
Contamination

inspectors on our sites review closely possible spilled fuel for ground contamination

Sound emissions

bring poorer working environment for our staff in office containers and break time areas

NL already introduced strict NO_x regulations for the building sector



Greater London area has started a stepwise reduction on construction machinery to finally zero emission machines

Situation on the ground

Impressions

of PV floating and PV fixed tilt construction sites

Status quo

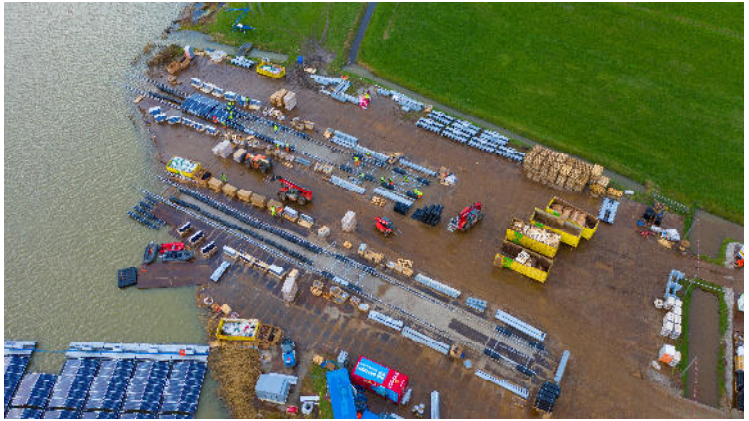
Our construction sites were running by Diesel gensets and fuel supply system on rental basis

Sizing

30 kVA for smaller sites, 60 kVA for bigger sites

27 MWp in Netherland: Biggest floating PV plant outside of China, realized in only 7 weeks

typical ground mounted construction site



Diesel genset incl. fuel supply on site, 30 kVA

Load consumption on our solar sites

How much is the load consumption on our sites?

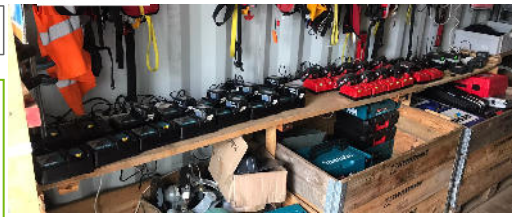
For bigger projects, gensets are 60 kW, so it will be 20-30 kW in average?

site with office and working containers

→ we didn't really know before we started measuring!

Results

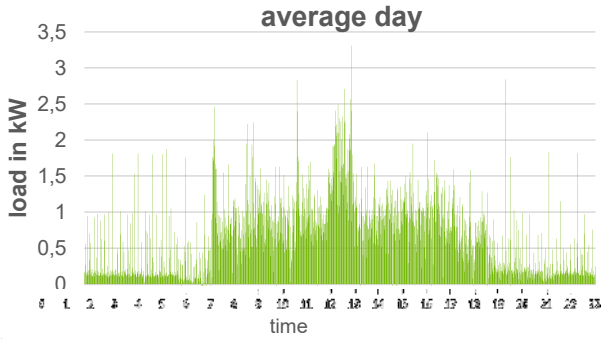
average power	2-3 kW
max power	20 kW

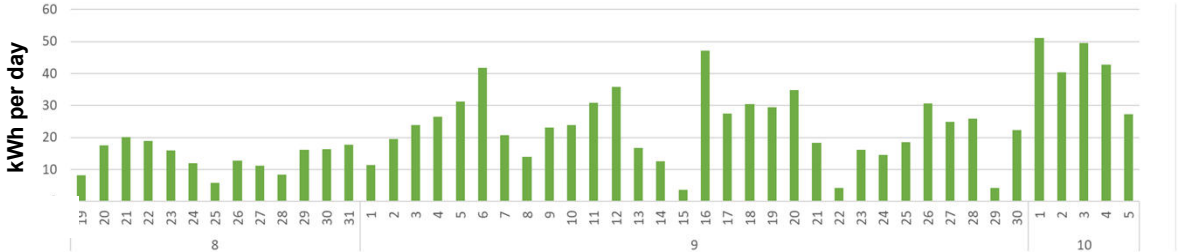


tool charger bank for 100+ tools

cooling for food and drinks

drying wet working clothes





BayWa r.e.quirements for a clean solution

Status quo

There are **hybrid PV-battery-diesel systems** on the market that include some PV panels that guarantee a visual “green impression”

→ **they won’t supply your load with green energy, though**

Our approach

BayWa r.e. doesn’t even include a genset in the solution

→ **we want to build solar with 100% solar**

Our system requirements were clear

PV DC system integration

PV AC system integration

Remote Monitoring

size and weight +
battery transport regulations

heating, cooling +
drying needs

battery sizing suitable for
summer + winter and
different climates

electric machinery
charging

→ Build Solar with 100% Solar

The way to get there

Simulation and Sizing

measuring and estimating the load on-site

varying the seasons and the climate

vary PV and storage power/energy

fix minimum required system specs

→ HOMER Pro

Engineering

planning and co-developing systems with our partners

adapting standard products to fit our needs

product and components defined

Testing and pilot

test in battery lab

review control principle for PV curtailment

first test on site in Spain 2018

PV mockup tables on the right are installed in the very beginning

working towards a solution

5 different mobile batteries tested on 10 projects during 3 years

- PV floating and PV ground mounted sites
- Southern Europe and central Europe
- Winter and Summer
- Electric machines as additional new load
- PV AC grid tied inverters implementation
- PV DC/DC charging implementation
- Lead acid and Li-ion batteries
- 20 kWh to 500 kWh storage capacity
- 30 kW to 600 kW battery power
- purchase and rental model
- 50k€ to 500k€ solutions

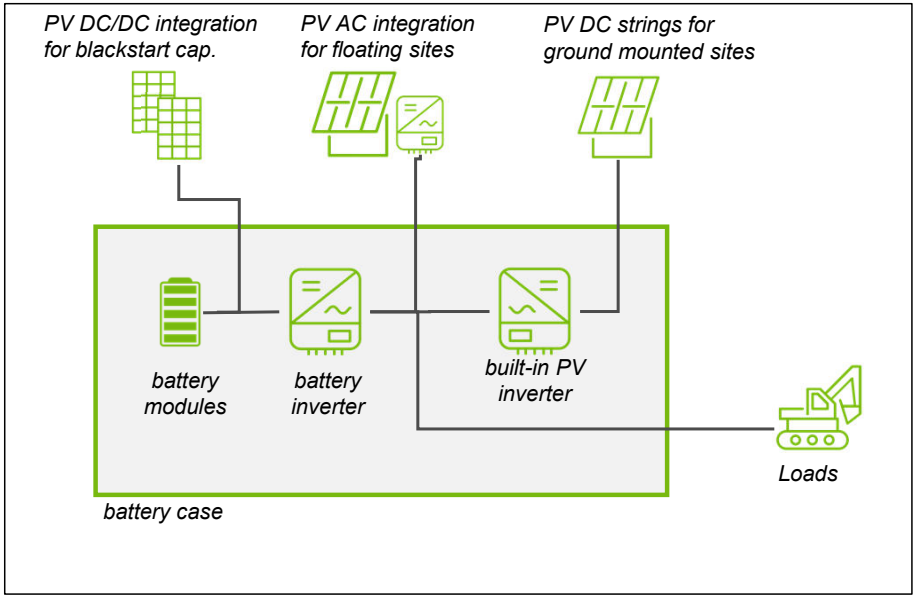
Technical learnings and improvements

Learnings: Detected areas for improvement

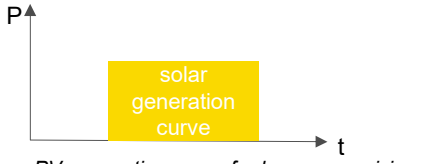
- Frequency control too rough for PV curtailment
- Grid-tied PV inverters not designed for offgrid operation
- Lead acid battery SOC estimation too inaccurate
- Max. connectable PV power for charging too low
- Battery capacity too low
- Charging duration too long

Implemented improvements over time

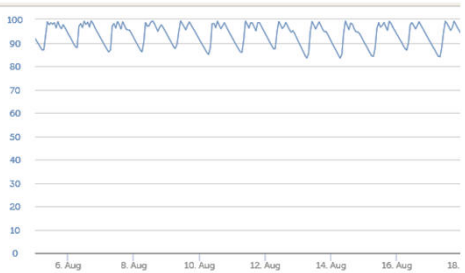
- Li ion instead of lead acid
- 3 times the battery capacity vs. pilot
- Faster charging capability of the battery 10h → 2h
- Frequency control → direct component communication
- PV Zero feed-in mode (load following)
- PV Blackstart capability in case of an empty battery
- Biggest tackle are cloudy winter days:
  - **ext. control needed:** PV AC system connection of up to 320 kWp (for a 45kW battery inverter)
  - **no ext. control:** Built-in PV inverter with DC/AC ratio of 6(!) → 120kWp on a 20kW inverter



battery system schematic



PV generation curve for heavy oversizing



Battery SOC for heavy PV oversizing

Battery vs. genset cost comparison: RENTAL option

Weekly site consumption 240kWh assumed for cost comparison

	gensets		mobile battery	
Solar PV on site	0 €	0 €	0 €	0 €
Power usable	20kVA	40kVA	45 kVA	45kVA
Fuel consumption (Genset)	140l/week	400l/week		
CO_2 emissions in operation	**370kg CO_2/week**	**1.056 kg CO_2/week**	-	-
Usable Capacity (Battery)	-	-	54 kWh lead acid	72 kWh Li-ion
Fuel cost (assuming 1,5€/litre)				
Total cost for small solar project	6.120€	14.400€	4.680 €	9.760 €
Cost per kWh supplied	**2,14 €/kWh**	**5,05 €/kWh**	**1,64 €/kWh**	**3,38 €/kWh**

PV + Battery is for us a cleaner and cheaper solution today already

vision/way forward

BayWa r.e. wants to further electrify more and more construction sites and reduce the Diesel genset use in combination with other innovations:

- **we are already implementing electric machines and**
- **electric vehicles/logistics on site**
- **smarter consumption**

  → e.g. for drying, isolation containers,..

more electric machines on site

Build Solar with 100% Solar

dehumidifiers for drying clothes

mobile battery below PV tables with DC connection of strings

Thank you

peter.hussinger@baywa-re.com