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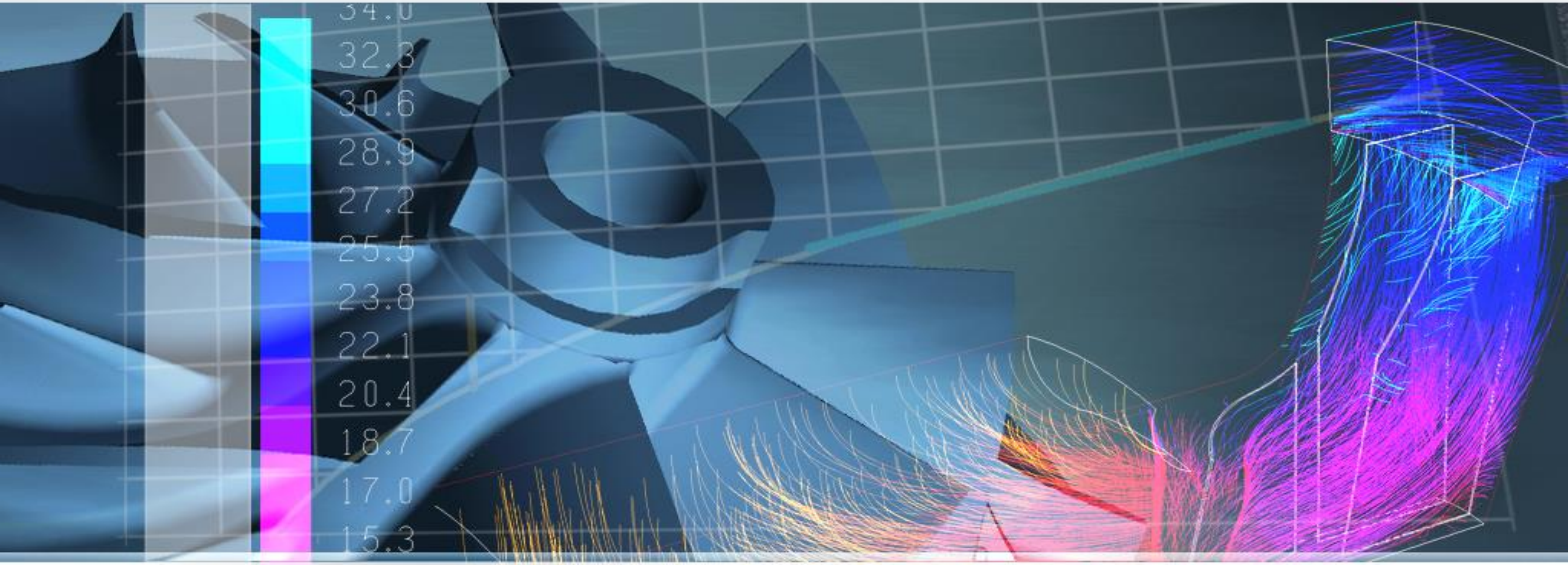

Institut für Luft- und Kältetechnik Dresden gGmbH

Off-grid solar cooling systems with ice block generation for fisheries in Indonesia

Wolfgang Hernschier, Jörg Waschull, Michael Goldberg

Rudolf Rauch, Frank Stegmüller

Content

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

1. Background

- **Political and economical background**
  - **Indonesia** is Southeast Asia's **most important economy** (energy demand +9% p.a.).
  - It has dedicated itself to **challenging greenhouse gas emission reductions**.
  - To reach the targets energy **efficiency measures** and cost-efficient **renewable energy applications** are considered.
  - To provide technical assistance in this regard the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Indonesian Ministry of Energy and Mineral Resources with its Directorate General for New and Renewable Energy and Energy Conservation have implemented two projects:
    - **'Least Cost Renewables in Indonesia' (LCORE-INDO) and**
    - **'Green Chillers' for energy-efficient cooling systems and cold supply in Indonesia's industry and commerce**

1. Background

- **Implementation**
  - Bridging the objectives of both projects, GIZ aims to **develop and demonstrate a least-cost energy solution** for providing efficient and sustainable **cold supply** to Indonesia growing **fishing industry** on the basis of **solar photovoltaic systems** (PV) – targeting social development in un-electrified remote coastal areas.
  - PV block ice generator will be implemented as **a pilot project** with a local manufacturing partner including the development of a **business model**.

AIREF

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2. Current state and targets

- **Energy supply for block ice machines either by island grids (Diesel supplied) or by medium sized dedicated Diesel generators.**

pictures: GIZ

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- Ice block transport and storage.

pictures: GIZ

2. Current state and targets

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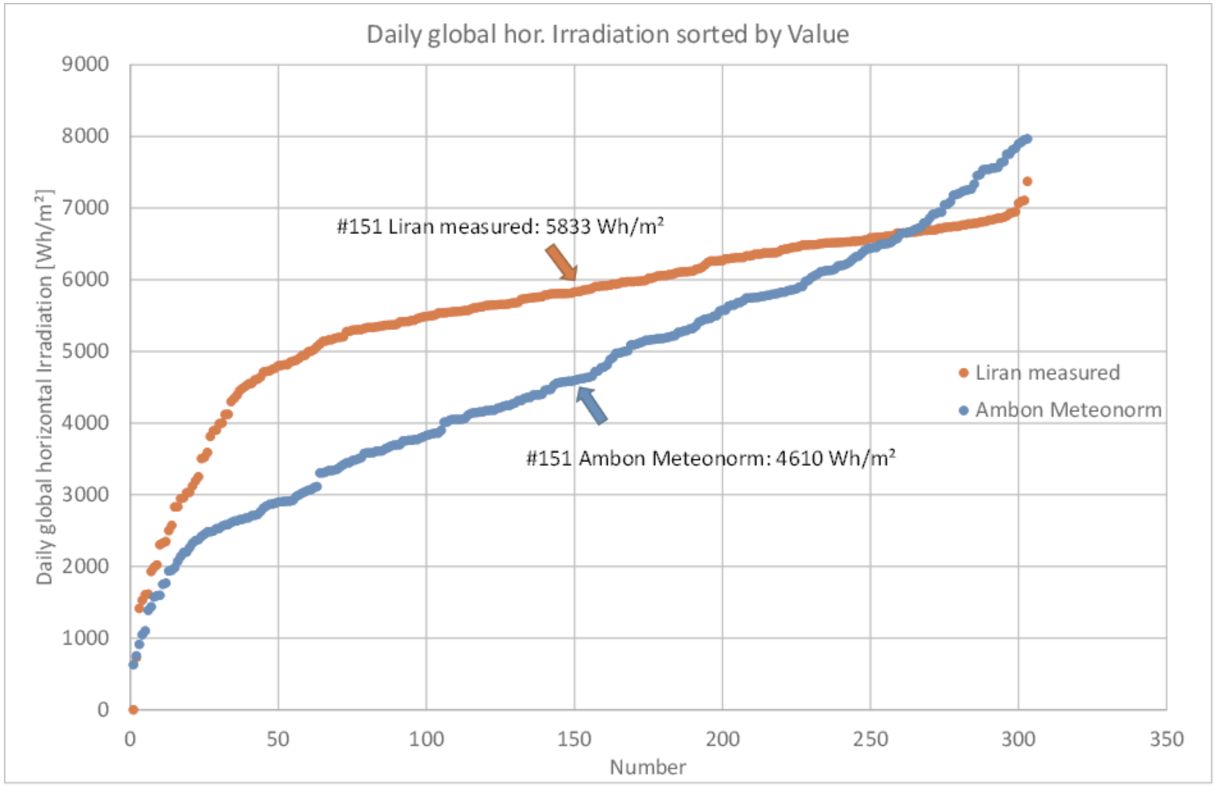
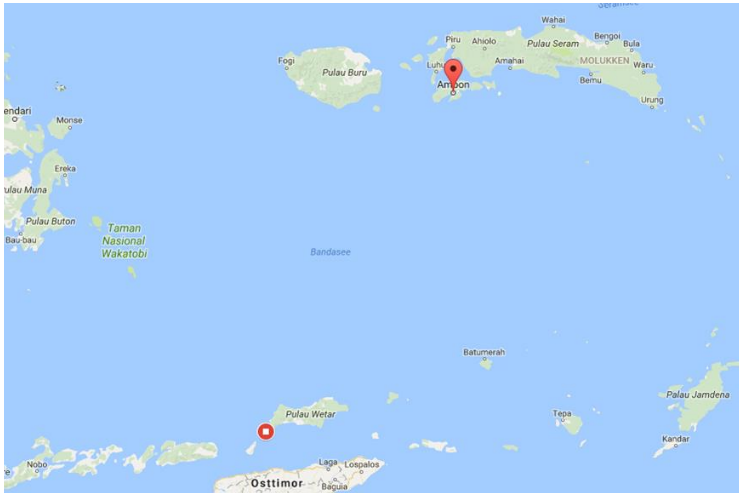
- **Design of an exclusively PV supplied block ice generator without back-up,**
- **Rated capacity of 1 ton of block ice at half of the days of a year,**
  - Analysis of irradiation conditions,
- **Minimum demand of electricity storage,**
  - Cold generation has to be synchronous to electricity (PV) supply,
  - Slow ice block growing → thermal storage required,
- **Generation of as much as possible complete ice blocks every day,**
  - Development of a block ice generator with part load capabilities.

3. Optimization of irradiation adapted cold generation

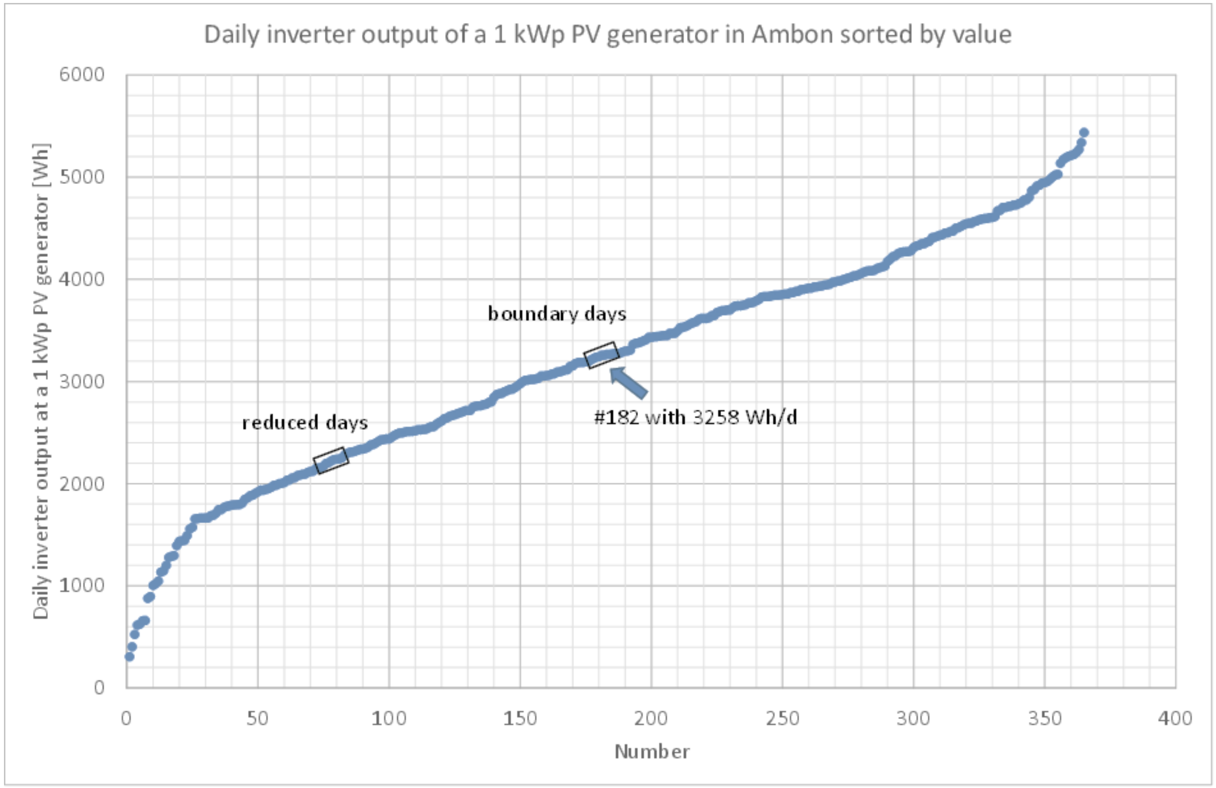
- Statistical analysis of availabe irradiation data





3. Optimization of irradiation adapted cold generation

- **Selection of representative days**



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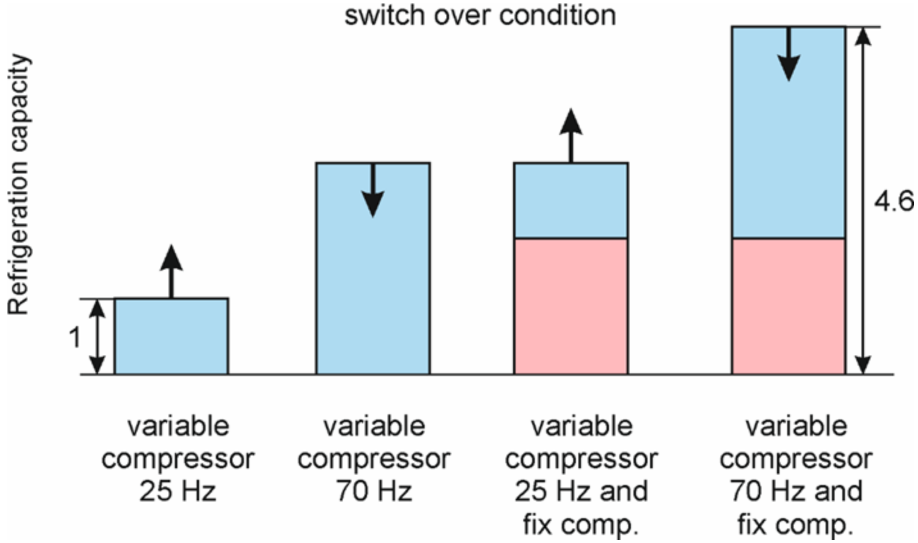
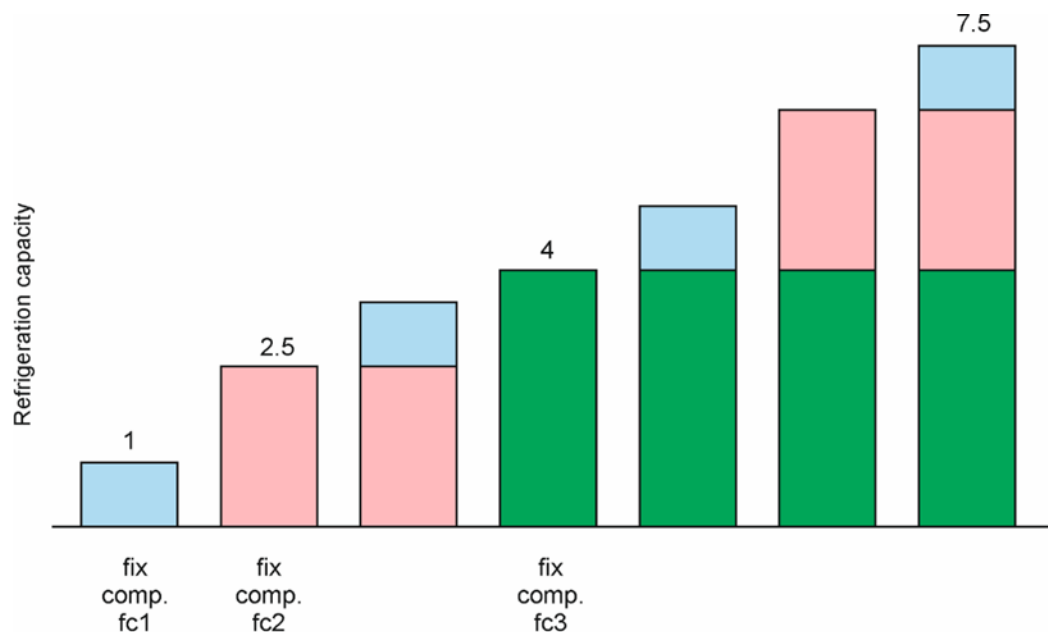
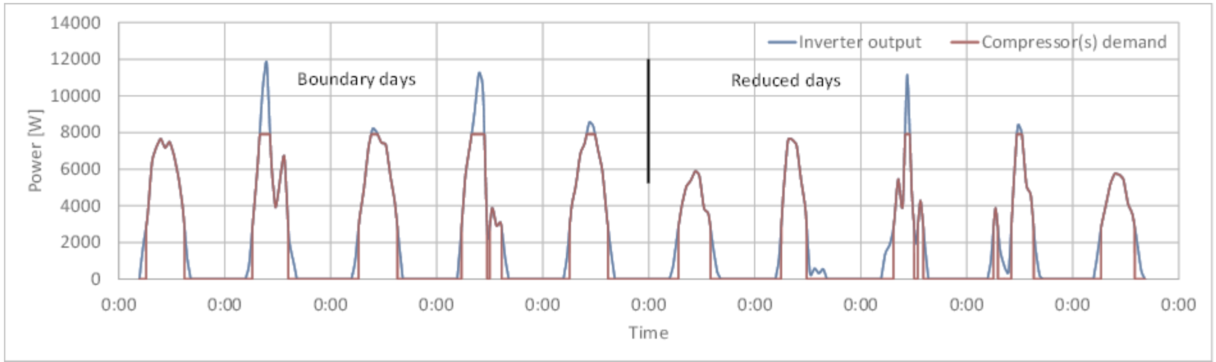
Options for flexibility of cold generation (examples)



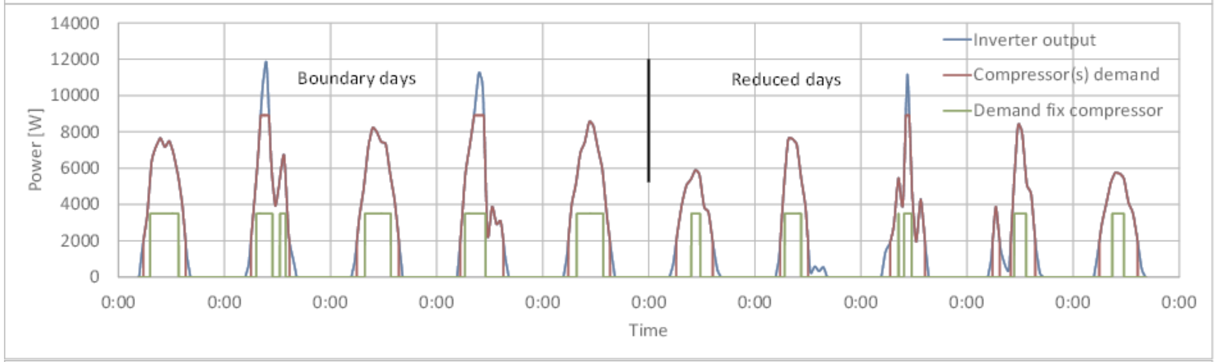


Options for flexibility of cold generation (examples)

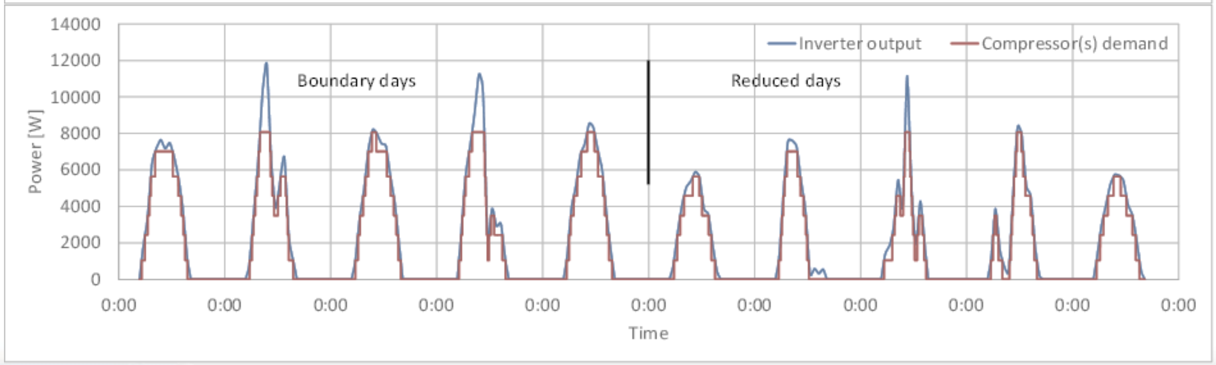
One variable compressor



One variable + on fix compressor



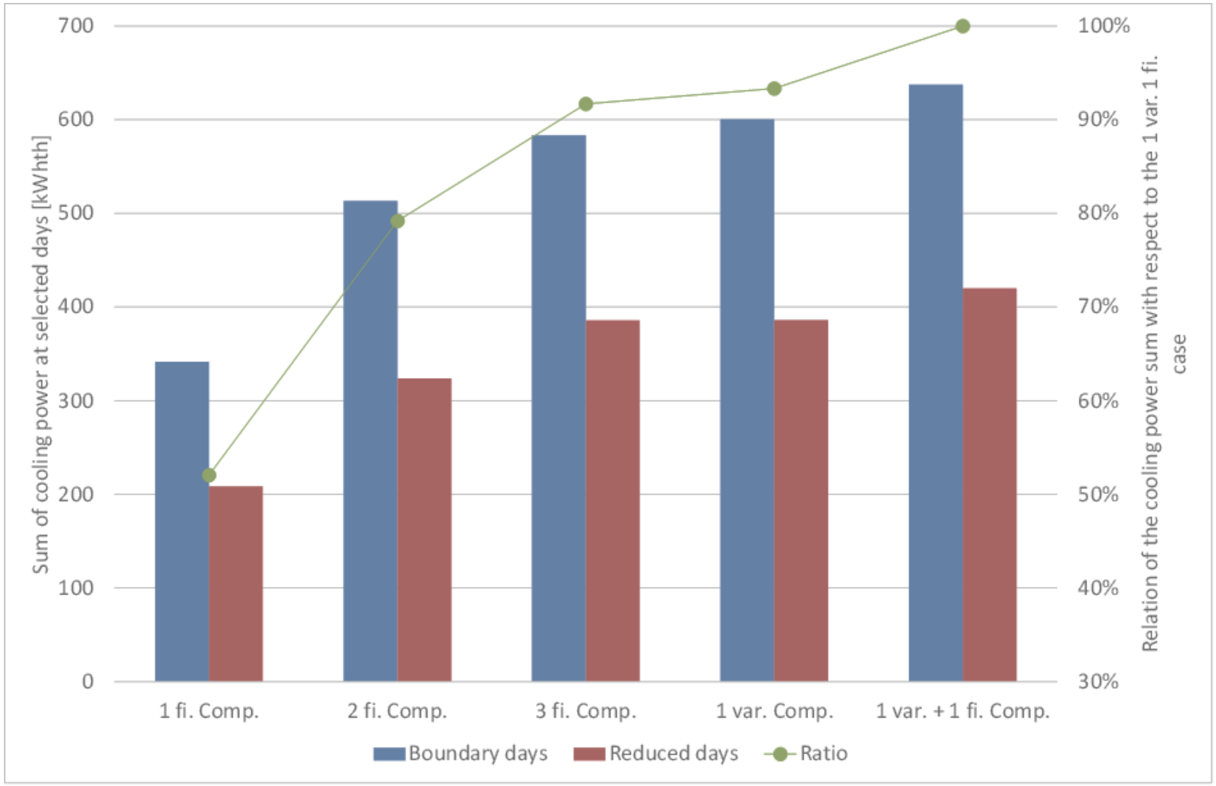
Three fix compressors



18 kWp PV generator

3. Optimization of irradiation adapted cold generation

Results of optimization calculations



3. Optimization of irradiation adapted cold generation

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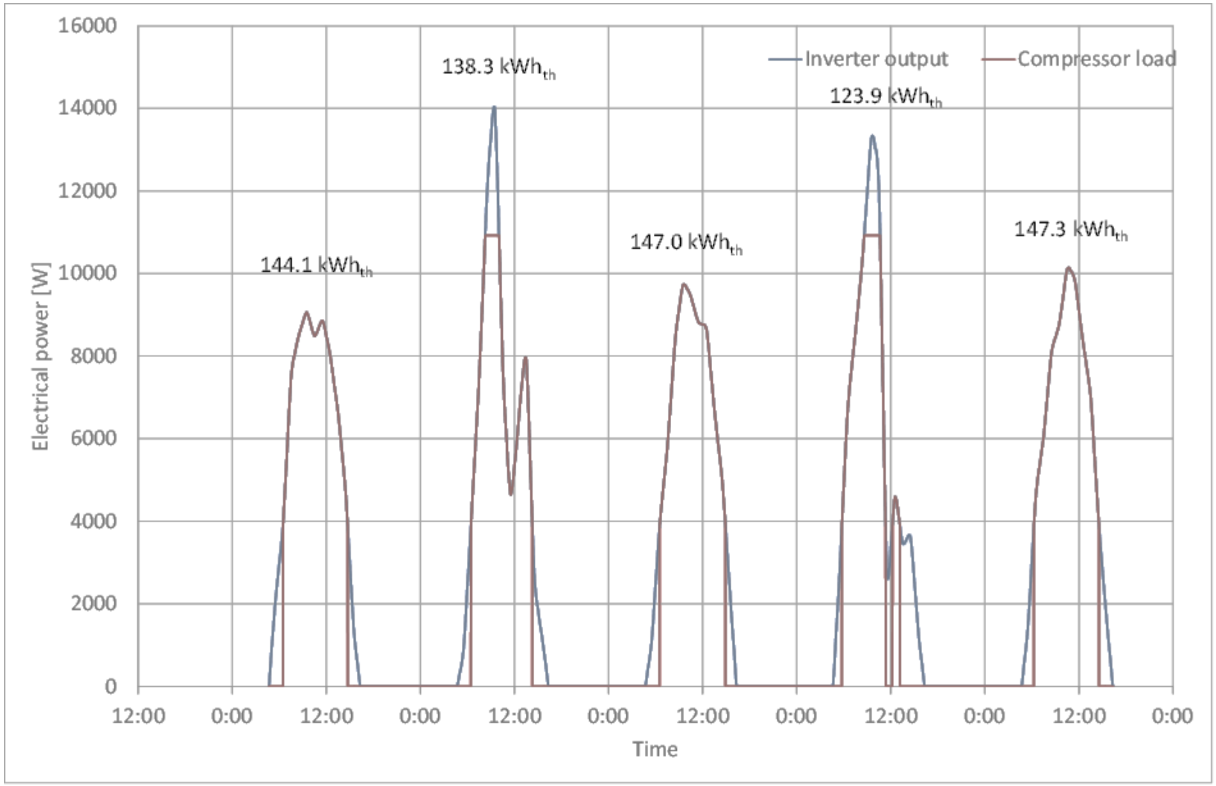
- **System design with „real“ components**
- **assumptions of conditions in the refrigeration cycle → fife days cooling demand: 700 kWh_{th}**



One certain variable speed compressor (Bitzer, R290), 21.3 kWp

180 days/a: 1000kg ice requirement fulfilled regarding cooling capacity

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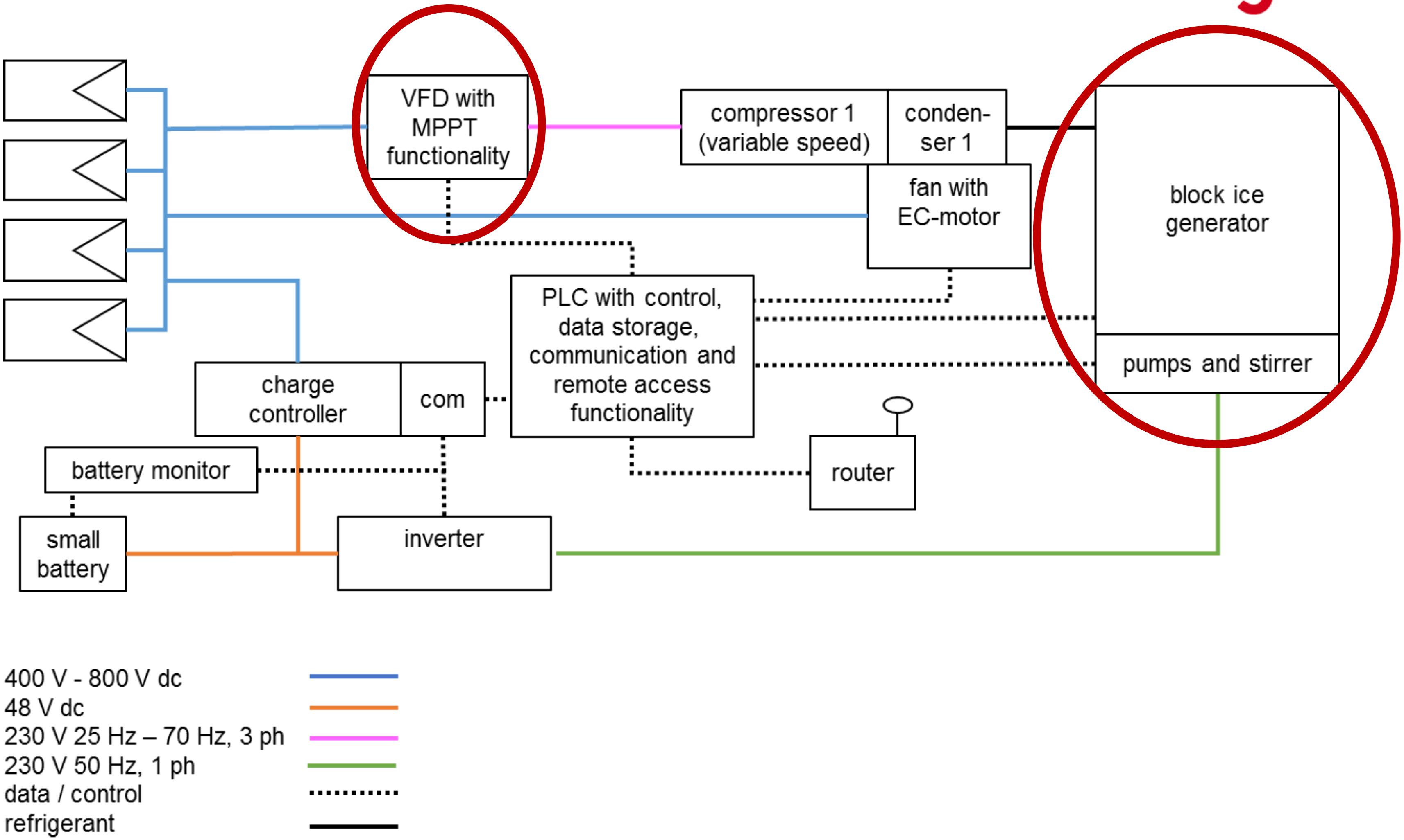
System design with „real“ components



5. VFD MPP-Tracking

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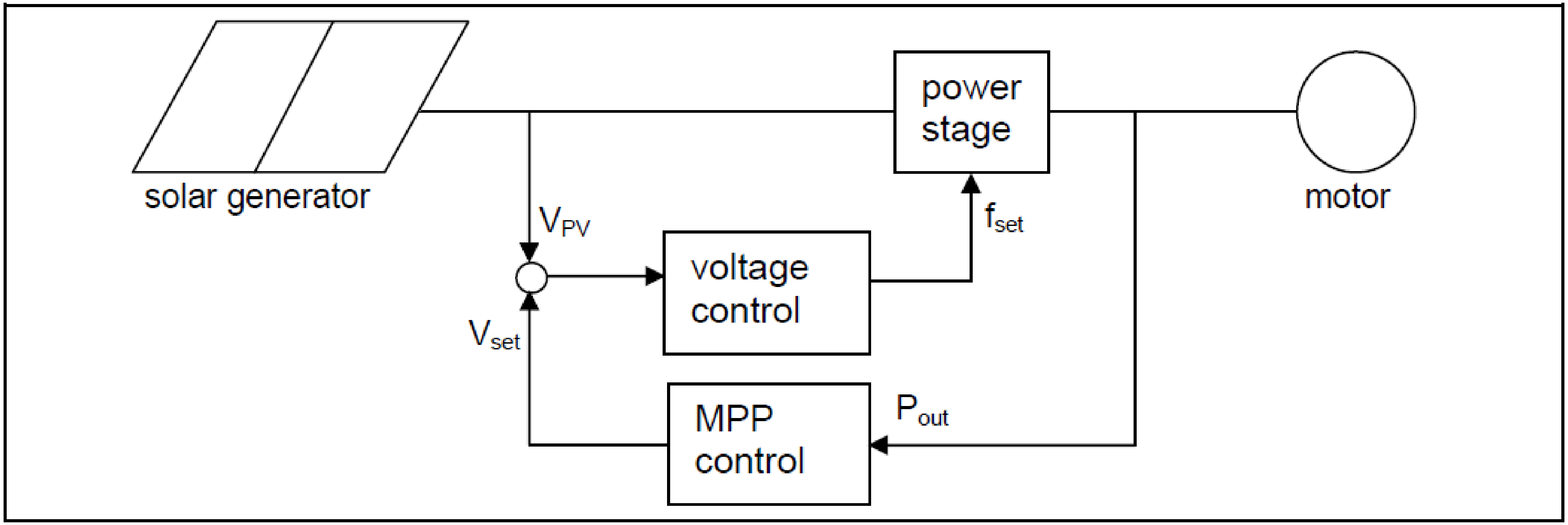
- **MPP tracking by compressor speed adaption**

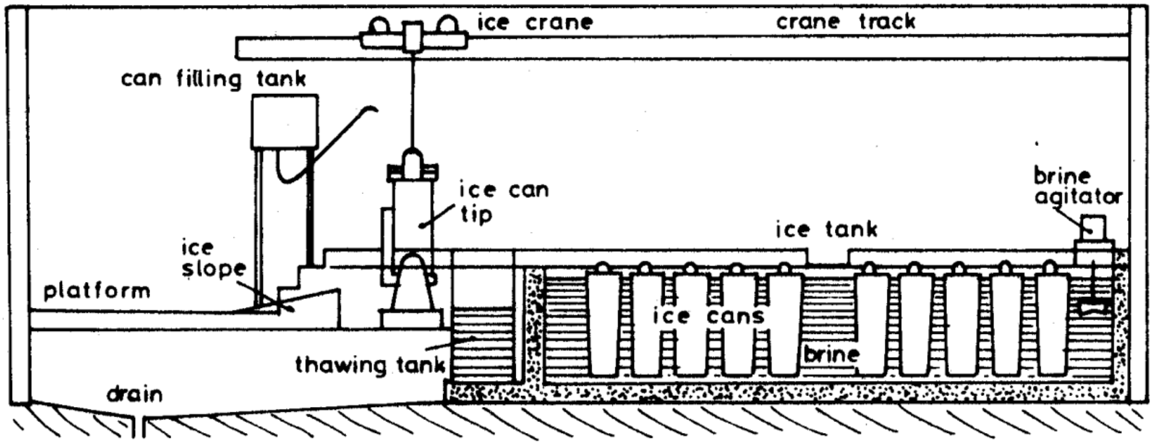


- **Software implemented in a VFD**

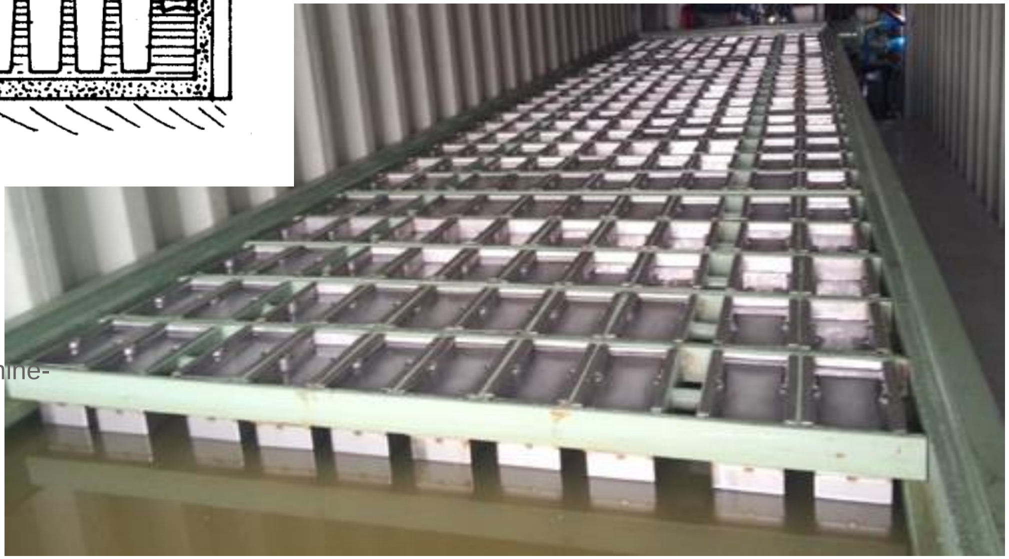
Co-founded by the German Ministry of Economics and Technology and the EuroNorm GmbH, Reg.No. IW072002

6. Block ice generation

- **Problem of conventional systems: simultaneous freezing of all blocks → poor or no part load capabilities**



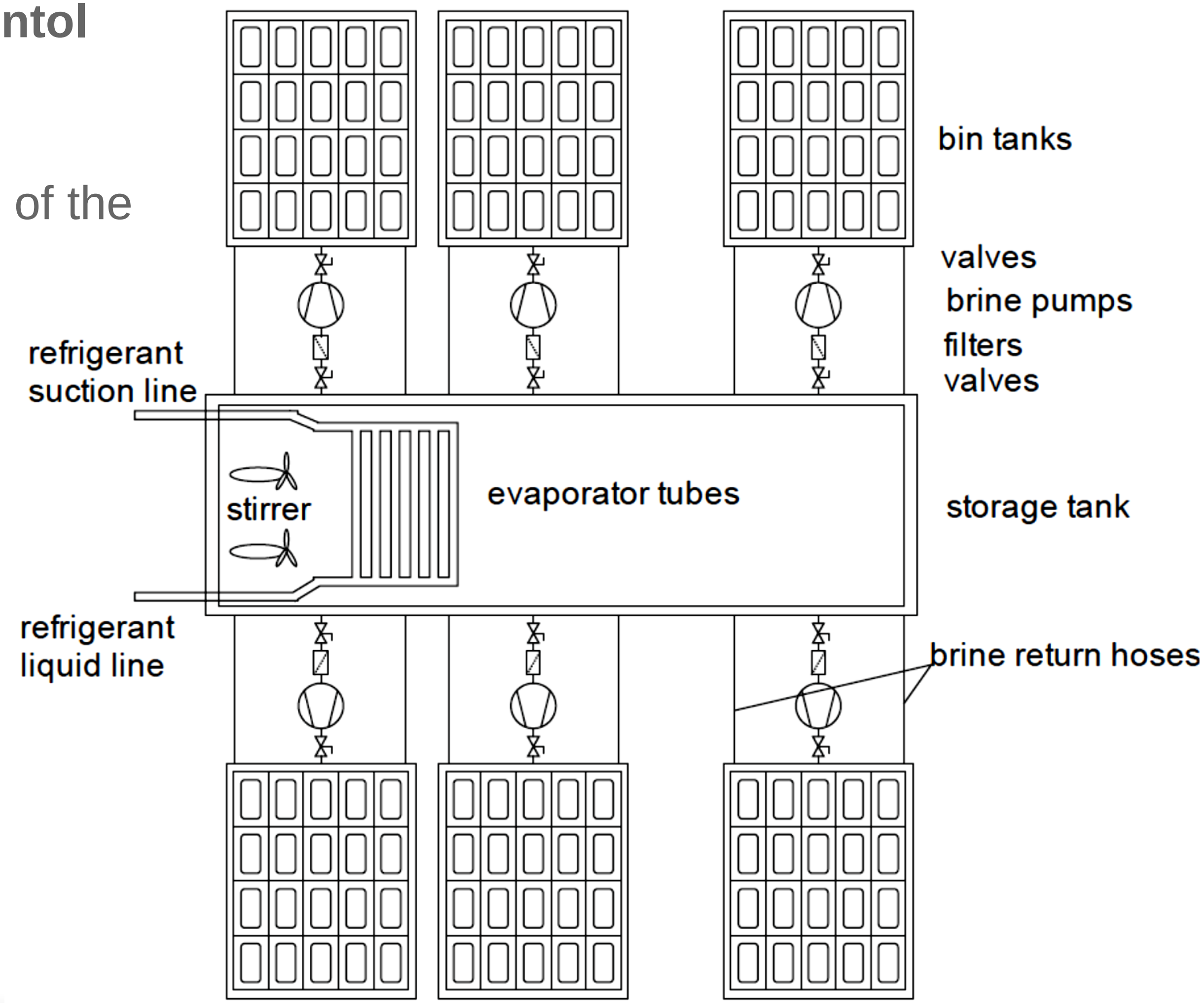
http://www.fao.org/docrep/003/p3407e/P3407E08.gif



https://5.imimg.com/data5/ON/XU/MY-1684608/ammonia-ice-block-making-machine-500x500.png

6. Block ice generation

- **Solution: compartmentalization of the bin tank + integration of a storage tank + automatic operation contol**
- **Requirements**
  - common freezing state of the bins w.o. stirrer
  - knowledge of freezing state



adaptable conversion of electricity to cold fulfilled regarding cooling demand

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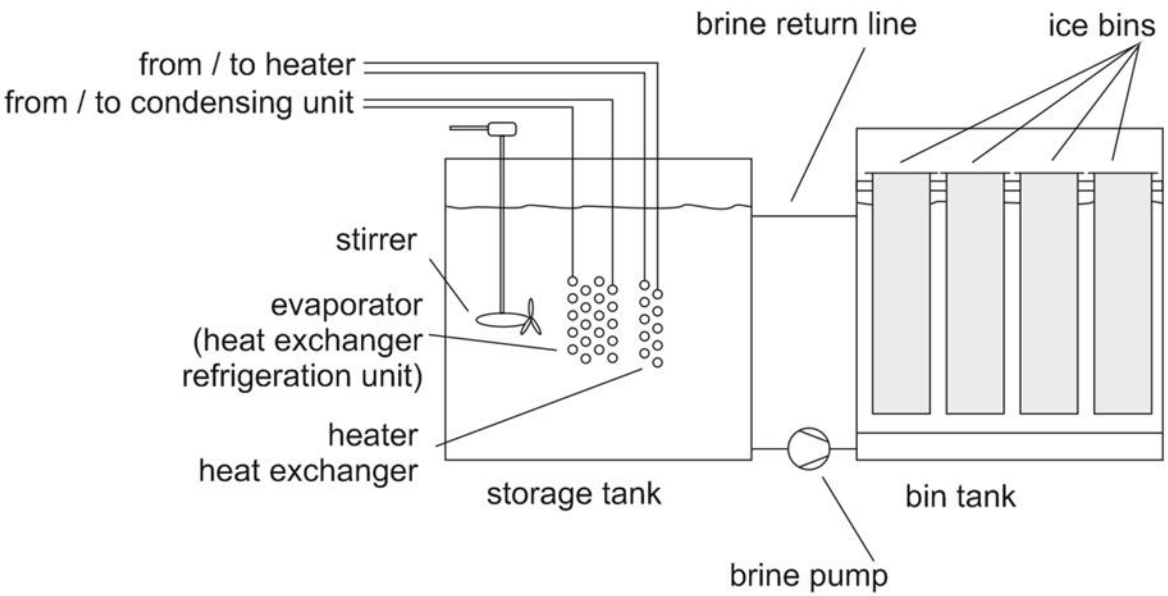
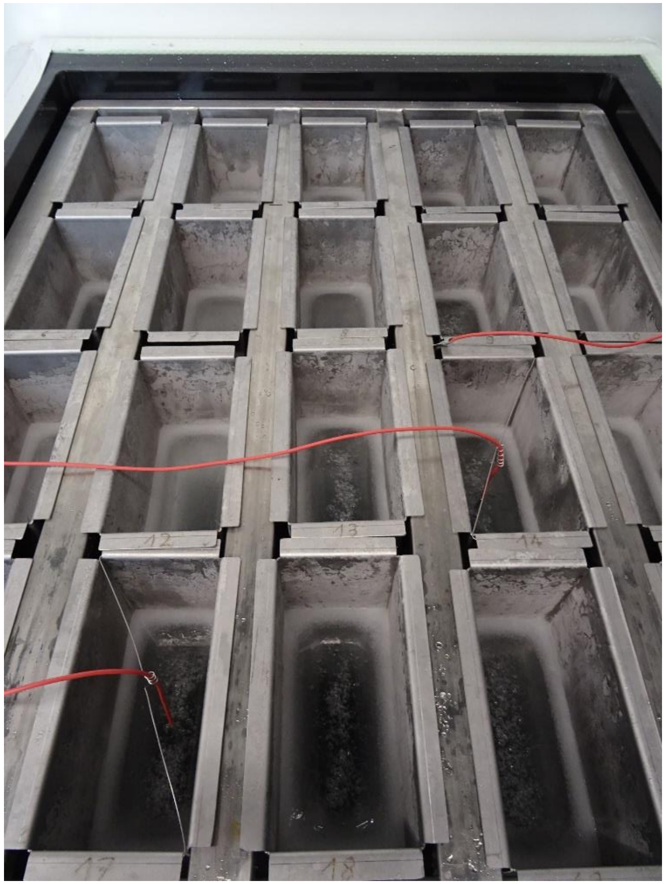
6. Block ice generation

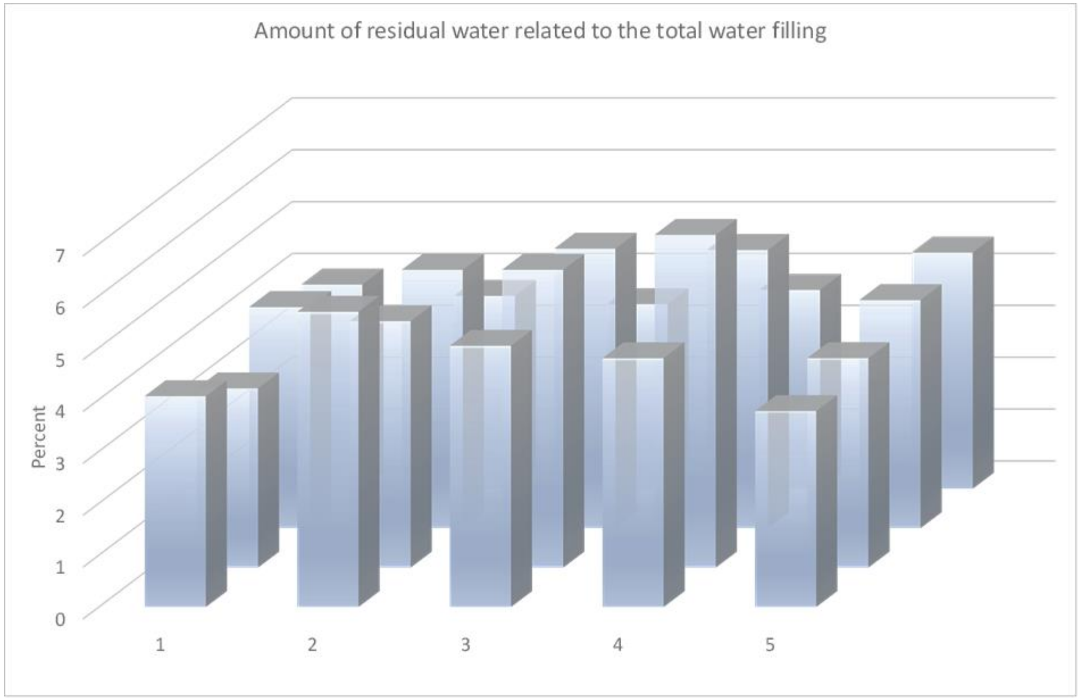
- Own experiments with test rig (bin tank scale 1:1)





6. Block ice generation

- Results: common freezing state with an optimized hydraulic design



- 6.5 h freezing at -8 °C, min. 3.4 % residual water, max. 6.4 % residual water
- Remaining differences are expected to have no practical relevance.

6. Block ice generation

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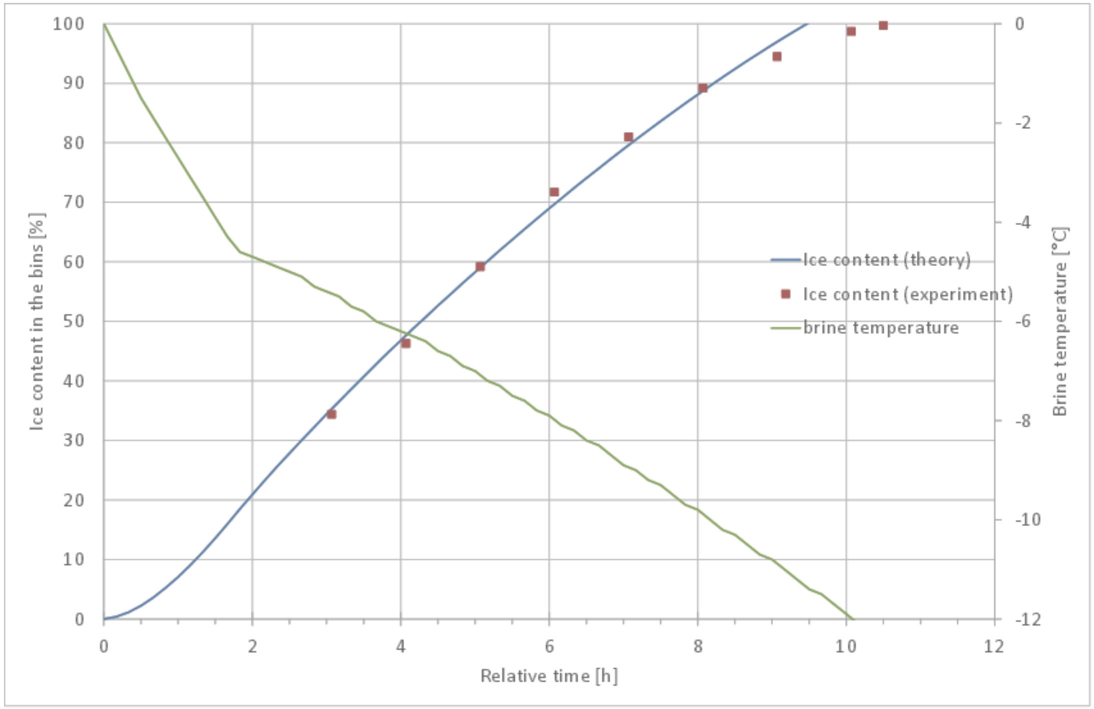
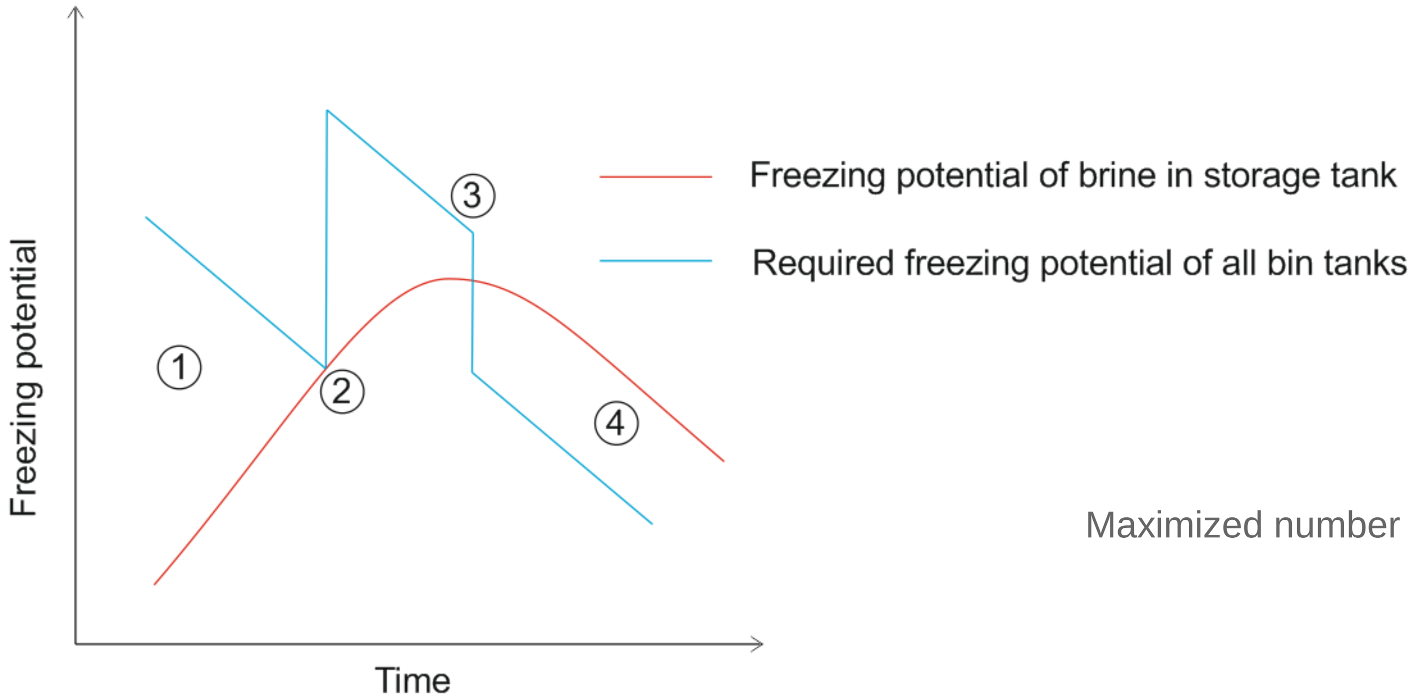
- Ice block growing model in dependence from brine temperature
- Freezing state estimations by simple brine temperature measurement



- PLC required to calculate freezing state of every bin tank

Block ice generation

- **Proposed operation mode**
  one part: bin tank operation decision – afternoon
- **„Freezing potential“ as common term for the „useful“ heat capacity of the cold brine and the required solidification enthalpy**

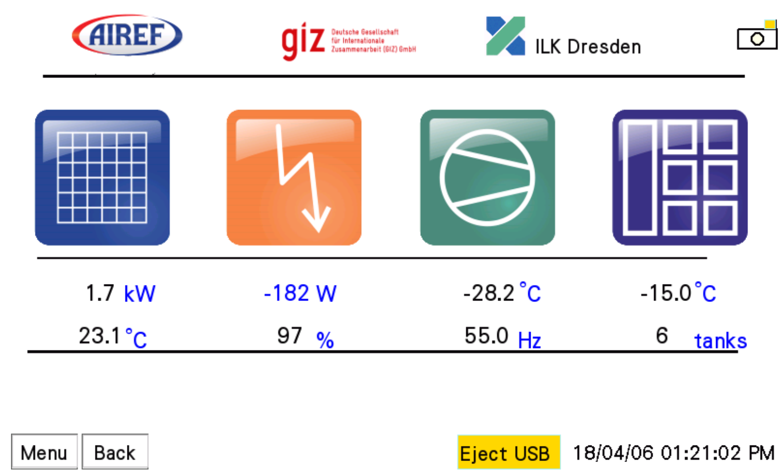


Maximized number of finished ice blocks

✓

Current state of the project

- **Pasuruan, Indonesia:**
  - Erection of the tanks, set-up of hydraulic system
  - Set-up of the refrigeration cycle and the 25 kWp PV-generator.
- **Dresden, Germany:**
  - Implementation of the VFD- and control software,
  - Development of teminal software,
  - Test of proposed control regime with original hardware and downscaled refrigeration cycle and PV generator
  - Two weeks visit of an Indonesian GIZ engineer for knowledge transfer



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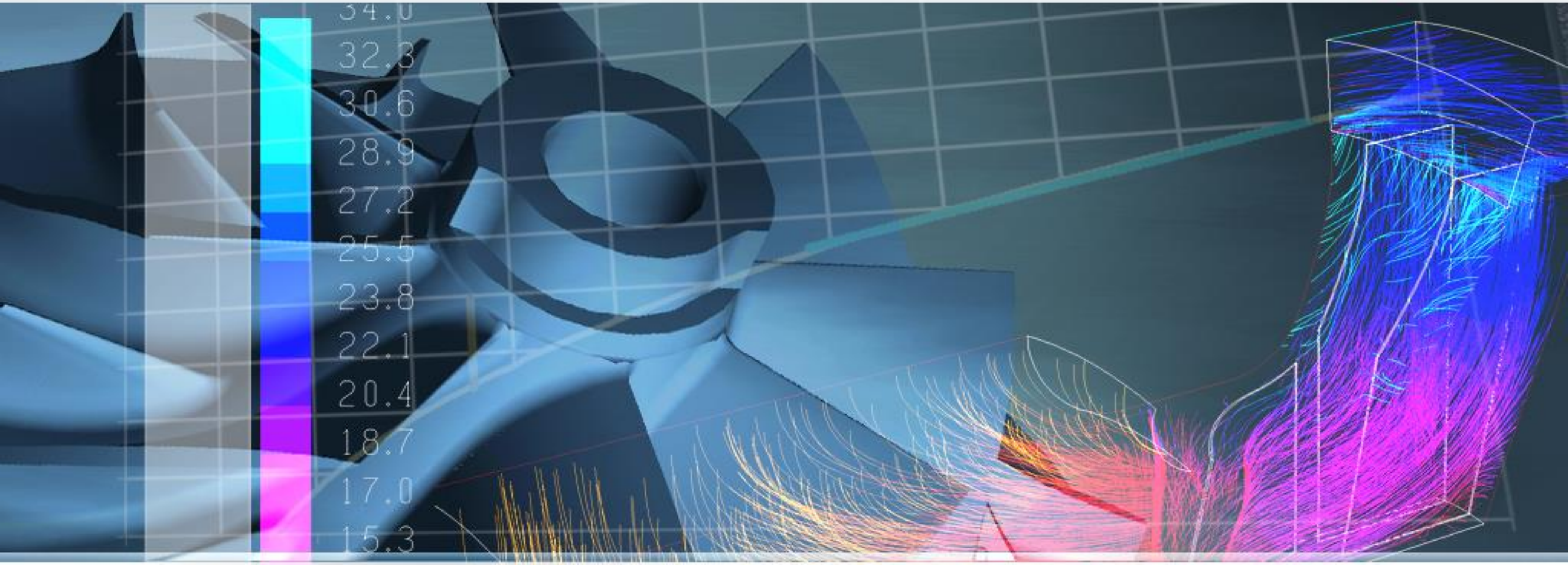

Block Ice made
at ILK Dresden

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