Solar Facilities for the European Research Area

SFERA -III 2nd Summer School
October 5th - 6th, 2021, Almería (Spain)

Lecture:

Influence of the system design on the pay-back time and solar fraction of SHIP applications

Prepared by:

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 823802.

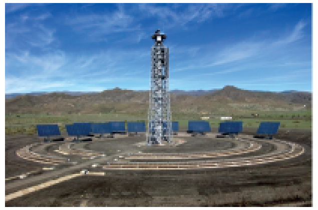
Contents:

2 min about me

Need a **local guide?**
I lived 4 years in Almería

A life under the sun

- Industrial Engineer -
  - PhD Concentrating Solar energy for EOR
  - MSc. Thermal Energy Systems
  - MSc. Solar Energy
- Working on CSP since 2008
- Coordinator of the Solar R&D Dept. at CTAER (Almería, Spain)



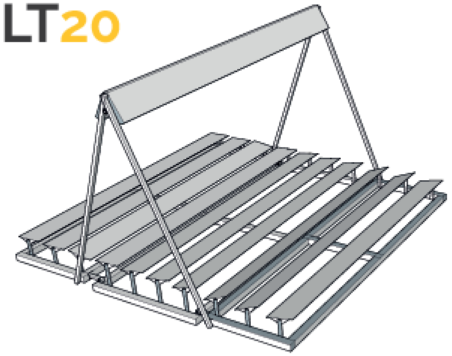
- Modelling around the world:

Masdar INSTITUTE

IRENA International Renewable Energy Agency

5 min about SOLATOM

FLT20



- SOLATOM was founded in 2016
- 9 projects in operation. IDAE subsidy granted in 7 projects: 3M€, 6,5 MW_t
- Invested by Enagas & BP Ventures - Exploring integration in Biogas & H_2
- www.solatom.com

Thermal oil

Pressurized water

Hot air

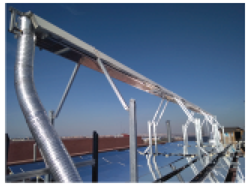
Steam

🟩 In operation 🟨 In construction 🟥 In development

ITC - Canarias

Margalida - Girona

UCIII - Madrid



Dadelos - Valencia

Solpinvap - Castellón

Herma - Cáceres

Magtel - Sevilla

Natural Cork - Badajoz

Solpinter - Almería

Goals of the presentation

Please **stop me** if you have any questions

GOALS

- Understanding the basics of SHIP design
- Understanding the influence of different desing parameters in the economics of the project

DISCLAIMER

- 70 % Professional experience in SOLATOM
  30 % Academic references

  Slightly biased to SOLATOM's approach

- Focused on "influence" rather than absolute values (Only relative variations of KPIs, not absolute values)
- Most of results are calculated with the pre-feasibility tool RESSSPI (www.ressspi.com)
- The most important thing is common sense
- Not native english speaker. Be gentle with typos :)

FUNDAMENTALS OF SHIP DESIGN

Ref: SOLATOM (Construction of Magtel project)

INPUTS

- Available surface
  - Area available in m^2 (solar field and boiler room) and SHAPE!
  - Type of surface (e.g. Concrete/Shandwich rooftop, land, ...)
  - Orientation/Inclination
  - Distance from the boiler room / integration point

beyond pre-feasibility

- Structure underneath (also foundations)
- Shadows
- Water/Power supply availability
- Dust/Salty/Acid atmosphere
- Vegetation
- Uncontrolled glares (e.g. Airports, office space...)
- Available space for storing during construction (Security issues)
- Legal requirements (e.g. ”Suelo urbanizable” in Spain)

FUNDAMENTALS OF SHIP DESIGN

Ref: SOLATOM (Visit to client in Sabadell)

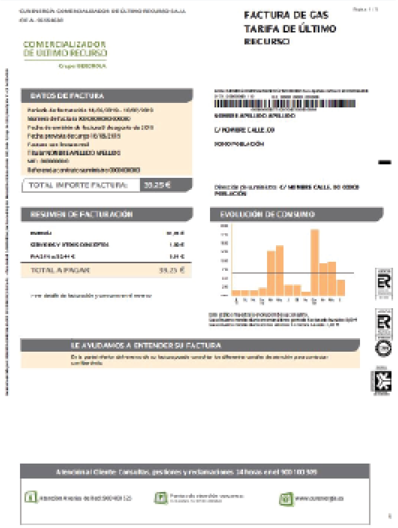
INPUTS

- Process data
  - Type of fluid used (e.g. Thermal oil, Water, Steam, ...)
  - Thermodynamic properties (e.g. Operating pressure, temperatures, quality ...)
  - Type of water treatment (e.g. Osmosis, decalcification, grid water ...)
  - Close circuit (e.g. Return of condensates, raw water, mixture, ...)
  - Storage available

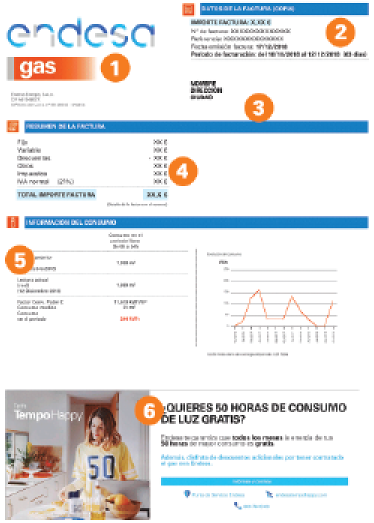
beyond pre-feasibility

- Type of components (Heat recovery systems)
- Type of burner (on-off, modulating, ...)
- Operating requeriments of external equipment (valves, flow measurements, ...)
- Integration point (e.g. Steam header, interconnecting piping, ...)

FUNDAMENTALS OF SHIP DESIGN


FACTURA DE GAS
TARIFA DE ÚLTIMO RECURSO

Ref: Iberdrola



¿QUIERES 50 HORAS DE CONSUMO DE LUZ GRATIS?

Ref: Enagas

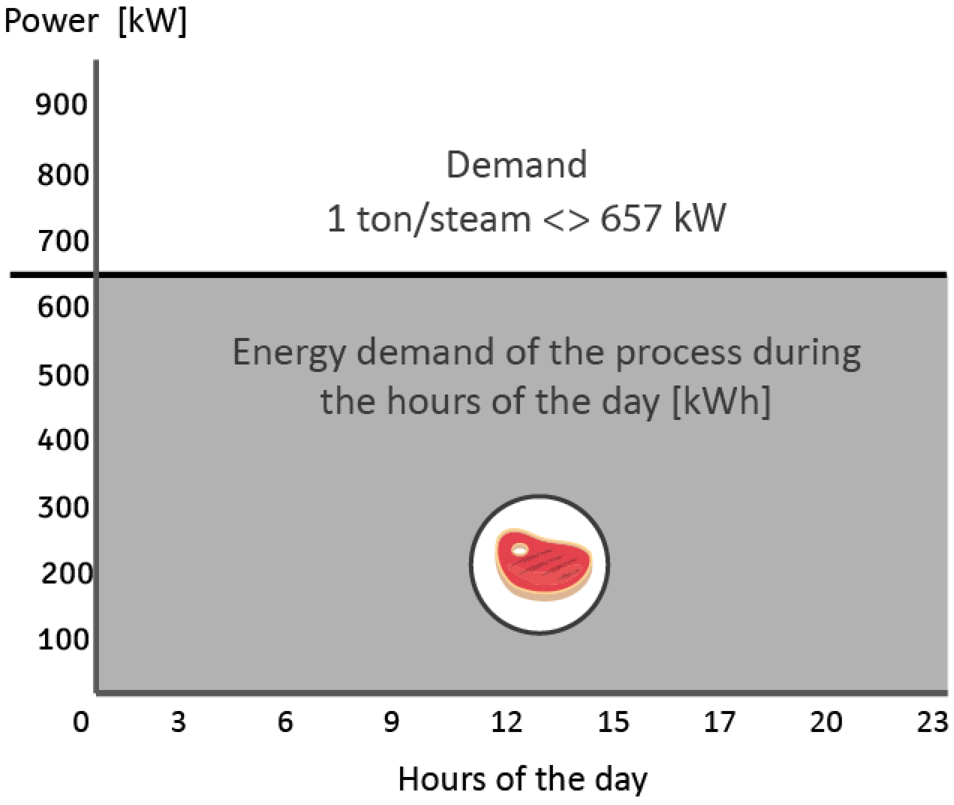
INPUTS

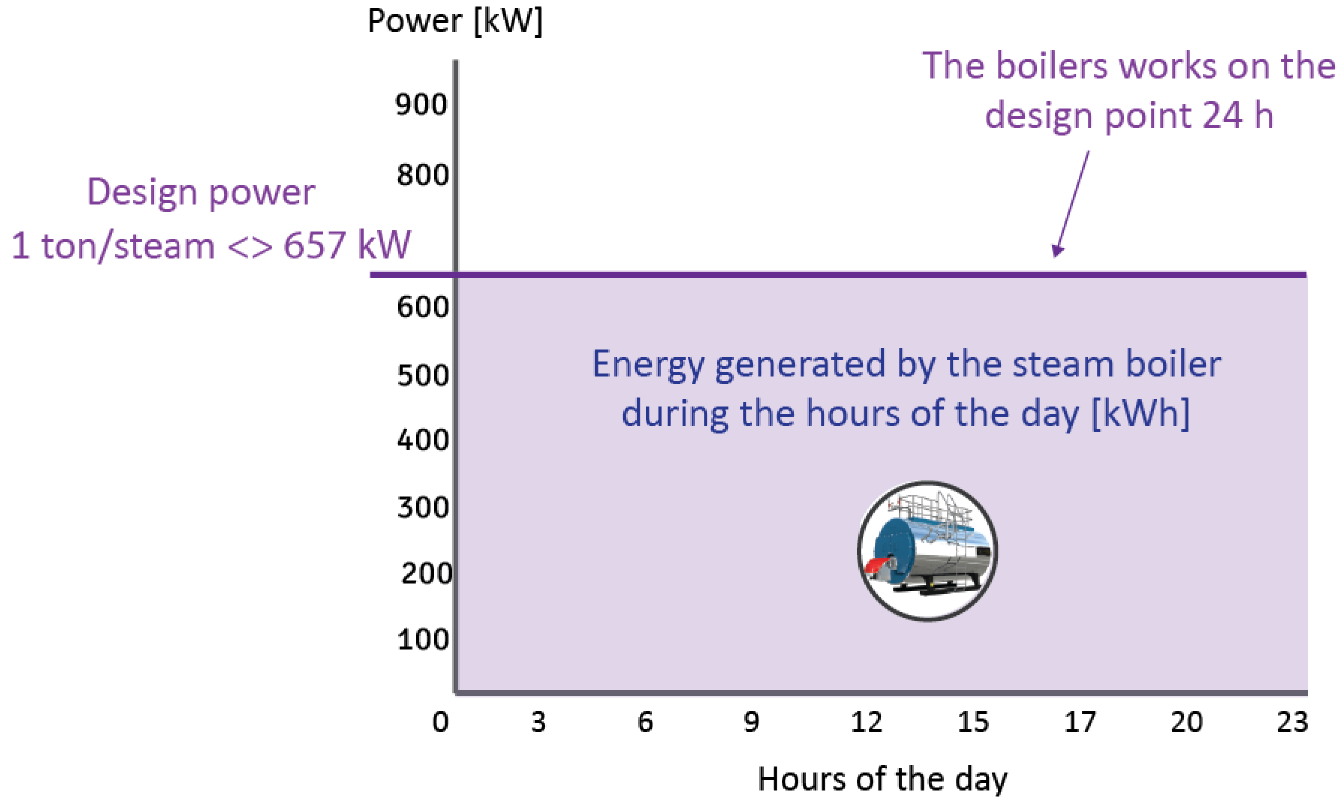
- Demand data
  - Type of fuel used (e.g. NG, LNG, Fueloil, ...)
  - Cost of fuel in €/kWh
  - Daily/Weekly/Monthly profile (hourly based simulations)
  - !! Careful with aggregated bills (burners + boilers)

beyond pre-feasibility

- Breakdown of fuel cost (Capacity payments, indexing, ...)
- In-situ measurements of demand (if aggregated bills)
- Parametric studies (Client scenarios)

FUNDAMENTALS OF SHIP DESIGN





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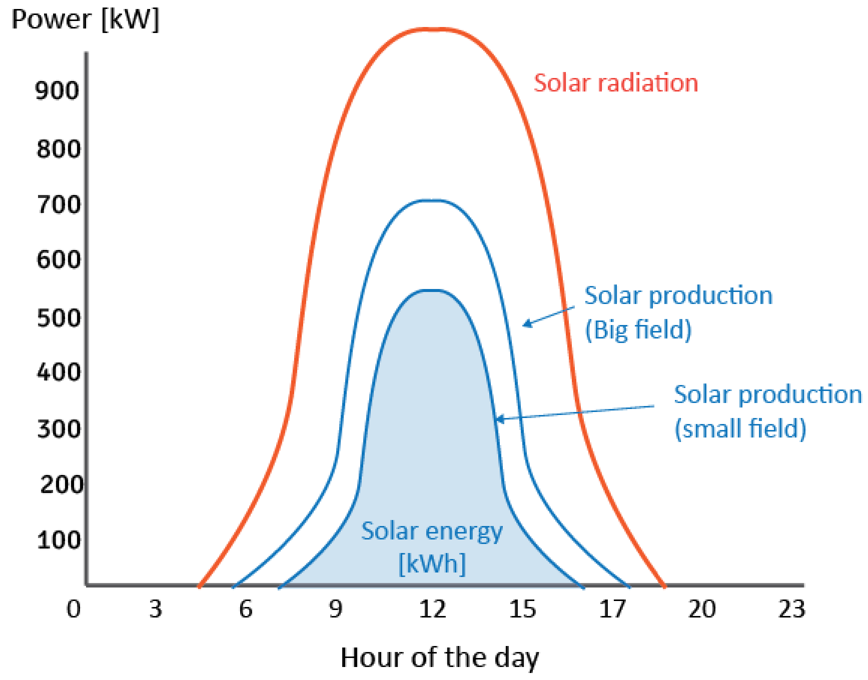
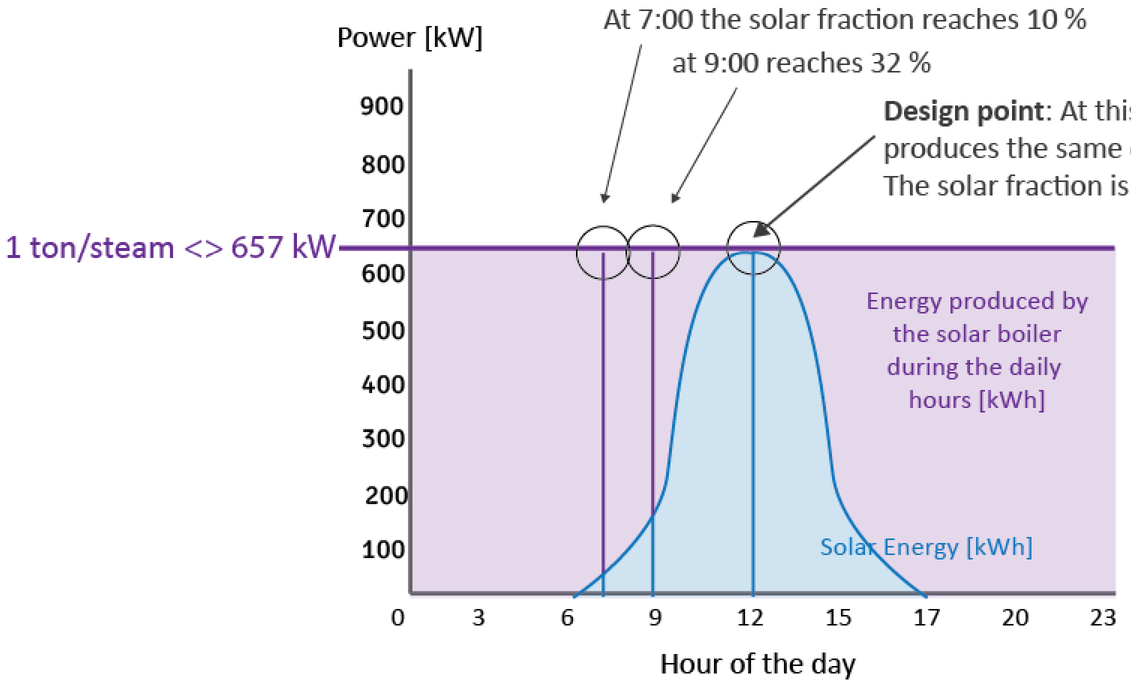




At 7:00 the solar fraction reaches 10 %

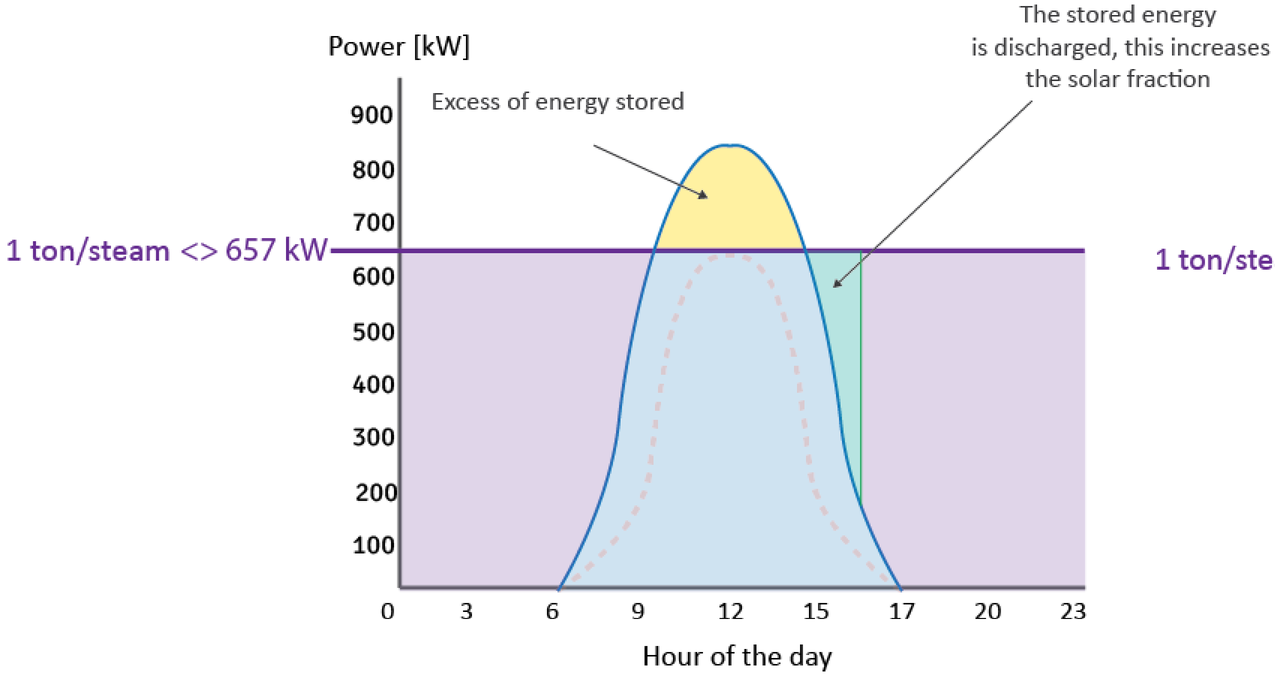
at 9:00 reaches 32 %

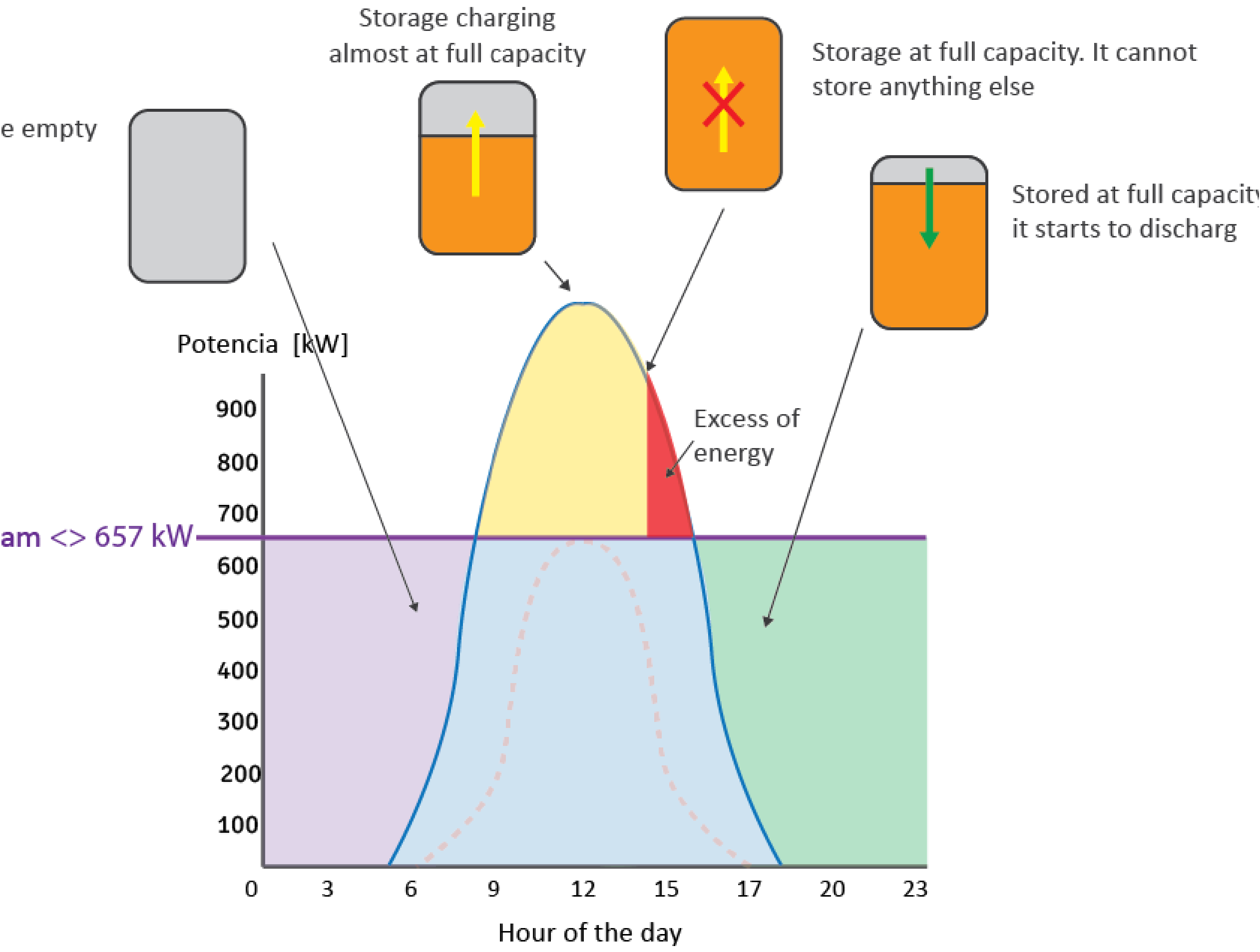
Design point: At this time the solar field produces the same output than the boiler. The solar fraction is 100 %

The solar fraction is the fraction between the solar energy and the energy produced by the boiler

🟦 / 🟪 = SF

FUNDAMENTALS OF SHIP DESIGN





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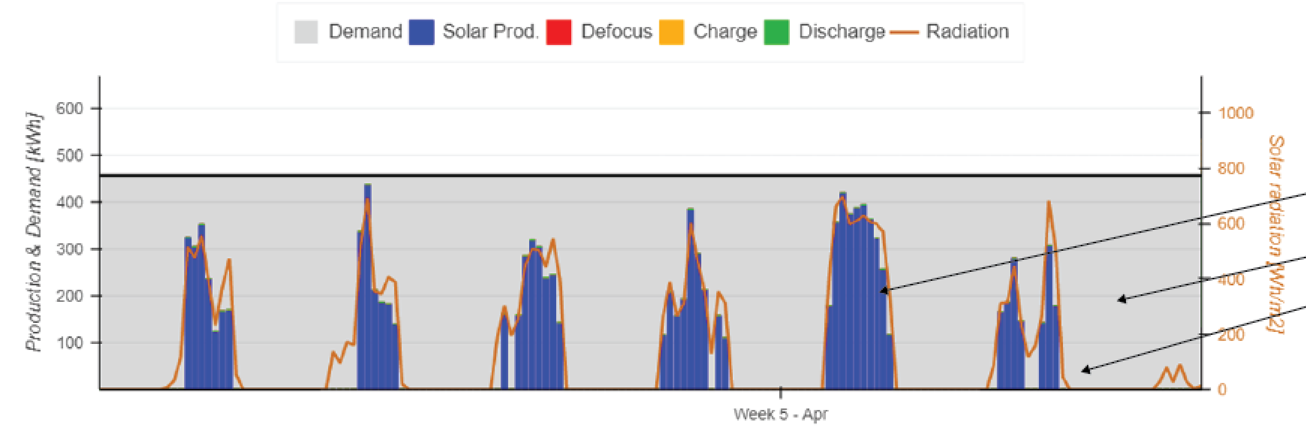
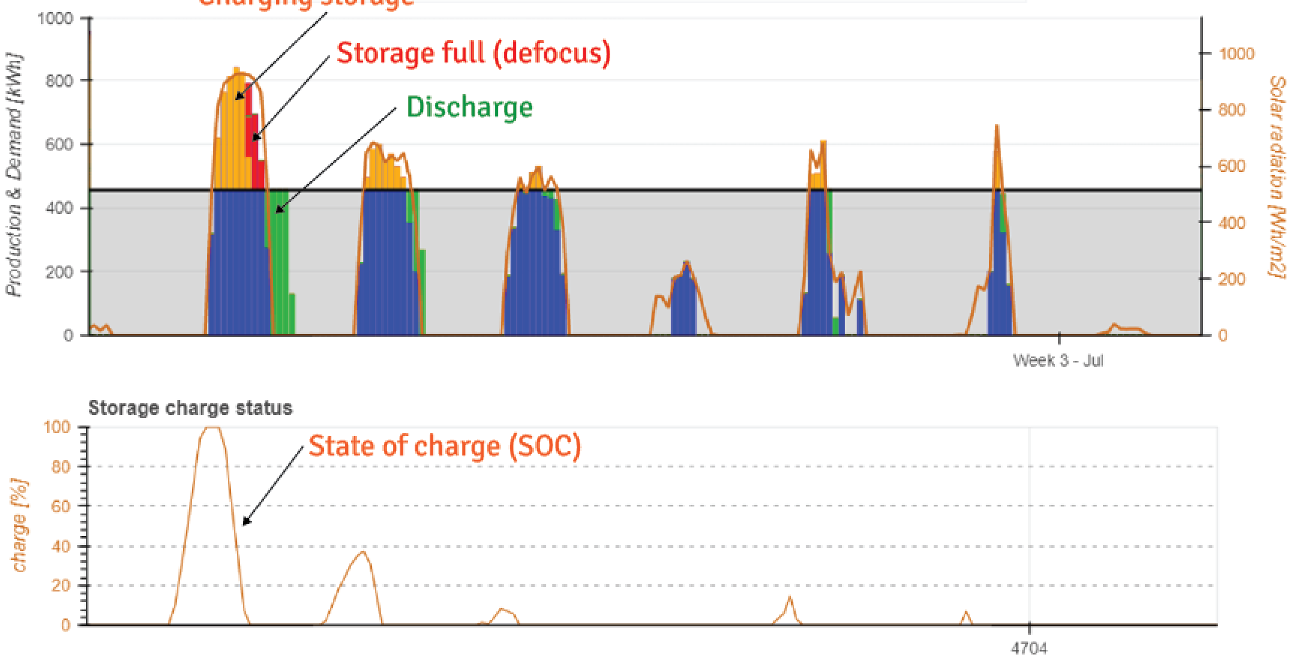


Solar production

Thermal demand

Solar radiation (DNI)

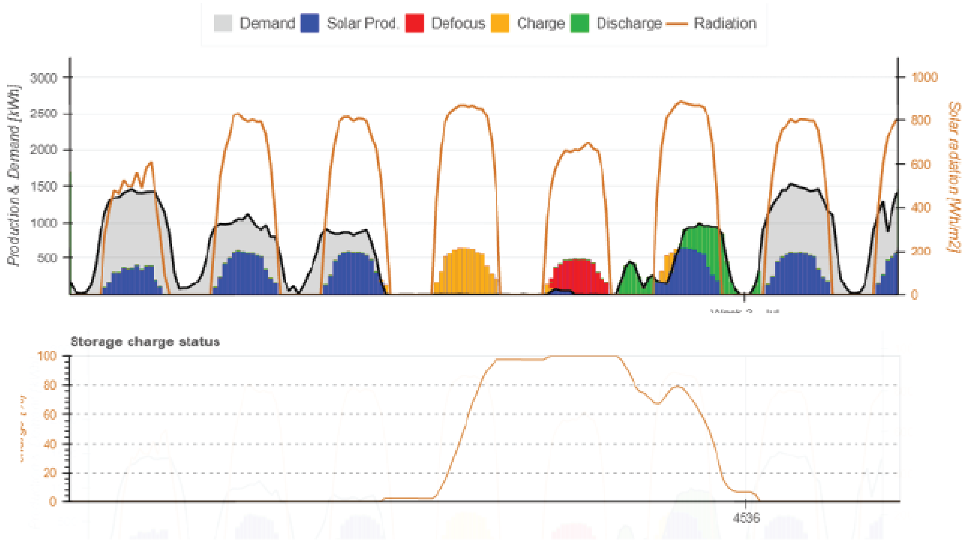


Charging storage

Storage full (defocus)

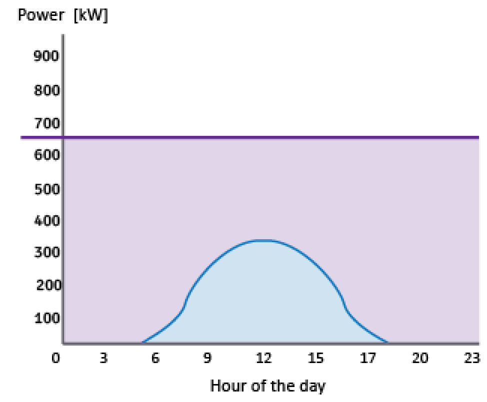
Discharge

State of charge (SOC)

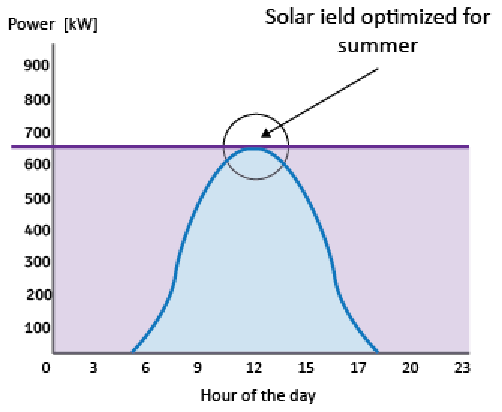


FUNDAMENTALS OF SHIP DESIGN

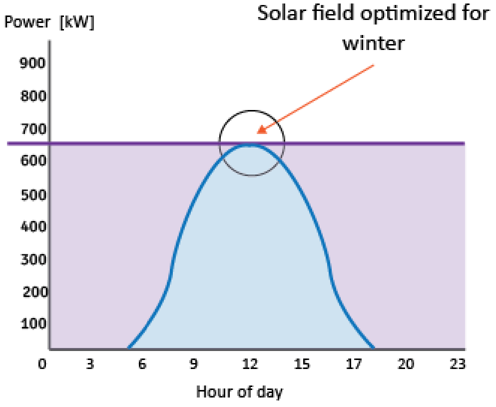
Production during winter



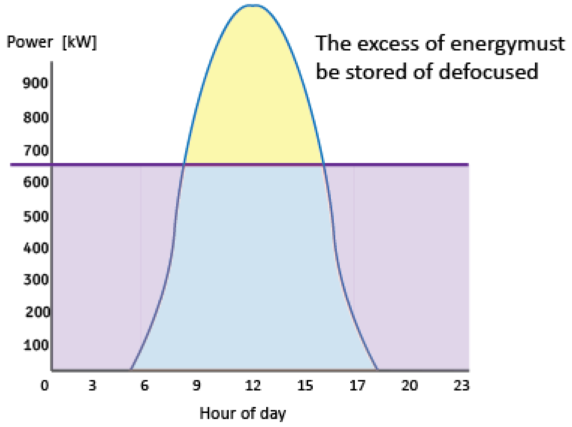
Production during summer

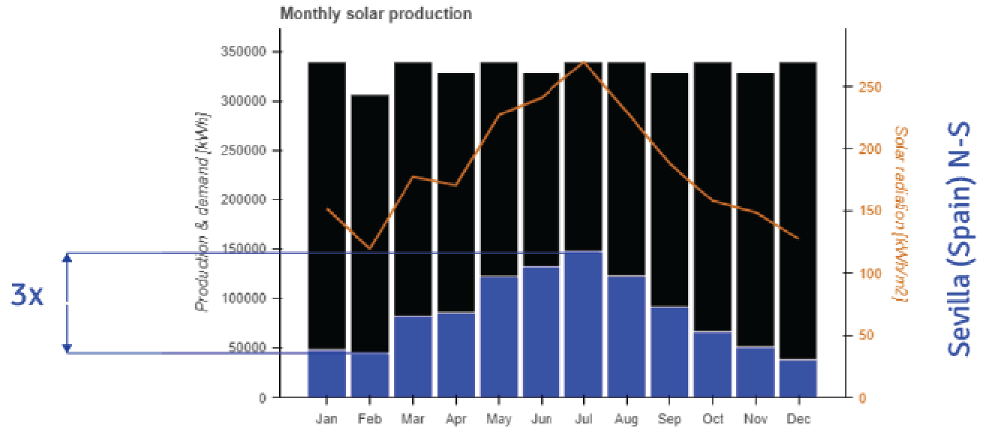

Solar ield optimized for summer

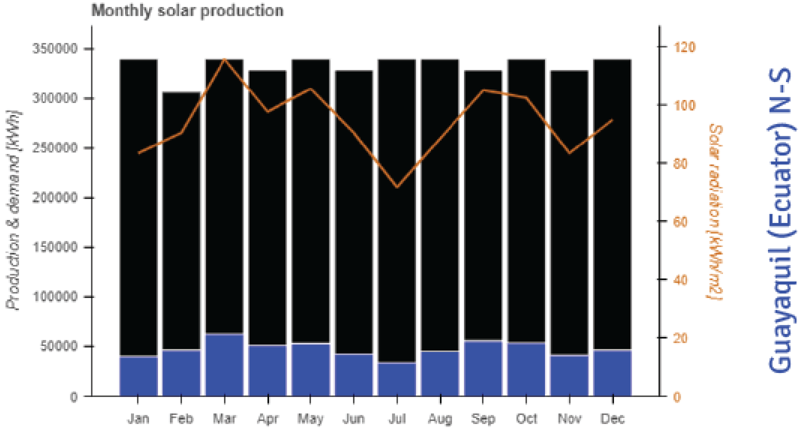
Production during winter


Solar field optimized for winter

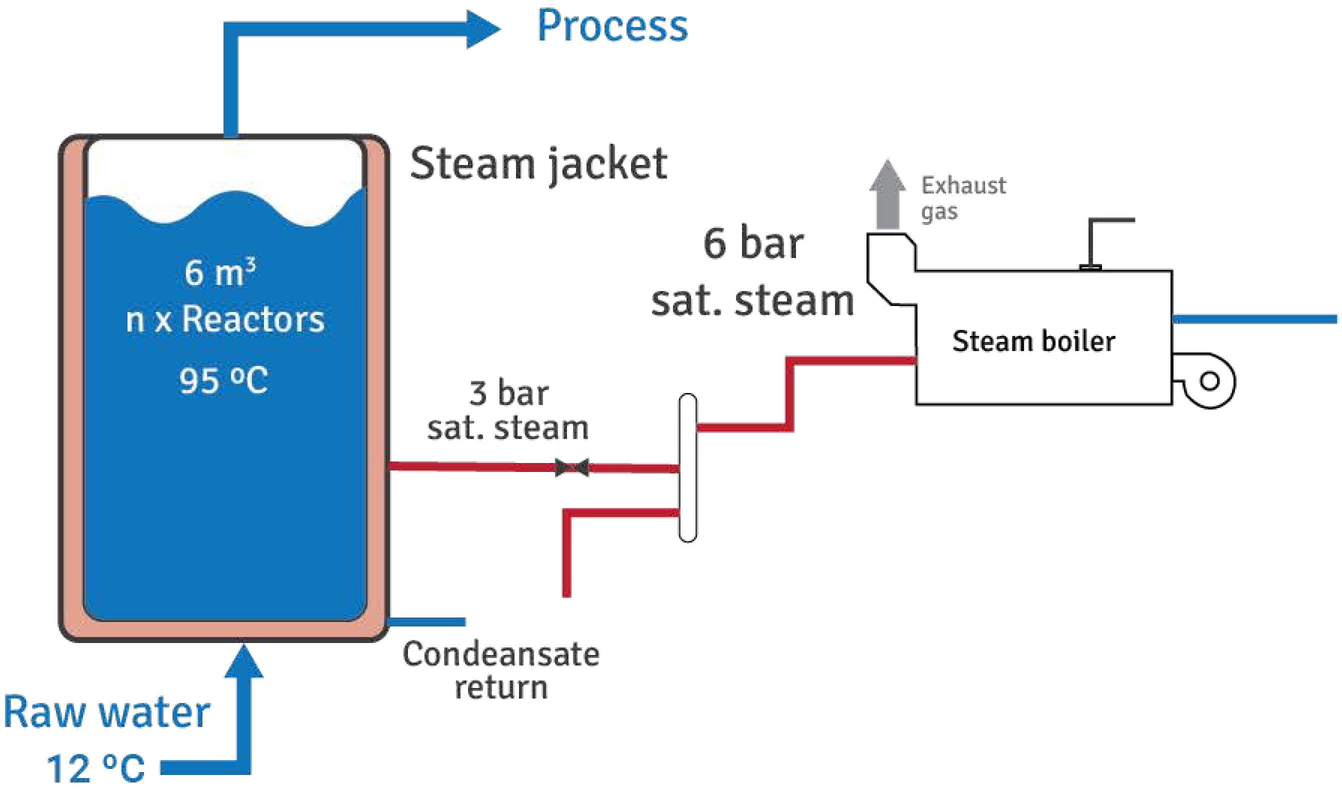
Production during summer


The excess of energymust be stored of defocused





IMPACT OF DESIGN PARAMETERS



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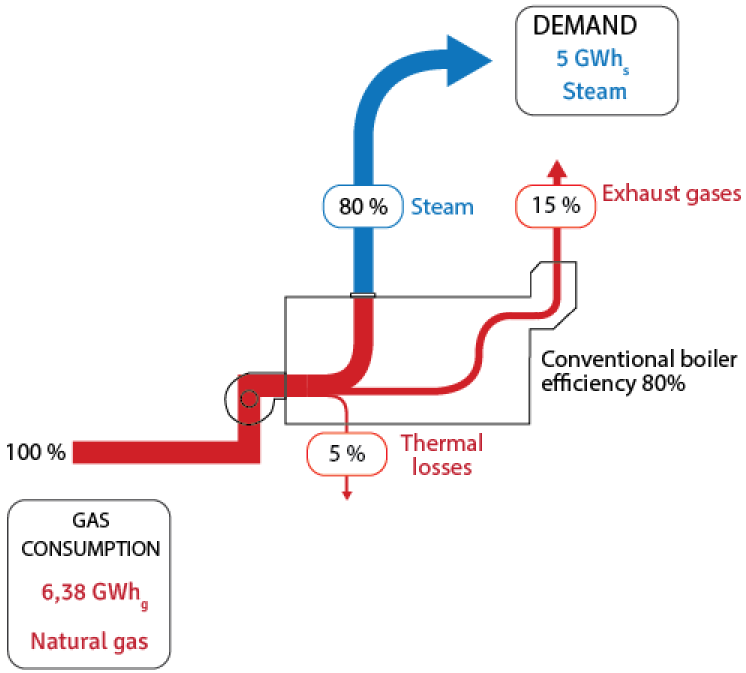


DEMAND
5 GWh_s
Steam

80 % Steam

15 % Exhaust gases

Conventional boiler
efficiency 80%

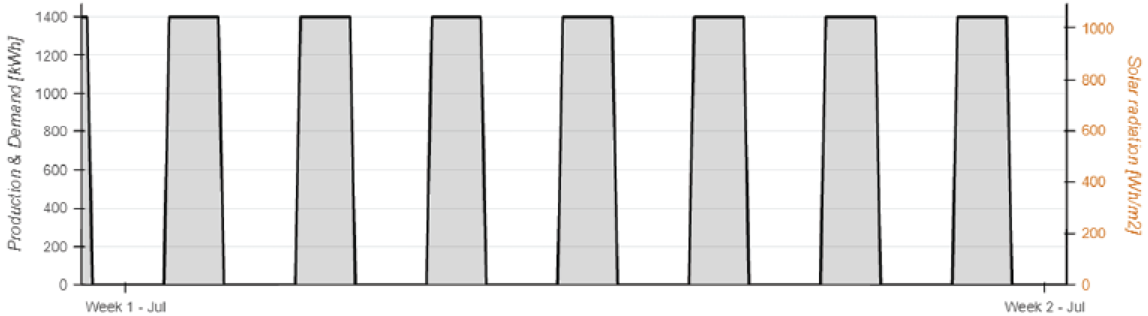
100 %

5 % Thermal losses

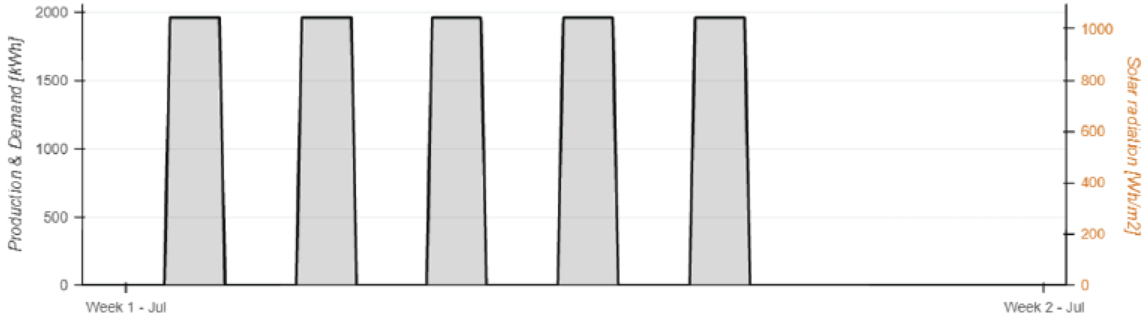
GAS CONSUMPTION
6,38 GWh_g
Natural gas

A
8760 h/year
24 h/7
583 kWh

B
3650 h/year
9-18 h/7
1400 kWh



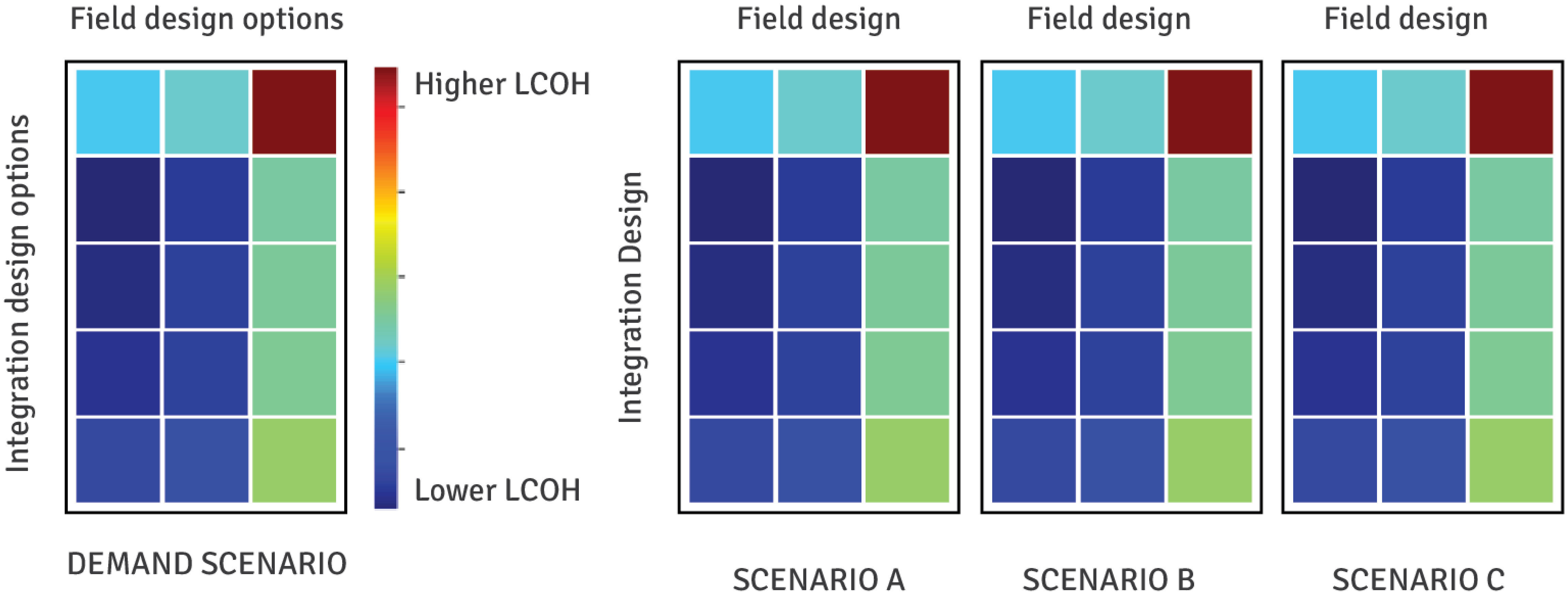
C
2607 h/year
9-18 h/5
2607 kWh



IMPACT OF DESIGN PARAMETERS

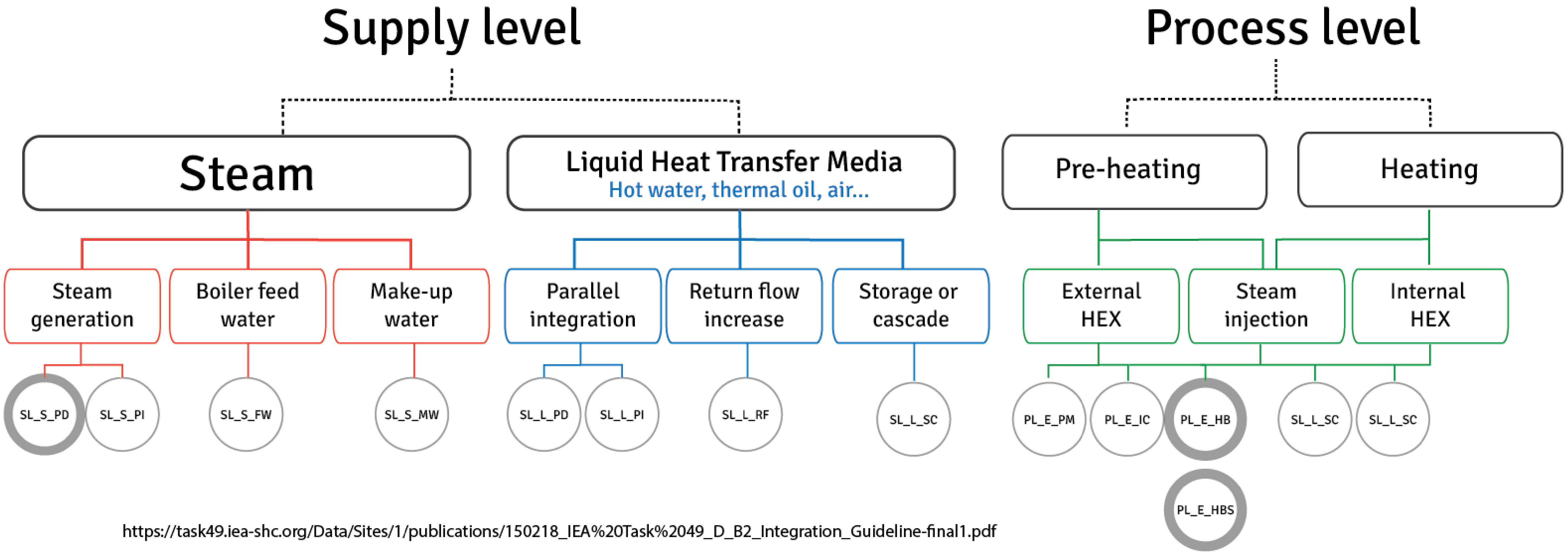
	[0,2] GWh/year	[5,10] GWh/year	[20, x] GWh/year
1 shift	82 %	13 %	0 %
2 shifts	18 %	53 %	0 %
3 shifts	0 %	34 %	100 %
Only 5 days	92 %	62 %	0 %
6 days (Saturday)	8 %	38 %	63 %
7 days	0 %	0 %	37 %
Holiday Stop	100 %	100 %	43 %
No stop	0 %	0 %	57 %

IMPACT OF DESIGN PARAMETERS



IMPACT OF DESIGN PARAMETERS

Integration concepts from IEA SHC-Task 49



Supply level

Process level

Steam

Liquid Heat Transfer Media
Hot water, thermal oil, air…

Pre-heating

Heating

Steam generation

Boiler feed water

Make-up water

Parallel integration

Return flow increase

Storage or cascade

External HEX

Steam injection

Internal HEX

SL_S_PD

SL_S_PI

SL_S_FW

SL_S_MW

SL_L_PD

SL_L_PI

SL_L_RF

SL_L_SC

PL_E_PM

PL_E_IC

PL_E_HB

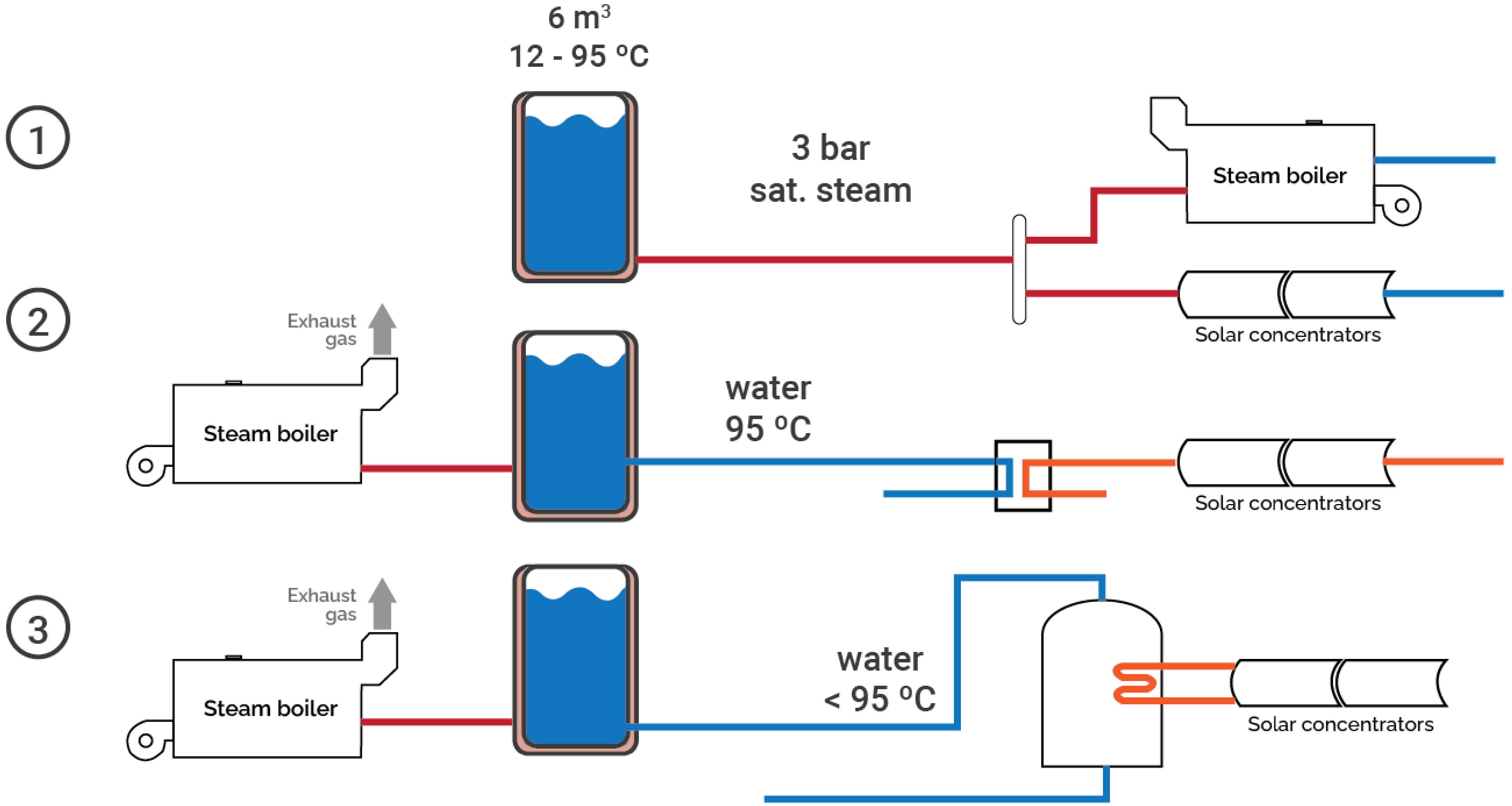
SL_L_SC

SL_L_SC

PL_E_HBS

https://task49.iea-shc.org/Data/Sites/1/publications/150218_IEA%20Task%2049_D_B2_Integration_Guideline-final1.pdf

IMPACT OF DESIGN PARAMETERS

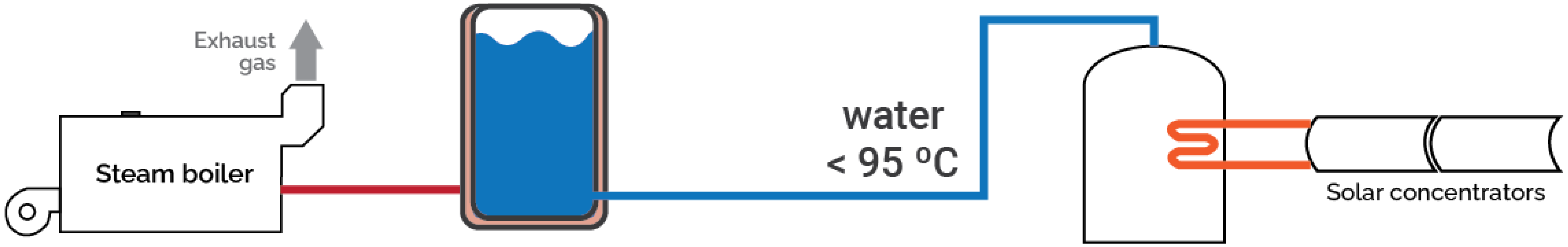


SUPPLY LEVEL

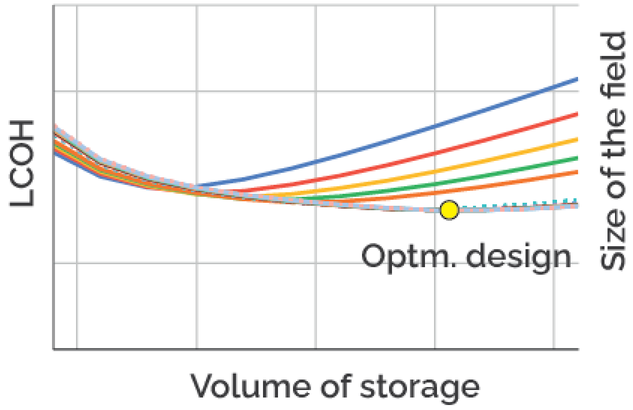
PROCESS LEVEL

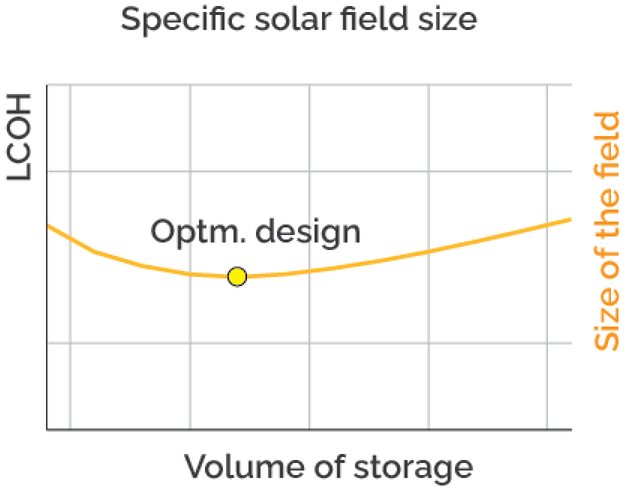
PROCESS LEVEL

IMPACT OF DESIGN PARAMETERS



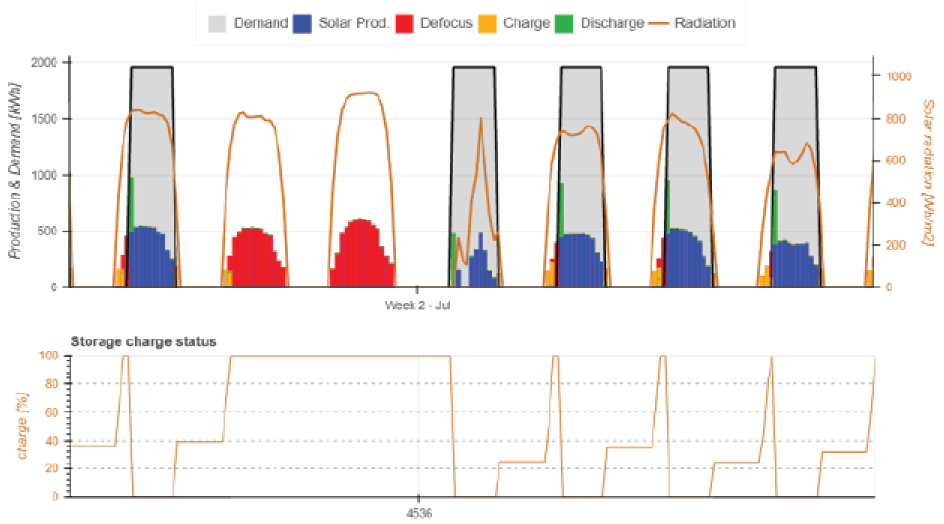
PROCESS LEVEL



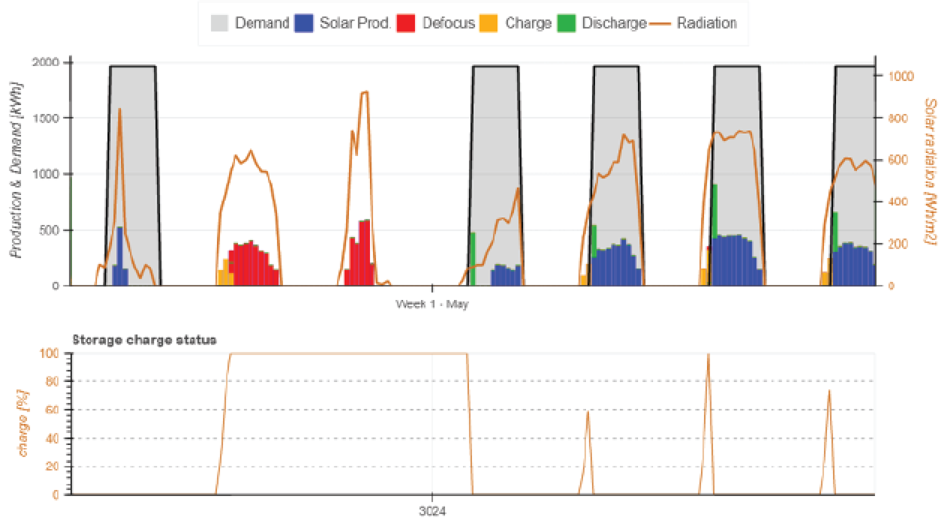


IMPACT OF DESIGN PARAMETERS

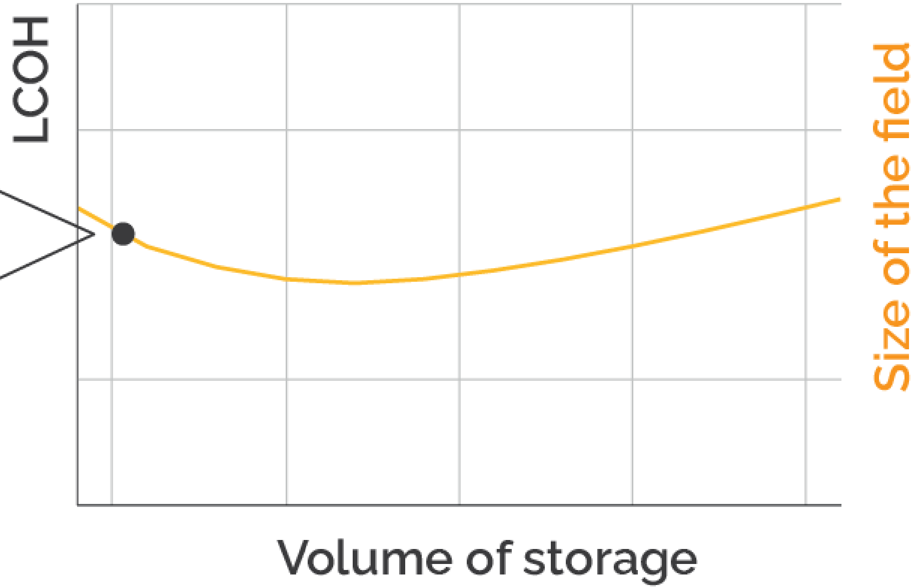
SUMMER WEEK



SPRING WEEK

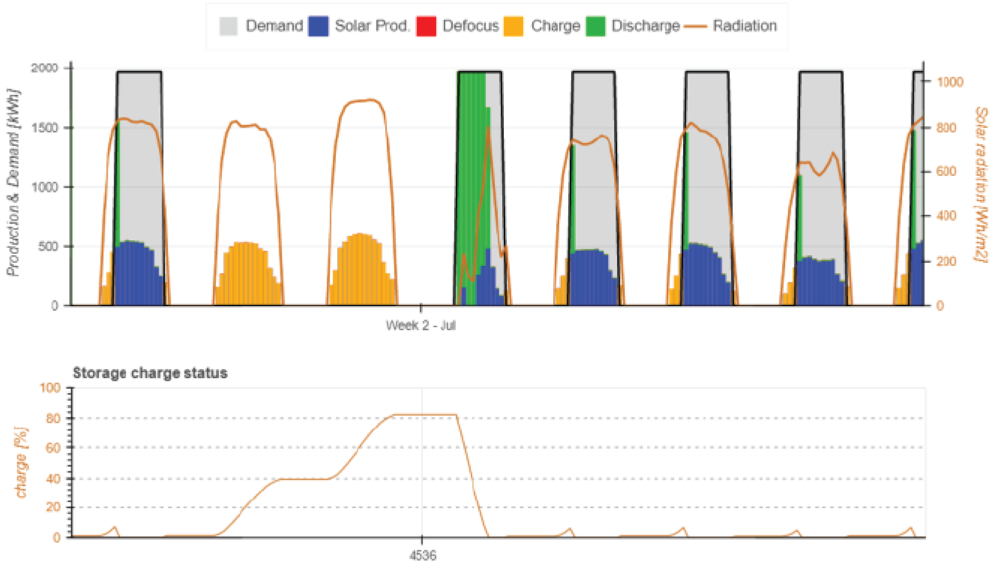


Specific solar field size

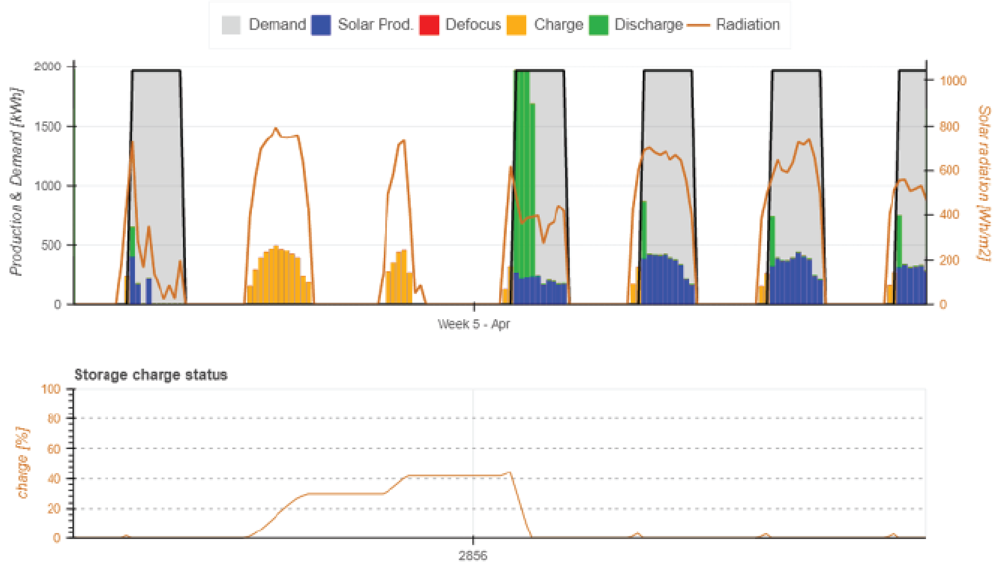


IMPACT OF DESIGN PARAMETERS

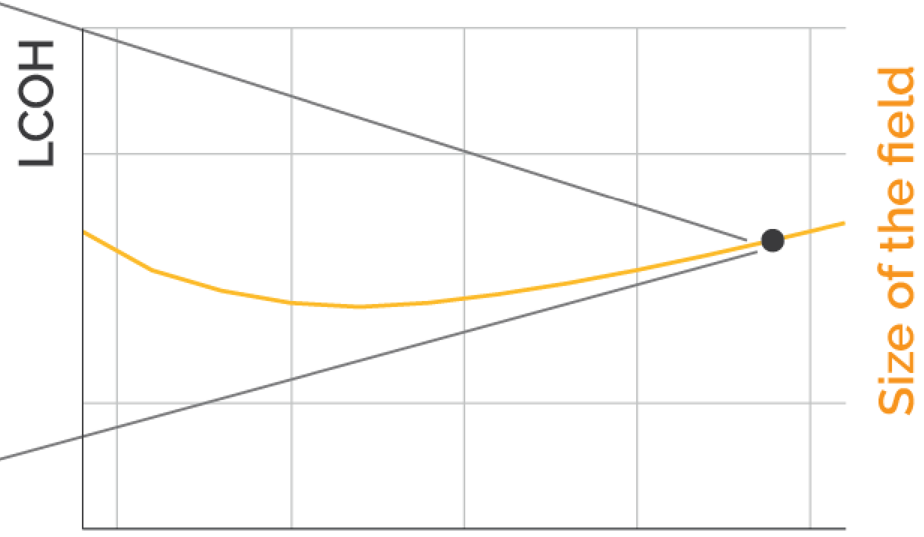
SUMMER WEEK



SPRING WEEK



Specific solar field size



Volume of storage

IMPACT OF DESIGN PARAMETERS

① Supply Level - SL_S_PD - Direct Steam Generation

② Process Level - PL_E_HB - External Heat Exchanger Heating bath

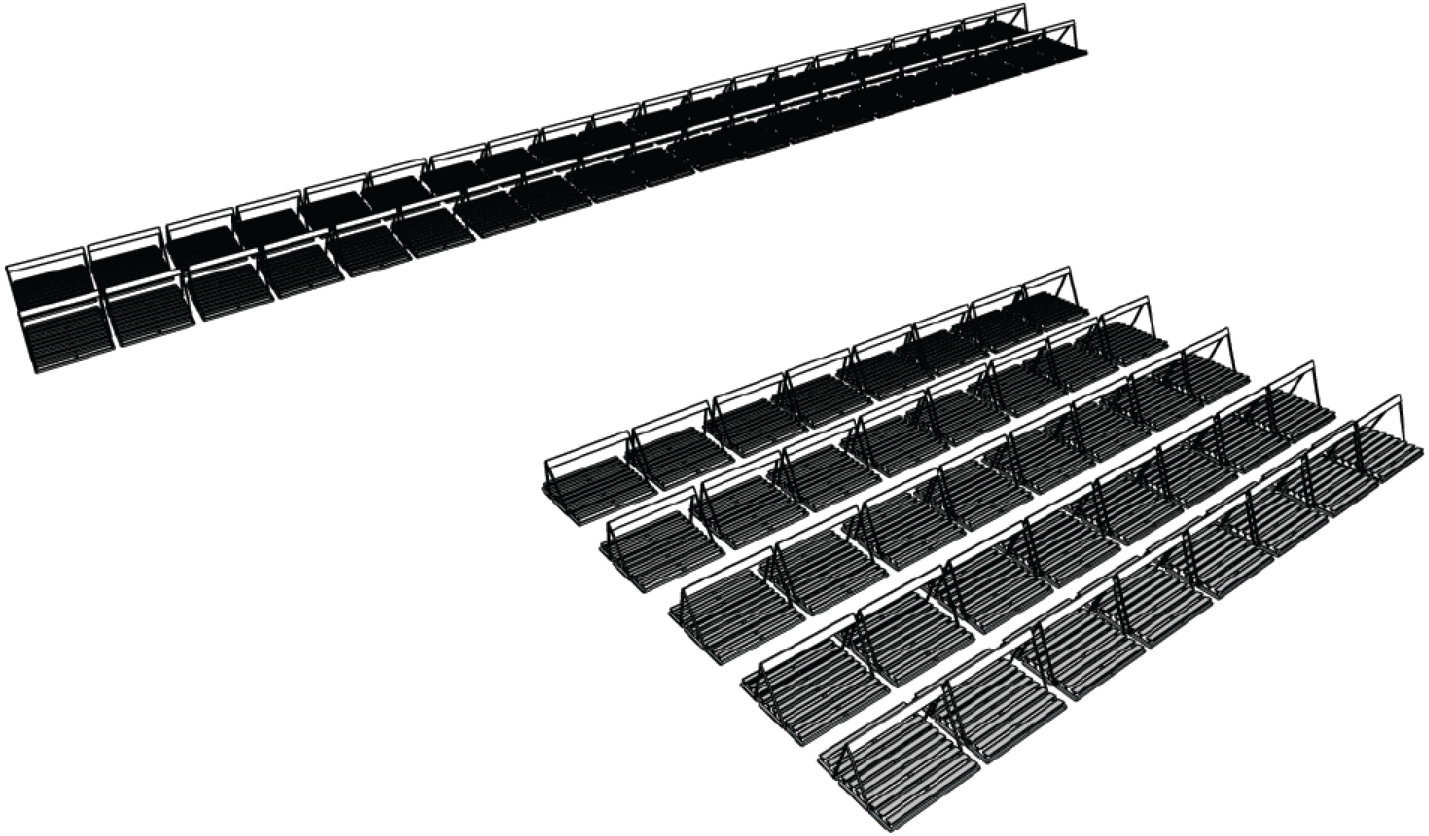
(3a) Process Level - PL_E_HB - External Heat Exchanger Heating bath - Storage under opt.

(3b) Process Level - PL_E_HB - External Heat Exchanger Heating bath - Storage opt.

(3c) Process Level - PL_E_HB - External Heat Exchanger Heating bath - Storage over opt.

IMPACT OF DESIGN PARAMETERS

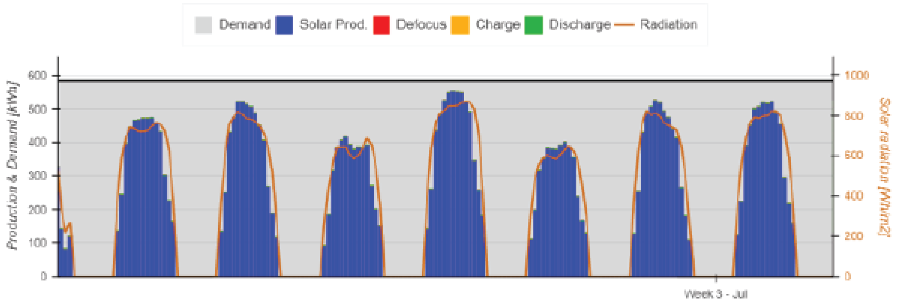
- ⓐ Free land
- ⓑ Squared shaped land
- ⓒ Squared shaped rooftop



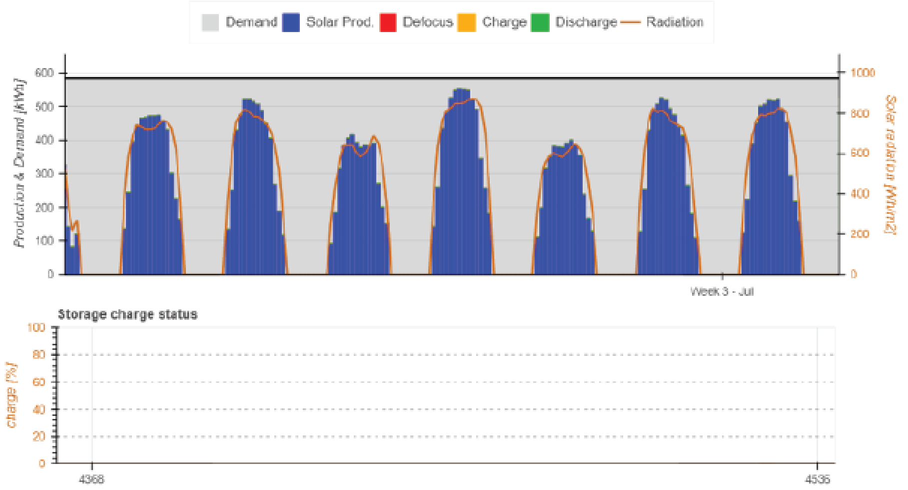
IMPACT OF DESIGN PARAMETERS

A - 1 - a

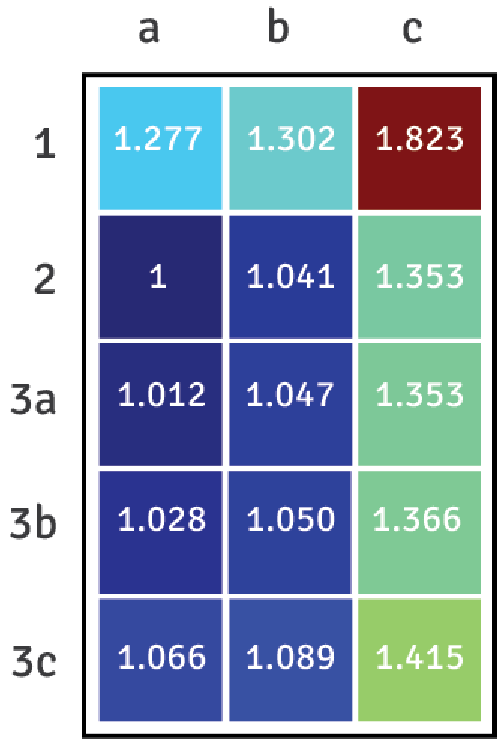
A - 2 - a



A - 3b - a



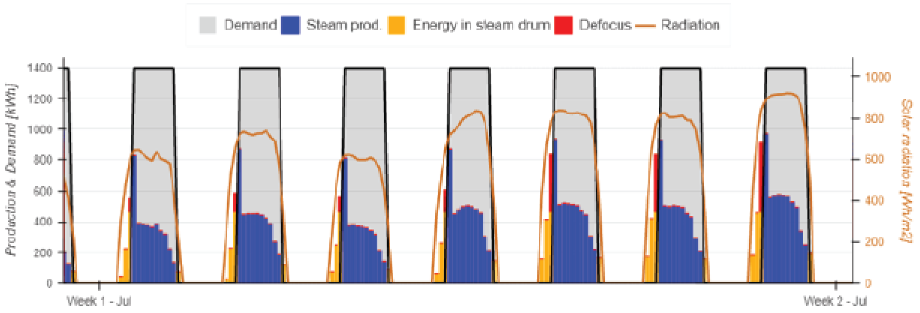
SCENARIO A



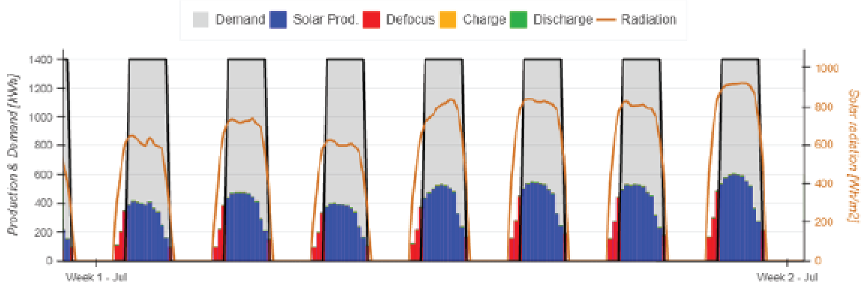
	a	b	c
1	1.277	1.302	1.823
2	1	1.041	1.353
3a	1.012	1.047	1.353
3b	1.028	1.050	1.366
3c	1.066	1.089	1.415

IMPACT OF DESIGN PARAMETERS

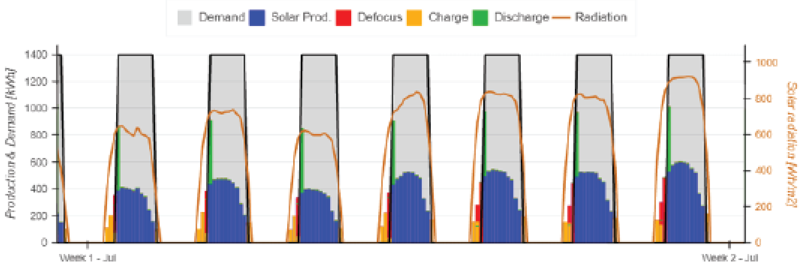
B - 1 - a

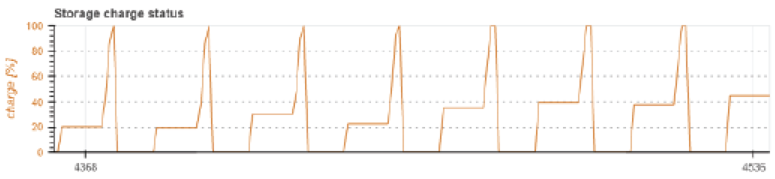


B - 2 - a

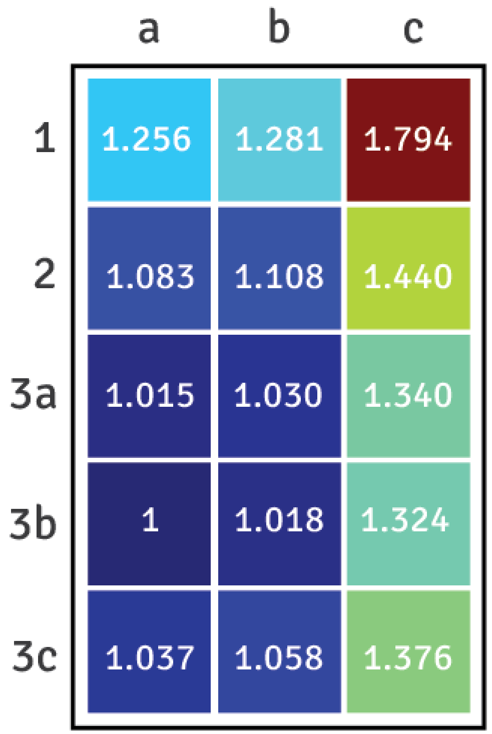


B - 3b - a





SCENARIO B



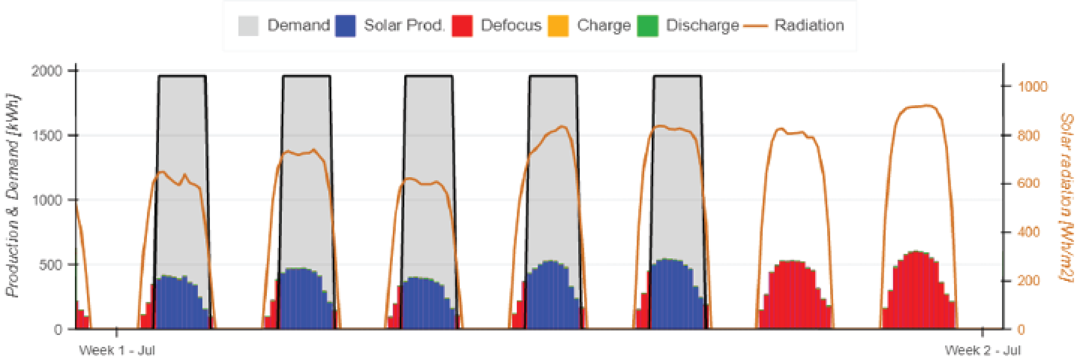
	a	b	c
1	1.256	1.281	1.794
2	1.083	1.108	1.440
3a	1.015	1.030	1.340
3b	1	1.018	1.324
3c	1.037	1.058	1.376

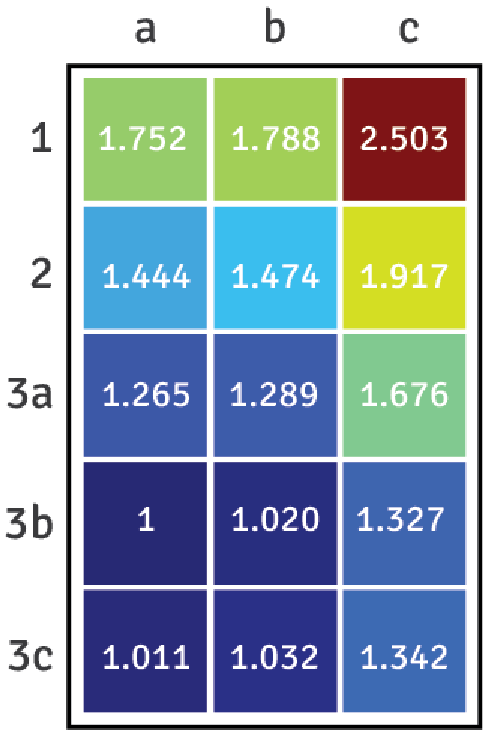
IMPACT OF DESIGN PARAMETERS

SCENARIO C

B - 1 - a

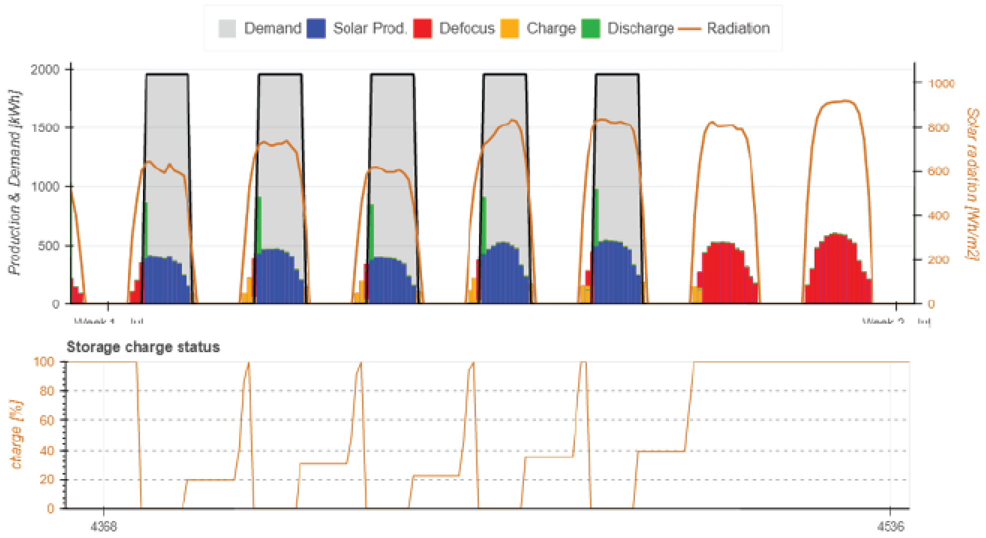
B - 2 - a

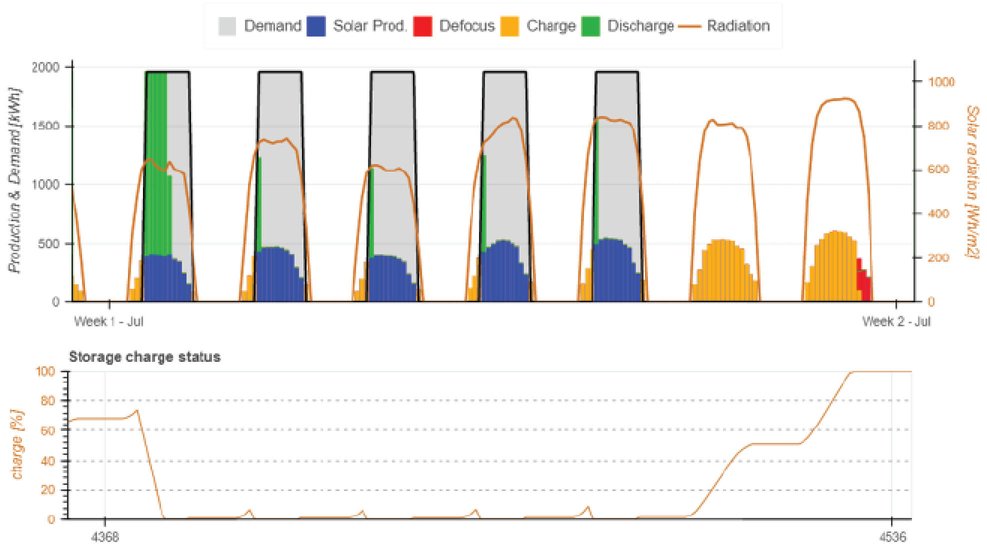


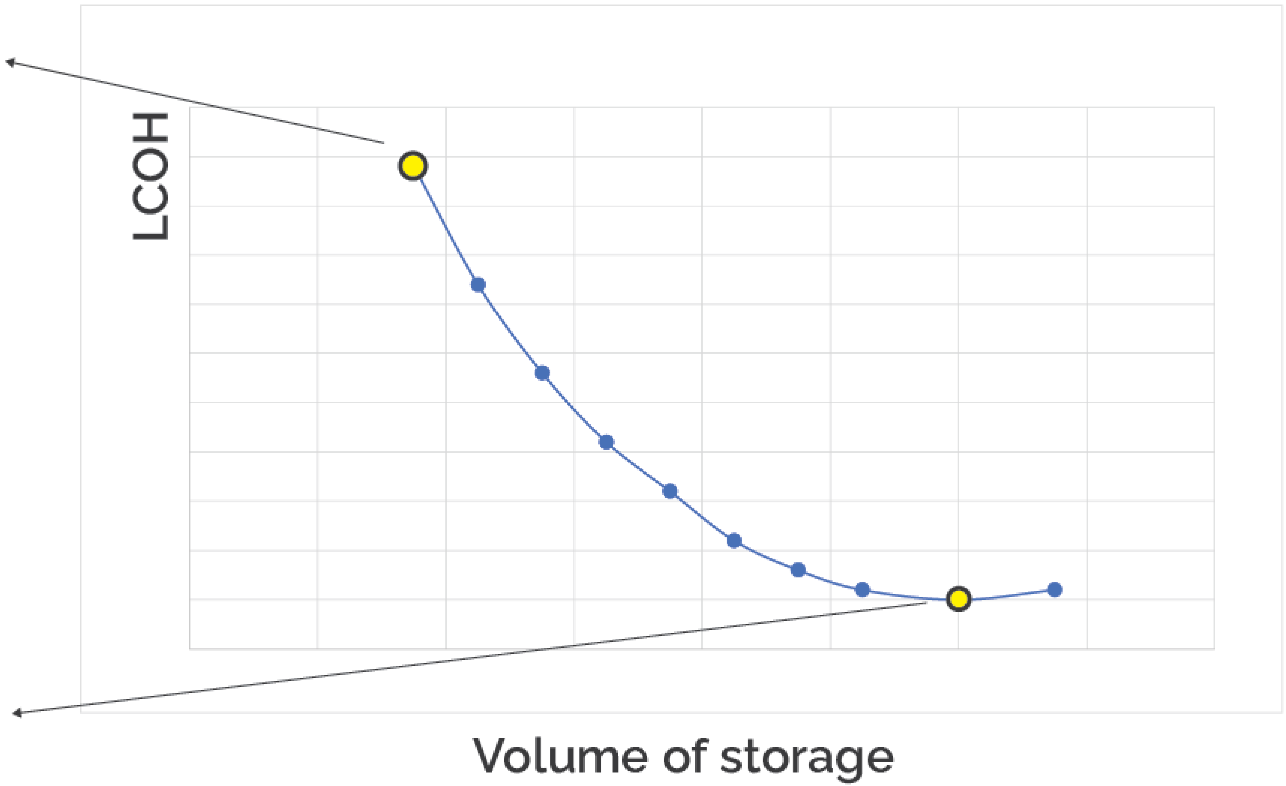


	a	b	c
1	1.752	1.788	2.503
2	1.444	1.474	1.917
3a	1.265	1.289	1.676
3b	1	1.020	1.327
3c	1.011	1.032	1.342

IMPACT OF DESIGN PARAMETERS



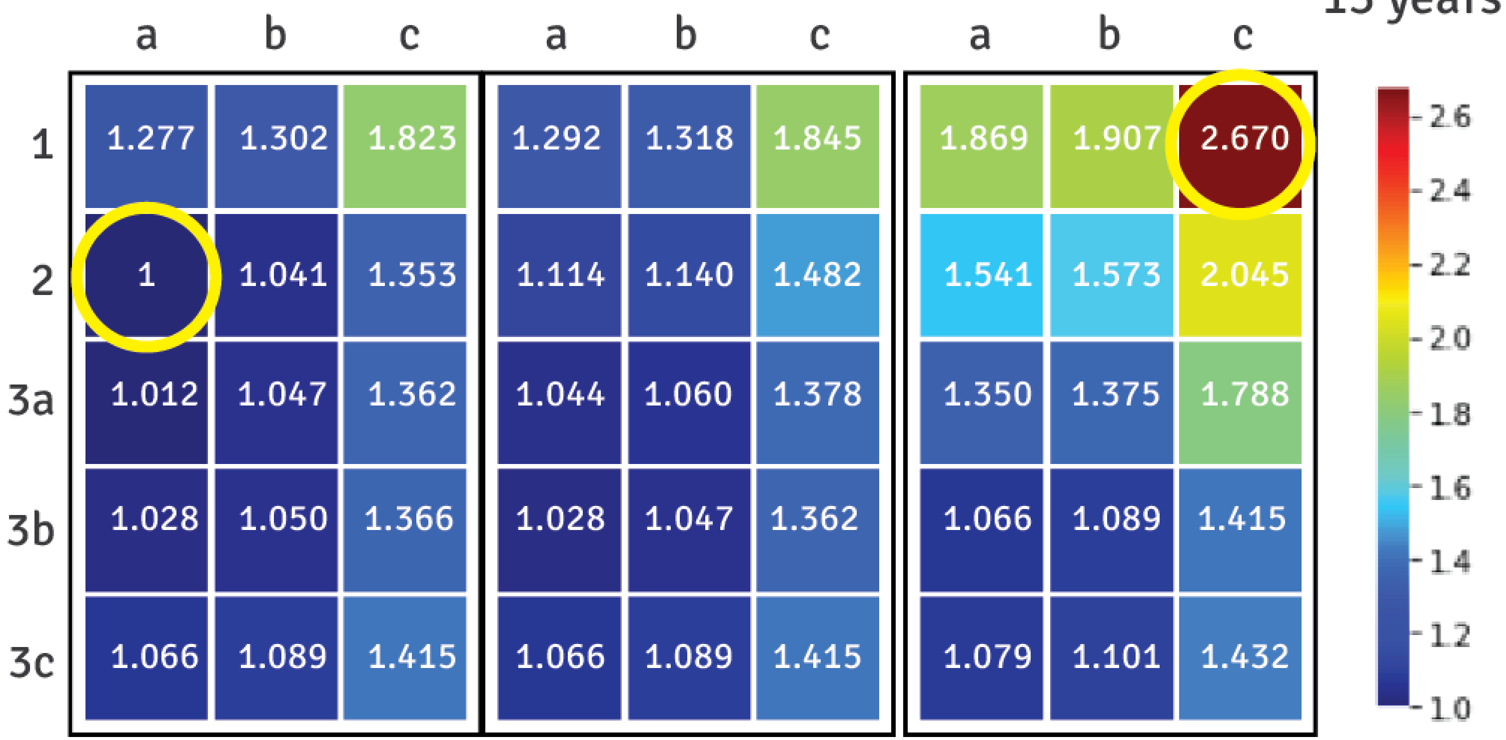




IMPACT OF DESIGN PARAMETERS

13 years payback

7 years payback



	SCENARIO A			SCENARIO B			SCENARIO C		
	a	b	c	a	b	c	a	b	c
1	1.277	1.302	1.823	1.292	1.318	1.845	1.869	1.907	2.670
2	1	1.041	1.353	1.114	1.140	1.482	1.541	1.573	2.045
3a	1.012	1.047	1.362	1.044	1.060	1.378	1.350	1.375	1.788
3b	1.028	1.050	1.366	1.028	1.047	1.362	1.066	1.089	1.415
3c	1.066	1.089	1.415	1.066	1.089	1.415	1.079	1.101	1.432

SCENARIO A

average = 1.215

SCENARIO B

average = 1.245

SCENARIO C

average = 1.553

CONCLUSIONS - 3 main takeaways

- Every project is different and needs a different design
- Integration is very important (modularization)
- Process level usually more competitive but not always possible

Solar Facilities for the European Research Area

SFERA-III
2nd Summer School
October, 5th- 6th, 2021
Almería (Spain)

End of Presentation

- Thank you for your attention
- Questions ?

Prepared by:

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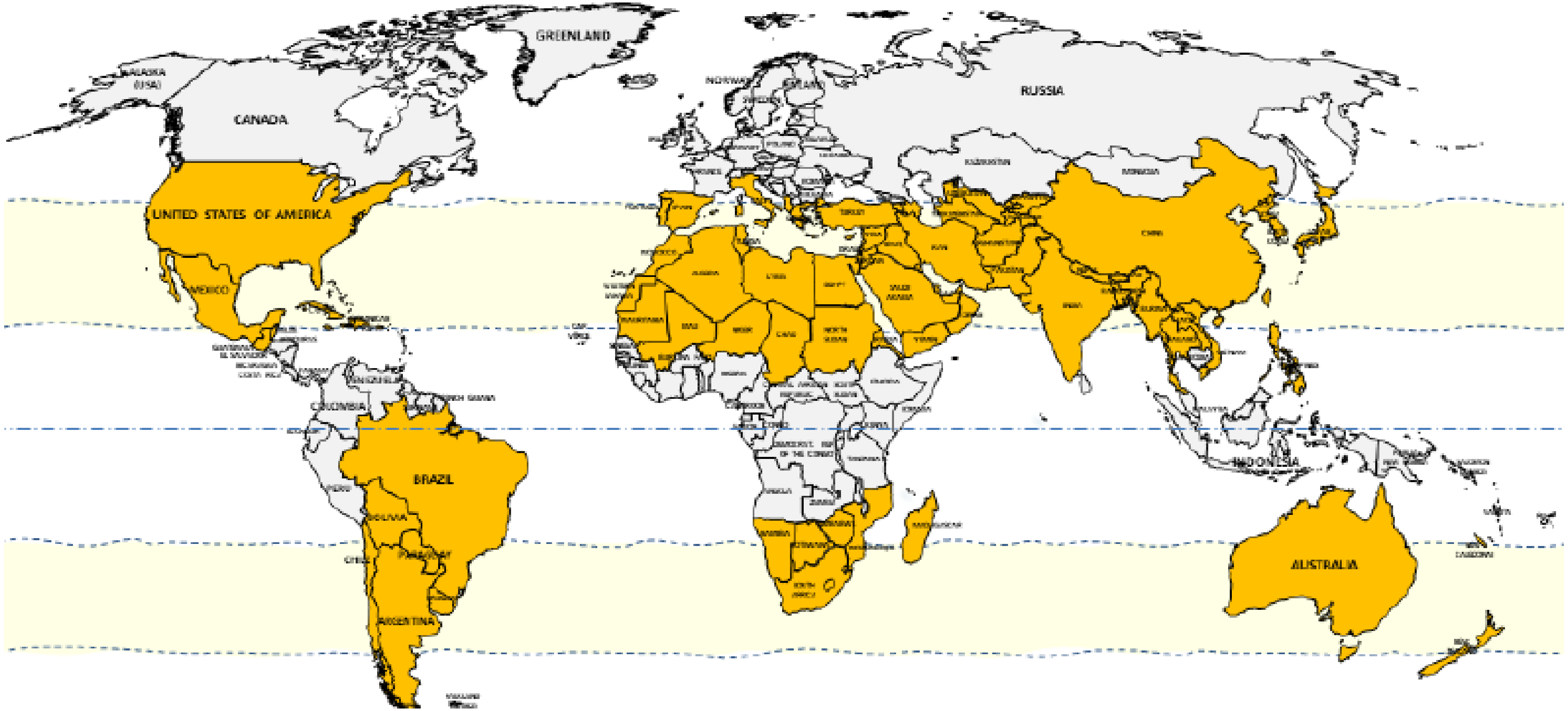
Solar Cooling for the Sunbelt Regions

Call for collaboration

Puneet Saini
Absolicon solar AB
Subtask B Task 65

Sunbelt regions



IEA SHC Task 65 : Scope

Scope

- Build on previous tasks 25, 38, 48 and 53
- T**arget size segment** on cooling and air conditioning between small scale (2 kW) to large scale (5 MW).
- Task duration: July 2020 – June 2024

SHC Task 25

Solar Assisted Air Conditioning of Buildings

1999-2004

SHC Task 38

Solar Air Conditioning and Refrigeration

2006-2010

Task 48

2011-2015

Task 53

2014-2018

IEA SHC Task 65 : Objectives

Objective

- Focus on innovations for **affordable, safe and reliable solar cooling systems for the sunbelt regions worldwide**

• The innovation driver and the **keyword is adaptation** of existing concepts/technologies to the sunbelt regions using solar energy either solar thermal (ST) or solar PV

- Working with new concepts and, and cooling integration schemes to get high share of cooling with minimal footprint

IEA

IEA SHC Task 65 : Subtask Structure

Subtask A: Adaptation
lead country: Italy
subtask leader: Dr. Salvatore Vasta, CNR-ITAE

Subtask B: Demonstration
lead country: USA
subtask leader: Wolfgang Weiss, ergSol Inc. (Limited Sponsor)

Subtask C: Assessment and Tools
lead country: Austria
subtask leader: Dr. Daniel Neyer, Neyer Brainworks

Subtask D: Dissemination
lead country: Germany
subtask leader: Prof. Dr. Paul Kohlenbach, Beuth University of Applied Sciences Berlin

Subtask B and your participation

Aim: Collection of design, and system integration guidelines for solar cooling projects

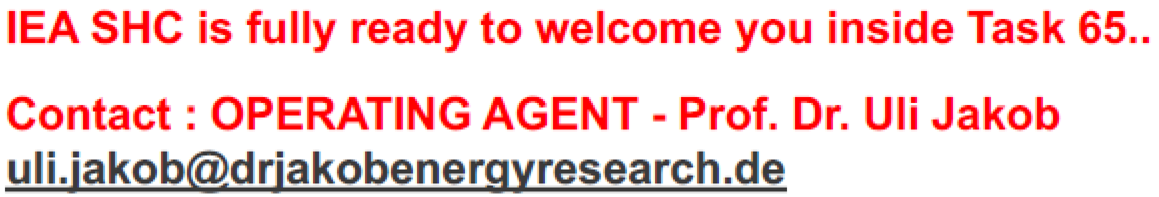
Key focus

- Hybrid cooling system (Solar thermal + HP + PV/PVT + boiler etc.)
- Systems with higher solar fractions
- Standard modular packages for solar cooling solutions.

If you have any solar cooling project data to share for activity B2, please contact

Puneet@absolicon.com

Task website https://task65.iea-shc.org/



IEA SHC is fully ready to welcome you inside Task 65..

Contact : OPERATING AGENT - Prof. Dr. Uli Jakob
uli.jakob@drjakobenergyresearch.de

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TASK65