SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

SHC TASK 66 Solar Energy Buildings

IEA SHC Task 66: Solar Energy Buildings

Integrated solar energy supply concepts for climate-neutral buildings and communities for the "City of the Future"

Design, construction and operation of a solar thermal family home

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22. December 1972 / married / 2 children

Exergenion // Engineering Consultant (Prien am Chiemsee)
2015 Self-employed consultant

Alstom Switzerland AG (Baden)

2013 – 2015	R&D Program Manager – Combined cycle gas turbine power plants
2007 – 2013	Team Leader – Heavy duty gas turbine development
2006 – 2007	R&D Project Manager – Heavy duty gas turbine development
2005 – 2006	Product Manager – Heavy duty gas turbines
2002 – 2005	Performance Test Engineer

Bertrandt AG (Munich)

2000 – 2002	BMW engine application and Performance Test Engineer

Technical University Munich TUM

1994 – 2000	Mechanical Engineering Dipl.-Ing.

Summary

- Energy storage is key for Solar Energy Buildings

- Storage also means being flexible to buy external energy when it is available and less costly

- For heating purposes, the energy should be stored as sensible heat, not electricity
  - When the sun is shining, heat is stored for later
  - But in future heat will also be stored when electricity tariffs are low

- Heat storage tanks are most profitable if sized for anything between 12 and 48 hours of wintertime storage without the need of external heat input

- Currently electric mobility with small commuter cars generates the highest savings to finance a Solar Energy Building (at least for Germany)

- Vertical thermal collectors are a perfect match with roof top PV
  - Ø Low stagnation temperatures in summer (<90°C), easy to integrate, high performance in winter, low-cost technology

Ingenieurbüro Exergenion Energietechnik Energieberatung

Overview

- 5 years in a highly self-sufficient solar home
- Design and construction
- Energy storage
- Construction
- Economics and conclusions

European building energy certificate

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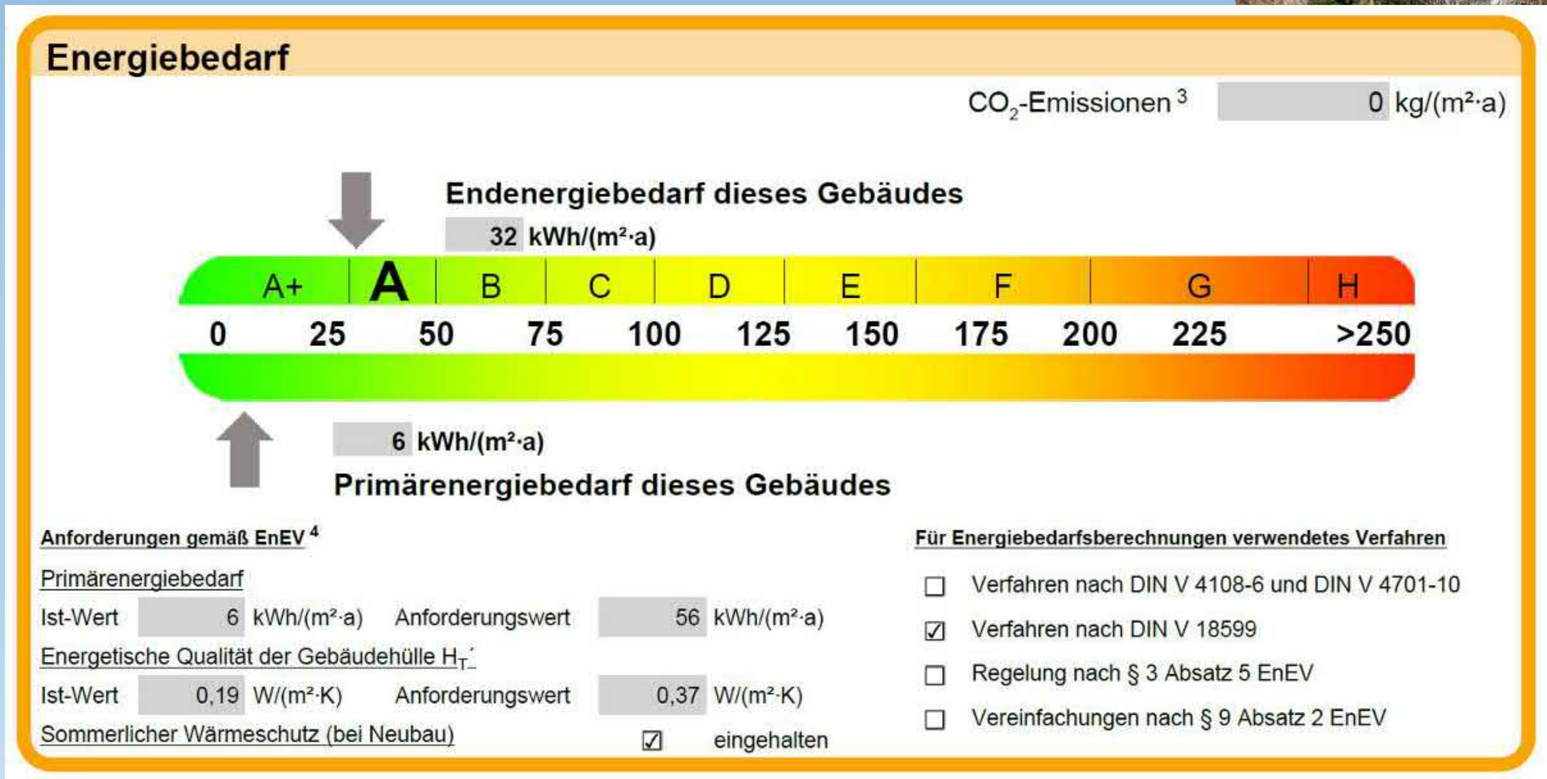
Not a passive house, but efficient

Building dimensions 11,3 m x 9 m
Basement, ground, 1st & 2nd floor


Energiebedarf

CO_2-Emissionen [3] 0 kg/(m²·a)

Endenergiebedarf dieses Gebäudes
32 kWh/(m²·a)

A+ | A | B | C | D | E | F | G | H

0 25 50 75 100 125 150 175 200 225 >250

6 kWh/(m²·a)
Primärenergiebedarf dieses Gebäudes

Anforderungen gemäß EnEV [4]

Primärenergiebedarf
Ist-Wert 6 kWh/(m²·a) Anforderungswert 56 kWh/(m²·a)

Energetische Qualität der Gebäudehülle H_T'
Ist-Wert 0,19 W/(m²·K) Anforderungswert 0,37 W/(m²·K)

Sommerlicher Wärmeschutz (bei Neubau) ☑ eingehalten

Für Energiebedarfsberechnungen verwendetes Verfahren

- ☐ Verfahren nach DIN V 4108-6 und DIN V 4701-10
- ☑ Verfahren nach DIN V 18599
- ☐ Regelung nach § 3 Absatz 5 EnEV
- ☐ Vereinfachungen nach § 9 Absatz 2 EnEV

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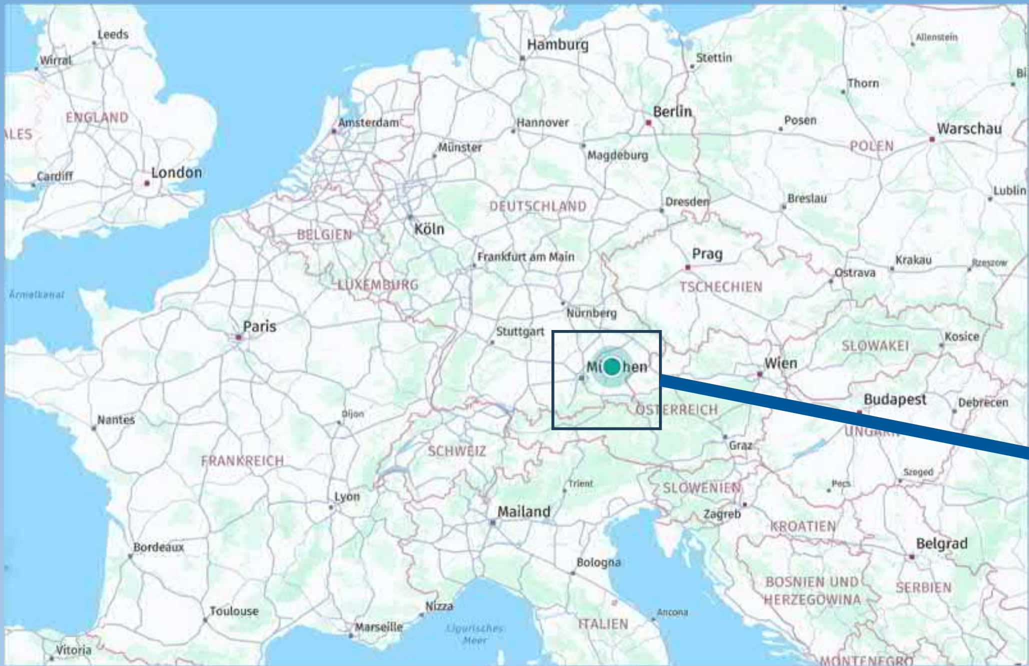
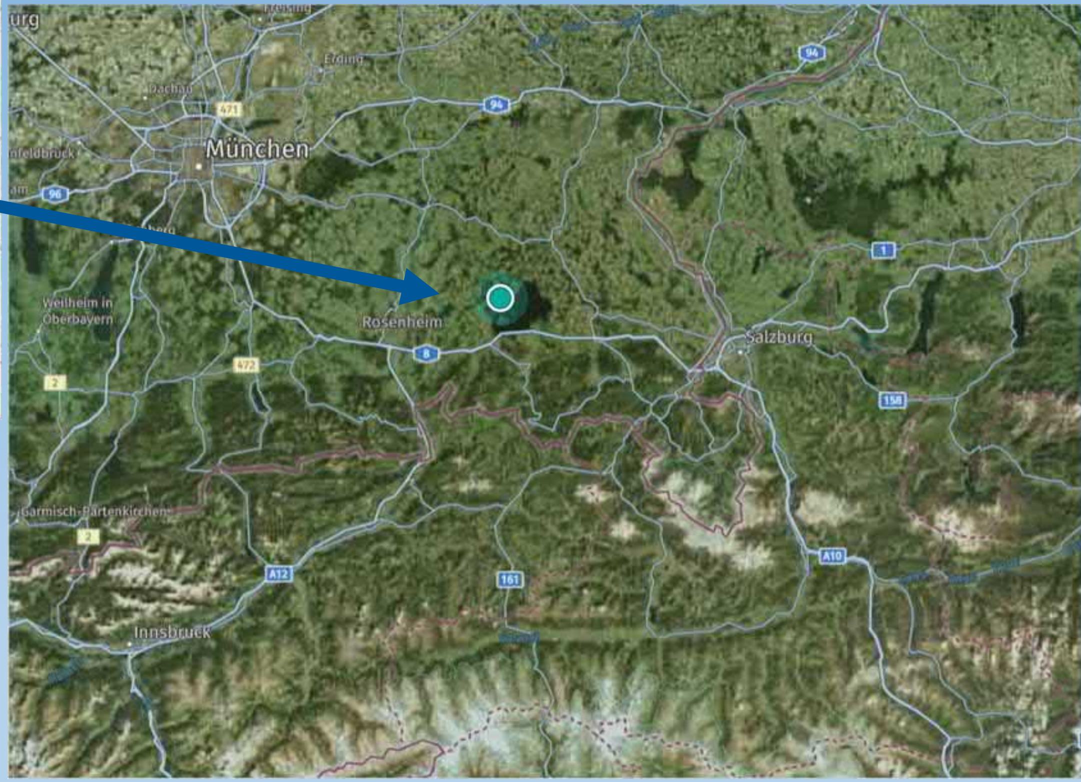
Location



5km north of the alps

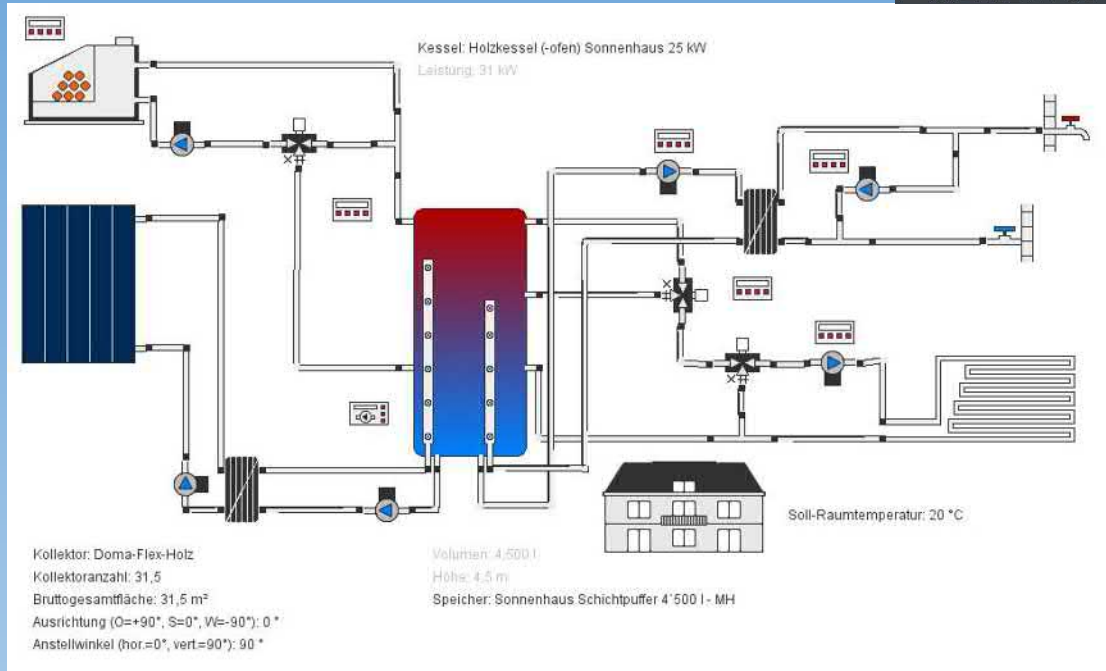


Common PV yield 1’200 kWh/kWp
Average ambient temperature 8,9°C

Building systems:

Heat

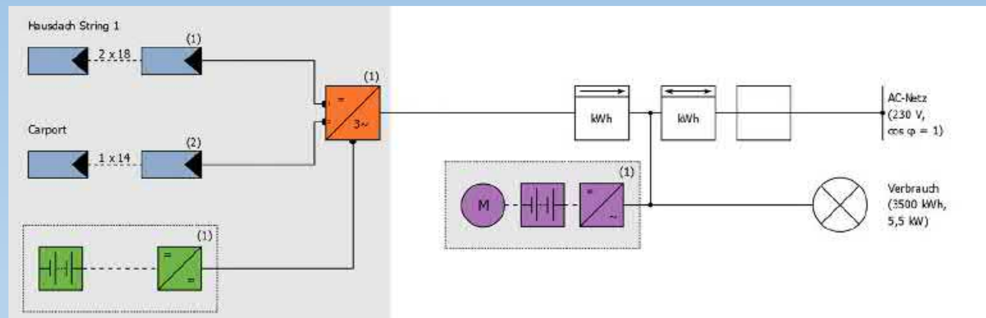
32 m^2 thermal collectors – south facade
24 kW log boiler located in living room
Stratified boiler tank 4’700 liters
Floor heating



Electricity

PV roof south 10 kWp
PV carport west 4 kWp

Battery storage 29 kWh
Electric vehicle 32 kWh (non bidirectional)



Other:

Rainwater storage
2 separate central ventilation systems

Energy demand 1

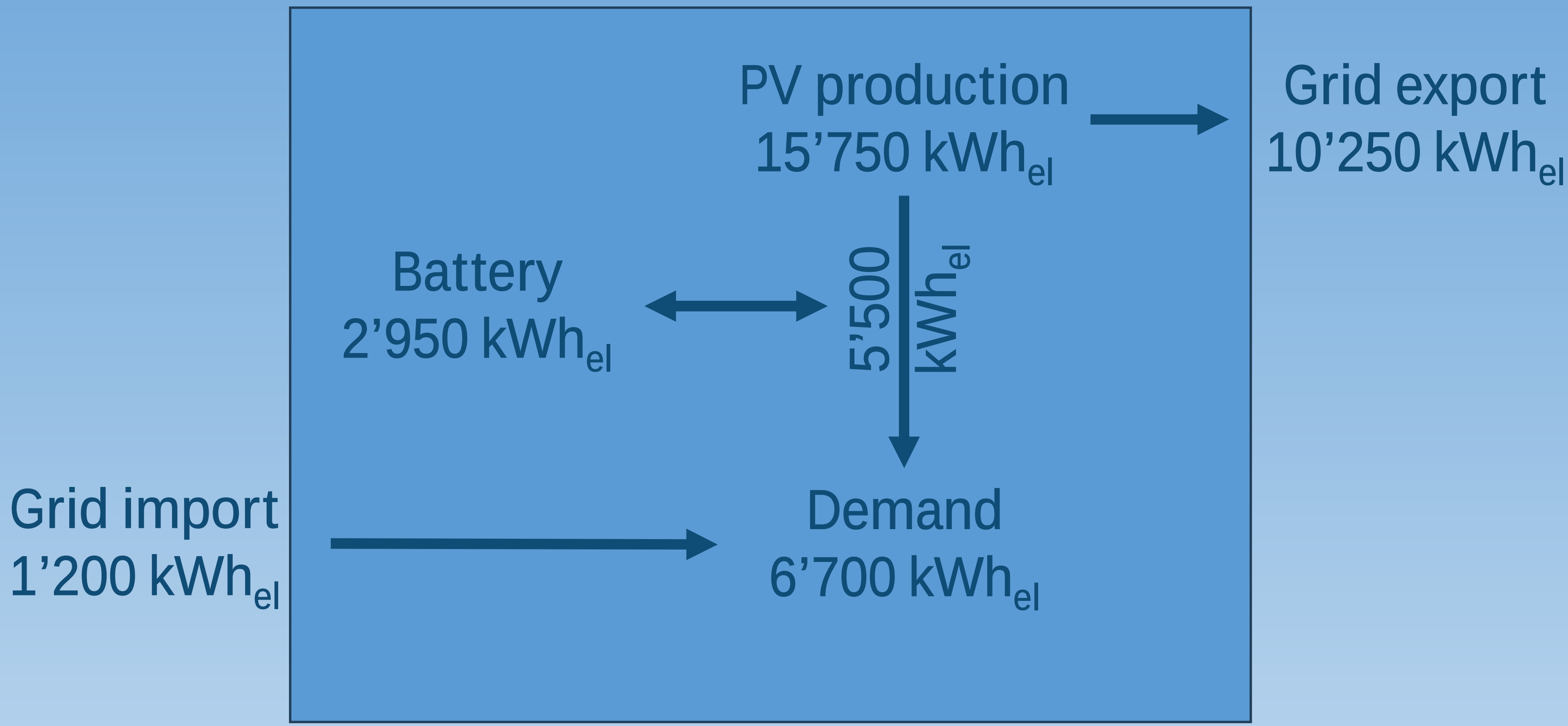
Electric energy

- Household (2 adults, 2 children):
  - 3’250 kWh_{el}

- Office - Exergenion (2nd floor)
  - 550 kWh_{el}
  - 5’000 km electric car – 16 kWh/100km – 800 kWh_{el}
- Commuting distance 2 x 35km – 5 days/w
  - 13’000 km electric car – 16 kWh/100km – 2’100 kWh_{el}

Σ 6’700 kWh_{el}

Annual Electric - Energy Balance



PV

- internal consumption 35%
- solar savings fraction 82%

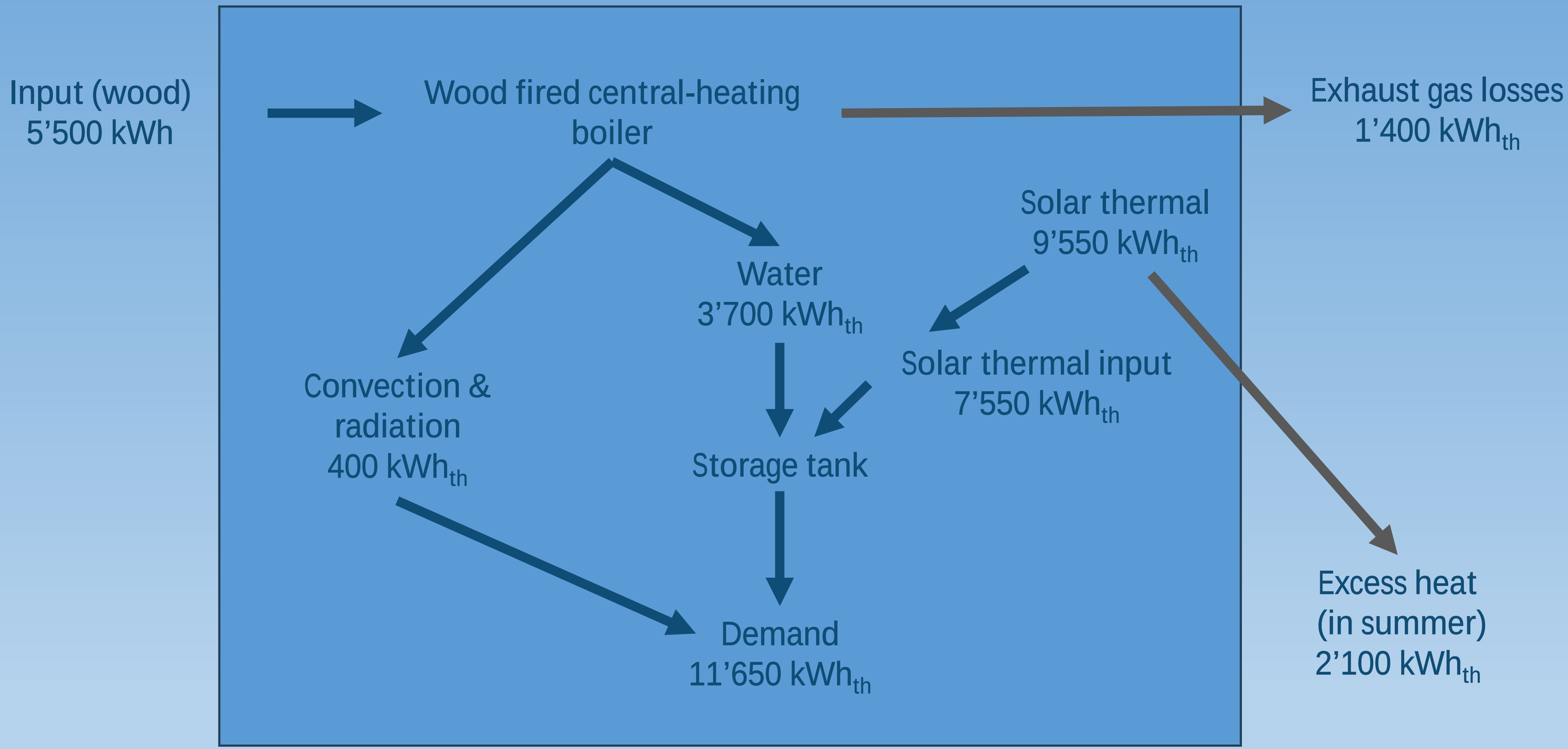
Energy demand 2

Heating and hot water

- Direct heating – floor heating
  - 7’400 kWh_{th}
- Indirect heating – usable heat losses from storage tank (in winter)
  - 1’900 kWh_{th}
- Indirect heating – convection and radiation from log boiler
  - 400 kWh_{th}
- Hot water
  - 1’950 kWh_{th}

Σ 11’650 kWh_{th}

Annual Heating - Energy Balance



Solar thermal

- solar savings fraction 65%

CO_2 Balance

Biomass 5’500 kWh (0,027 kg CO_2/kWh)
- 75 % wood logs as by-product from local forest management
- 25 % wood briquettes from a local sawmill

Biomass
150 kg (fossil) CO_2 emissions

Electricity (0,434 kg CO_2/kWh)
- 1’200 kWh grid import
- 10’250 kWh grid export

Electricity
Import 520 kg CO_2 emissions
Export -4’450 kg avoided CO_2

Total CO_2 emissions from building operation and electric mobility

minus 3,8 tons CO_2

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Design tools

Input creation for solar simulations

- Solar site assessment with shade measurement tools
- Proper evaluation of energy demand
    - Hot water demand
    - Electric consumers
    - E-Mobility and charging behavior (day/night)
- Building simulation

Solar simulations

- PV simulations (here pV*Sol)
- Energy system simulation (here Polysun)

A properly calibrated toolset and experience is needed for reliable results.

Simulations and reality

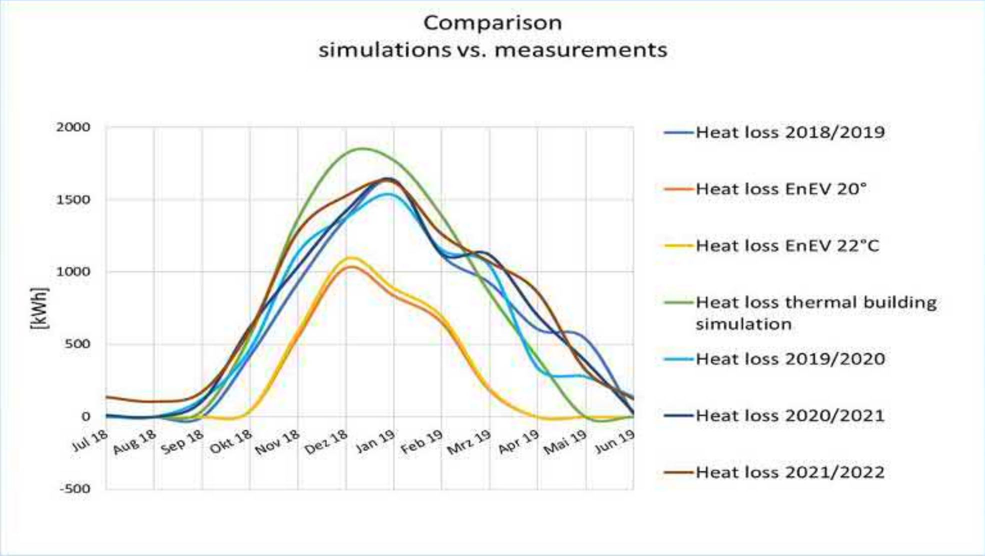
Heat – solar savings fraction

Building simulation

69%

Data recording

65%



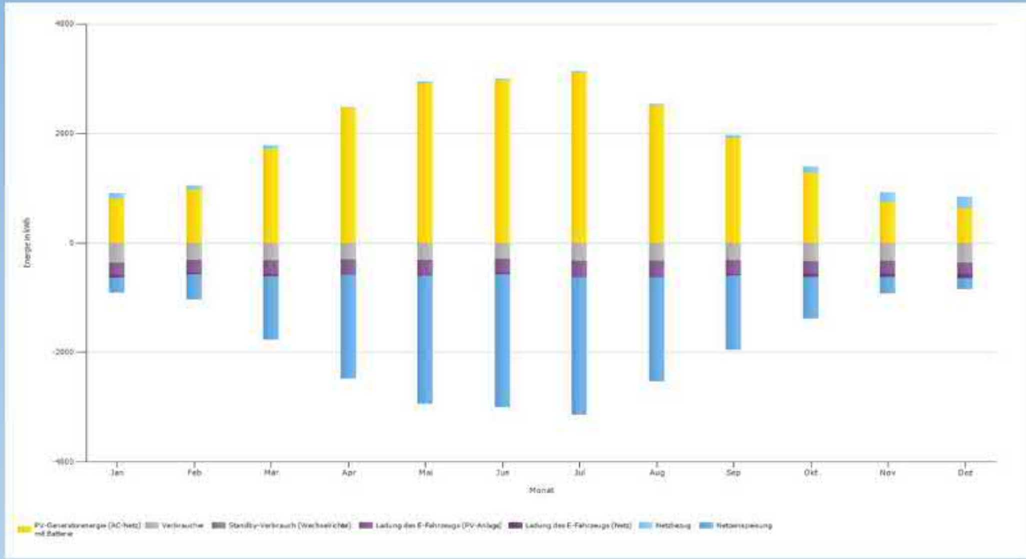
Electricity - solar savings fraction

PV simulation

87%

Data recording

82%



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Energy storage

Heat

Heat storage costs - 1 kWh_{th} approx. 25 – 50€

For the house presented a maximum capacity of 350 kWh_{th} of which 200 kWh_{th} are usually used

Electricity

Electricity storage costs - 1kWh_{el} approx. 300 - 500 €

In the house presented
29 kWh_{el} battery storage
32 kWh_{el} electric car

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Construction

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<u>Mix of different construction methods:</u>

- Basement – thermal insulated concrete
- Ground and 1st floor – solid construction filled with perlites
- South front - solid construction filled with perlites plus wood fiber ETICS
- 2nd floor and roof – timber frame construction

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Construction

Building integrated solar technology

- Rooftop PV with in-roof look
- Built-in thermal collectors

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Construction

<u>Building integrated solar technology</u>

- Stratified boiler tank from basement to top of ground floor to make use of convection heat losses

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Construction

<u>Stratified boiler tank</u>

- 20cm efficient insulation
- The top ends in the kitchen

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Highly modularized components

<u>Nonintegrated design:</u>

- Only components that fail must be individually replaced

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Construction

<u>Log boiler</u>

- Low emissions – 2 stage combustion
- 90% heat transfer to water cycle
- Low convection
- Low heat radiation

Integration of solar systems

Completion

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Additional investments (2018)

Building extra costs compared to German standard in 2018
- Insulation + 5’000 €
- Engineering + 15’000 €

Extra costs for components compared to a natural gas boiler
- Hardware + 60’000 €
- Engineering + 10’000 €

Subsidies - 40’000 €
Total extra cost + 50’000 €

- Annual savings heating - 950 €
- Annual savings mobility - 1’850 €
- Annual savings electricity (w/o car) - 1’300 €

Actual annual savings - 3’750 €

Break-even at actual energy prices **à** 13 ..14 years

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Conclusion

Advantages of a highly self-sufficient solar home concept

- Operation of the building is CO_2 negative
- Living and mobility are highly independent from energy prices
- Predictable investment and energy costs
- Local value creation:
  - § Building and energy components sourced entirely from Austria and Germany (with exception of Li-On batteries)

- Operation of the building in combination with e-mobility shows no resulting energy costs until 2039 (due to feed in tariffs)

Instant savings instead of risking high costs from burning fossil fuels

And the pleasure of living in a CO_2 negative building.

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Thank you for your attention

Ingenieurbüro Exergenion

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