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Comparison of Polysun and Simple-House in Carnot

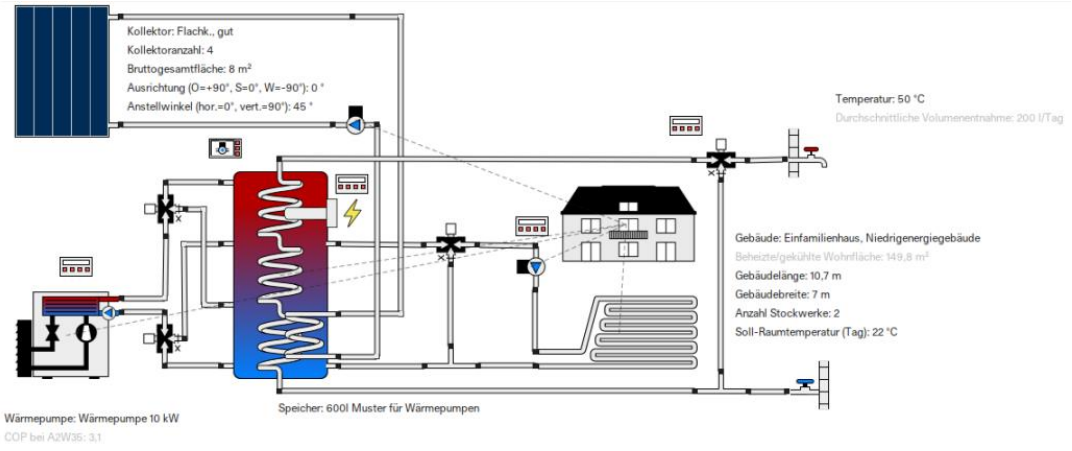
Patrick Kefer July 07 2022

Carnot User Meeting 2022

Motivation

- Polysun allows faster simulation runs
- Start with Polysun → Switch to Carnot for detailed simulation
- personal interest

System Overview



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System Simulation – HVAC control

- HVAC Control of Example Task 44
  - Overshoot of room temperature as expected

- Polysun seems to exactly meet heating demand !
  - No further details in documentation
  - Maybe pre-calculation ?
  - Shading, Ventilation control strategy not known in detail

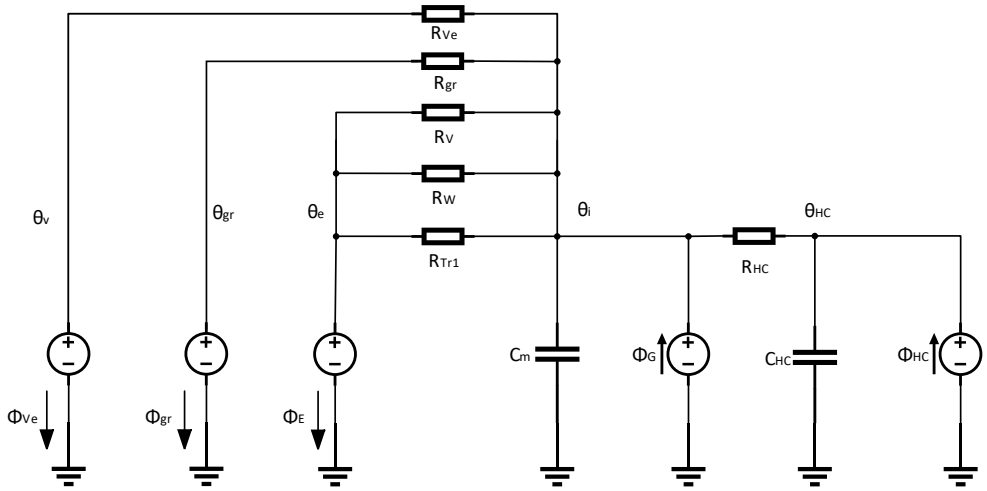
System Simulation

Parameters

- Model structure not the same
- some parameters have to be adapted (building, control)
- same Input data
  - DHW, internal gains, presence, electric load
- Storage model is different – not considered here

Building Models

Simple House



Subscripts

W	windows
E	external
G	solar
V	ventilation
Ve	controlled ventilation
Tr	transmission
HC	heating
gr	ground

Building Models

Simple House

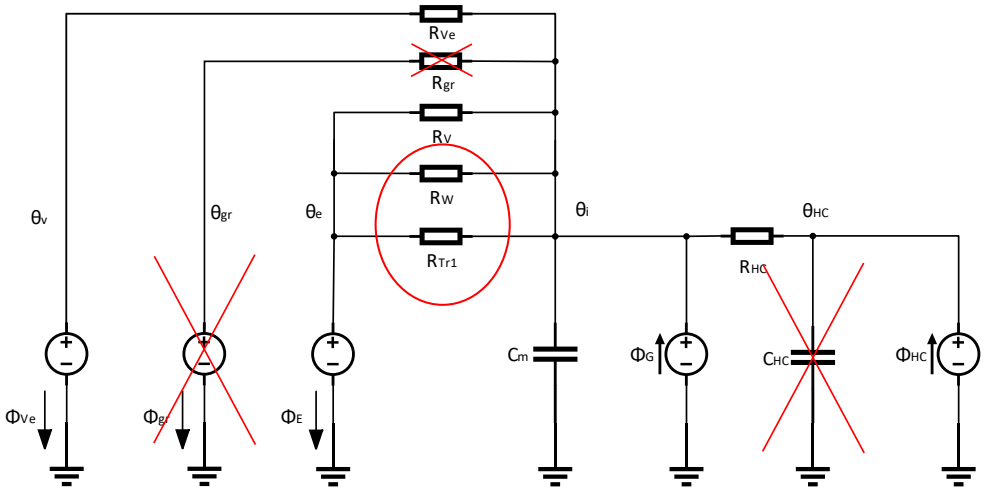
$$cap_{bldg}.\dot{T}_{bldg} = u_{A,walls}.\left(T_{amb} - T_{bldg}\right) + u_{A,ground}.\left(T_{ground} - T_{bldg}\right)$$
$$+u_{A,neigh}.\left(T_{neigh} - T_{bldg}\right) + G_{win}.A_{win}.I_{g,win} + \dot{Q}_v + \dot{Q}_{int} + \dot{Q}_{hc}$$

$$cap_{hc}.\dot{T}_{hc} = \dot{m}_{hc}.c_{fluid}\left(T_{flow} - T_{ret}\right) - \dot{Q}_{hc}$$

$$\dot{Q}_{hc} = \dot{Q}_{hc,nom}.\left(\frac{T_{diff}}{T_{diff,nom}}\right)^{n} \quad . \; . \; . \quad derived\ from\ EN442\ (simplified)$$

Building Models

Polysun



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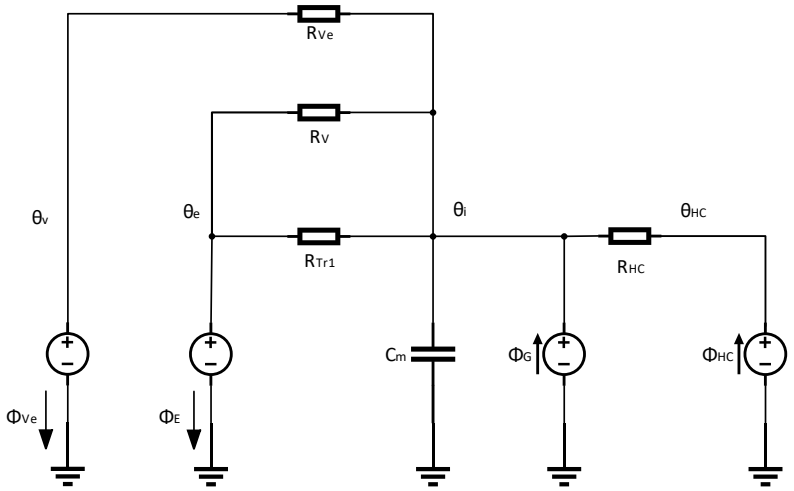
Building Models

Polysun



Subscripts

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Building Models

Polysun

$$HG - HL = M.C_p.\frac{\Delta T}{\Delta t}$$

HG ... *heat gains*

HL ... *heat losses*

M.Cp ... *building capcity*

$$HG = G.SHGC.WWR + HG_{people} \ldots + HG_{light} + HG_{equipment} + G_{sys}$$

G ... *irradiation on wall [W]*

WWR ... *window wall percentage*

SGHC ... *solar heat gain coefficient*

$$HL = HL_{Transmission} + HL_{Ventilation} + HL_{infiltration}$$

Building Models

Differences

- no IAM for Solar Gains in Carnot
  → removed for Validation

- (*presumably*) no thermal capacity for heating system

- no ground losses in Polysun
  → removed for Validation
  → carnot model addressed later on

Simulation Results

Polysun Dataset:

$$HWB = 30 \frac{kWh}{m^2 a}$$

$$U_{trans} = 0.35 \frac{W}{m^2 K} \rightarrow too\ small$$

$$C_m = 750 \frac{kJ}{m^2 K} \rightarrow spec.heat\ capacity$$

Polysun Result: $\approx 63 kWh/m^2 a$!

Carnot Results are way off when Polysun dataset is used !

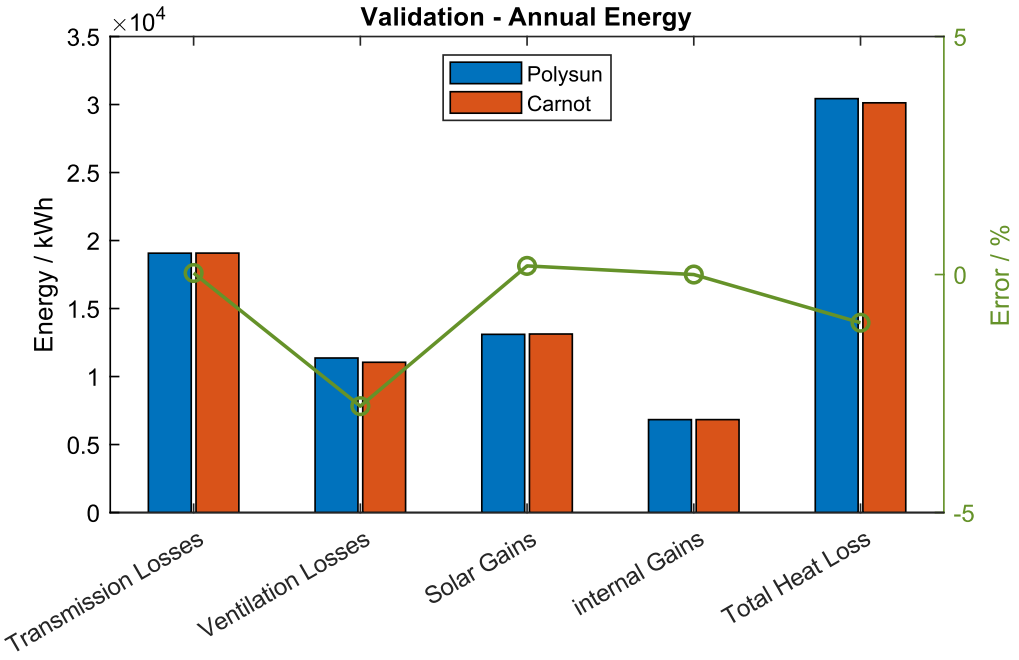
Simulation Results

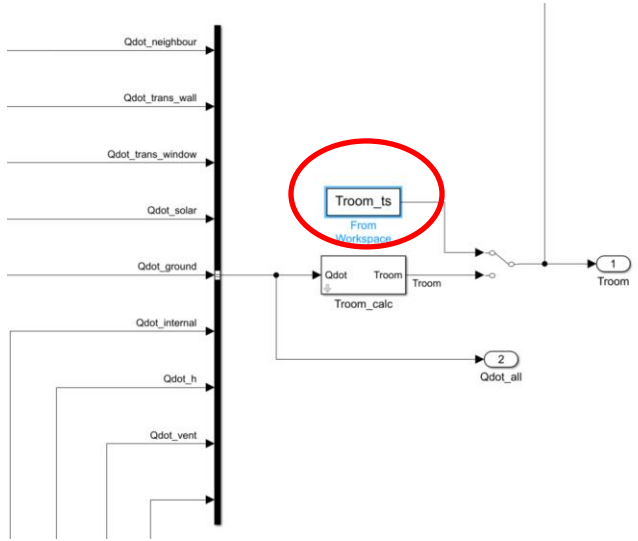
Adaptations

- U_{trans} and capacity C_M not in line with results
- U_{trans} related to A_{Hull} in Polysun
  - inner/outer, wall thickness etc. ?

- ✓ C_M increased to fit dynamic behavior in Carnot
- ✓ U_{trans} increased to fit dynamic behavior in Carnot

Validation Results – fixed Troom





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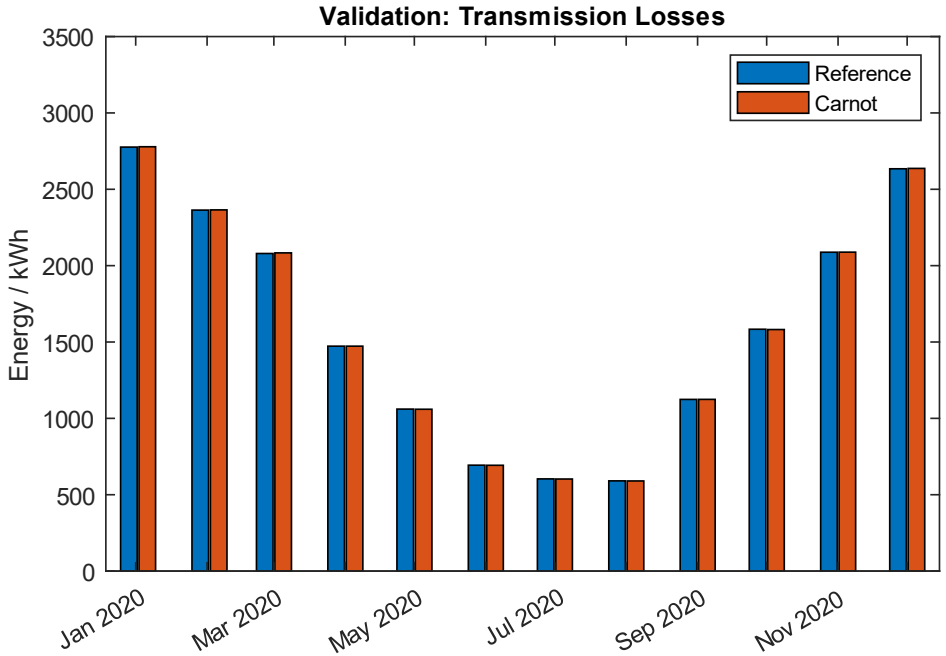
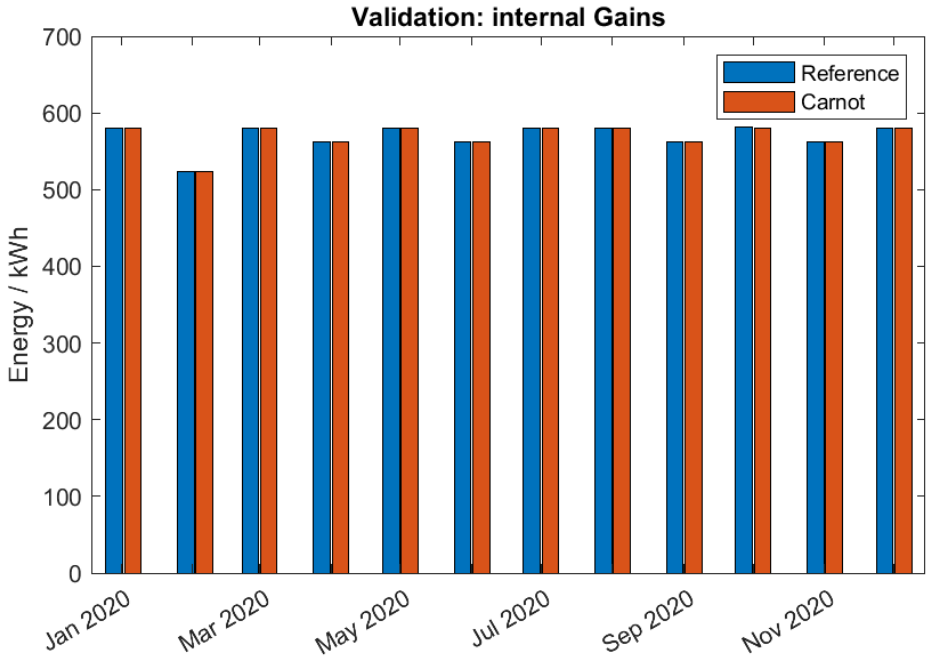
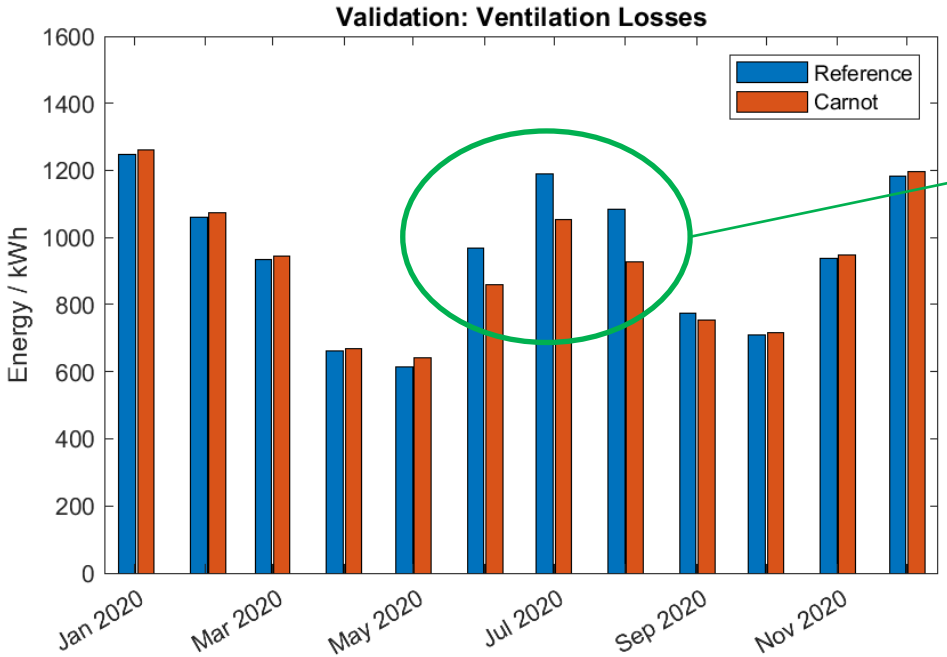
Validation Results – fixed Troom



Validation Results – fixed Troom

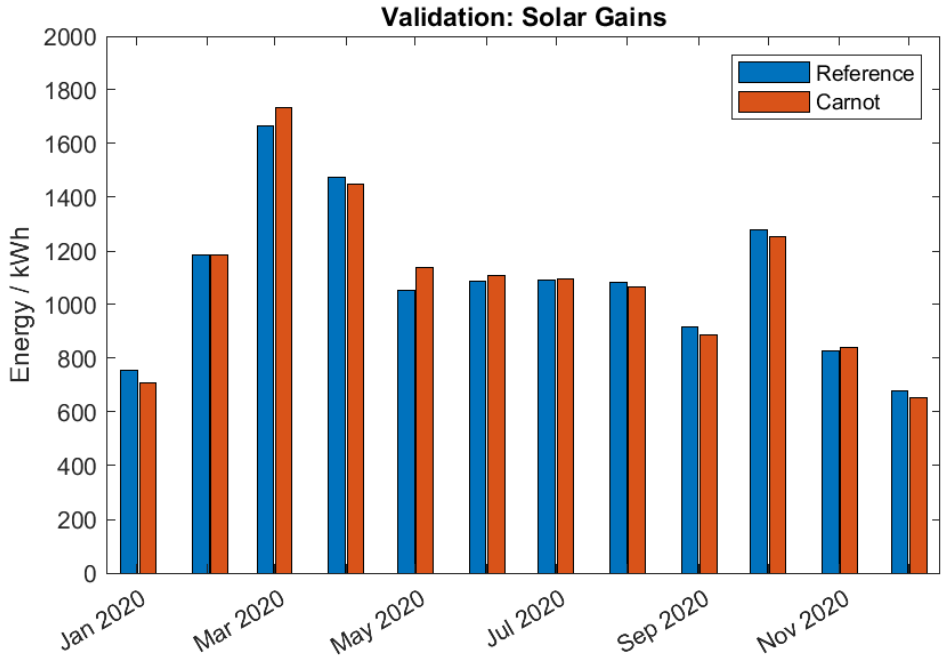


Validation Results – fixed Troom



- difference in $\rho . c_p$?
- Summer → HVAC control

Validation Results – fixed Troom



- Shading control
- radiation on inclined surface

Conclusions

- no ground loss, no IAM in Polysun
- ventilation/shading control (Summer) not 100% replicable
- Results are almost equal if
  - C_m and UA are adjusted
  - IAM for windows and groundlosses are changed

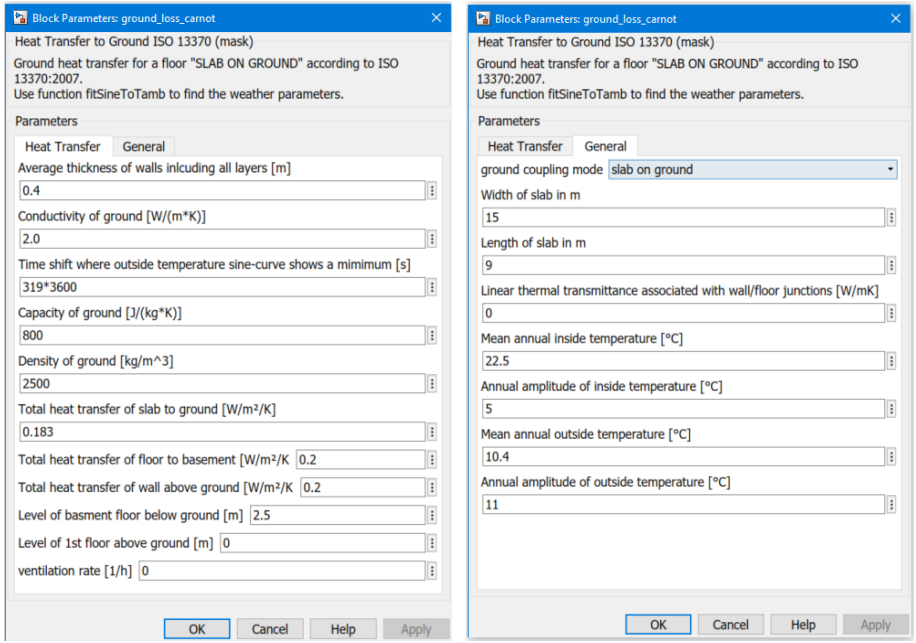
Conclusions

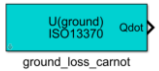
- C_m and UA
  - Adjustment *NOT* straight forward
  - A_{Hull} is not known from dataset
  - A_{Hull} calculation from dimensions yields different results for UA
  - Reference Area for C_m known
  - main problem for switching between simulation tools

Carnot Ground Loss Model - Update

- Currently ISO-13370 „Slab on Ground“
- Extended with „Heated Cellar“ and „Unheated Cellar“
- Switch to „Matlab Function“ for readbility
  - hardly any runtime penalties in accelerator mode

Carnot Ground Loss Model - Update





- choose model from Drop Down
- Ventilation rate
  - from building
  - seperate input

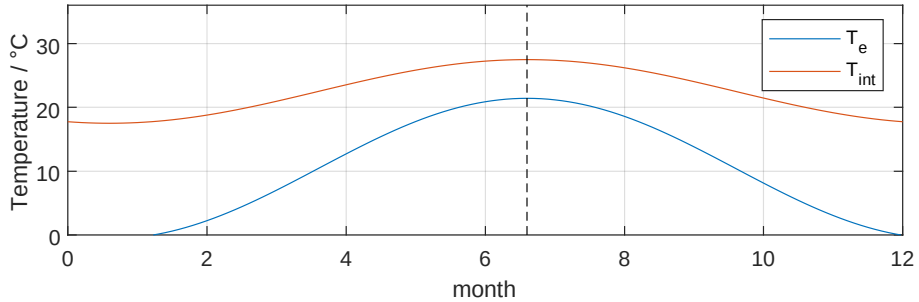
Validation with PHPP t.b.d.

Carnot Ground Loss Model - Update

internal / external temperature profiles

$$\Theta_{int,m} = \Theta_{int} - \widehat{\Theta}_{int}\, cos\left(2\pi\, \frac{m-\tau}{12}\right)$$

$$\Theta_{e,m} = \Theta_{e,m} - \widehat{\Theta}_{e}\, cos\left(2\pi\, \frac{m-\tau}{12}\right)$$



Carnot Ground Loss Model - Update

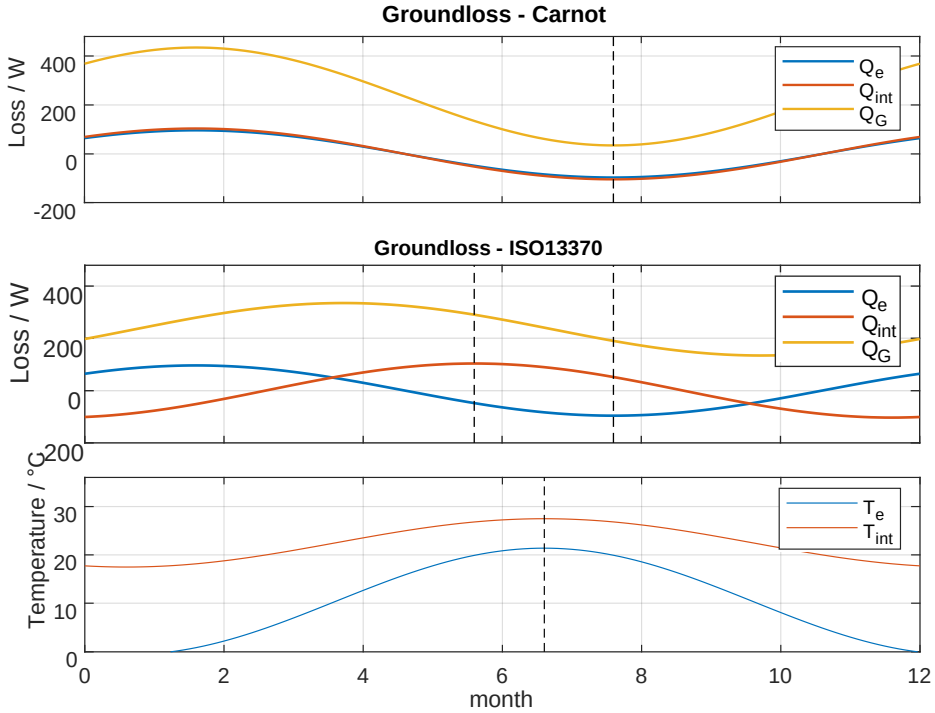
ISO 13370:

$$\Phi_m = \mathrm{H}_g(\overline{\Theta}_{int} - \overline{\Theta}_{\mathrm{e}}) - H_{pi}\widehat{\Theta}_{int}cos\left(2\pi\frac{m-\tau+\alpha}{12}\right) + H_{pe}\widehat{\Theta}_{e}cos\left(2\pi\frac{m-\tau-\beta}{12}\right)$$

Carnot Model:

$$\Phi_m = \mathrm{H}_g(\overline{\Theta}_{int} - \overline{\Theta}_{\mathrm{e}}) + H_{pi}\widehat{\Theta}_{int}cos\left(2\pi\frac{m-\tau-\alpha}{12}\right) + H_{pe}\widehat{\Theta}_{e}cos\left(2\pi\frac{m-\tau-\beta}{12}\right)$$

Carnot Ground Loss Model - Update



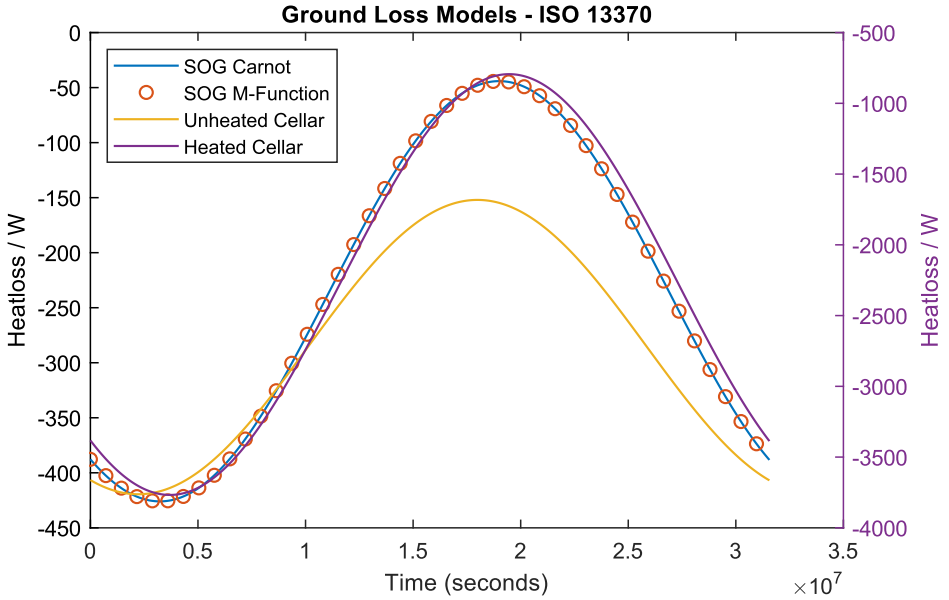
$\alpha = 1$

$\beta = 1$

$\tau = 0.6$

Ground Loss in phase with internal temperature correct ?

Carnot Ground Loss Model - Update



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Thank you for your attention