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# Comparison of Polysun and Simple-House in Carnot

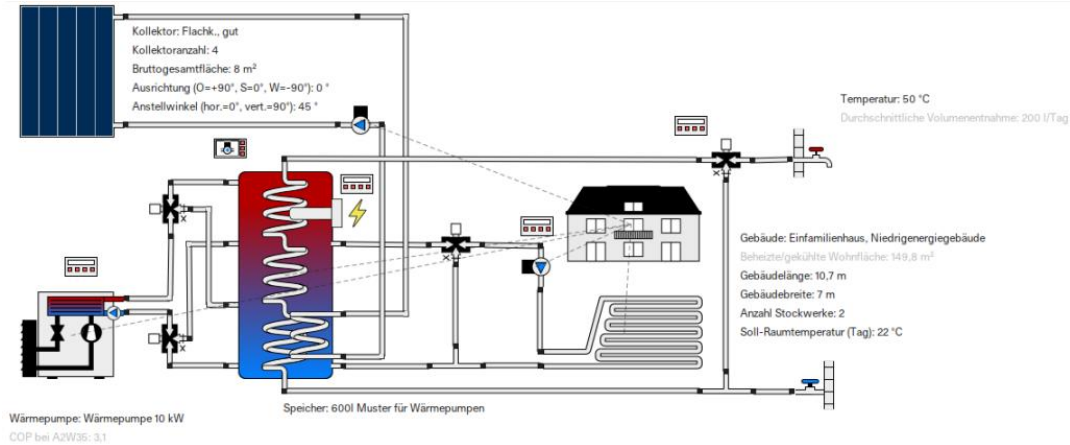
**Patrick Kefer July 07 2022**  
**Carnot User Meeting 2022**

HAGENBERG | LINZ | STEYR | WELS

# Motivation

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

# System Overview



# 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

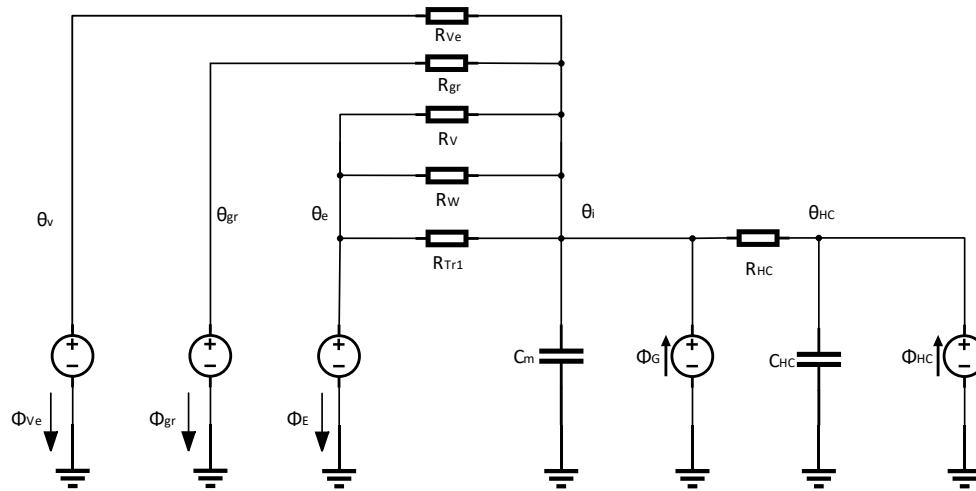
- Model structure not the same
- some parameters have to be adapted (building, control)
- same Input data
  - DHW, internal gains, presence, electric load
- Storage model is different – not considered here

# Building Models

## Simple House

### Subscripts

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



$$\begin{aligned} cap_{bldg} \cdot \dot{T}_{bldg} = & u_{A,walls} \cdot (T_{amb} - T_{bldg}) + u_{A,ground} \cdot (T_{ground} - T_{bldg}) \\ & + u_{A,neigh} \cdot (T_{neigh} - T_{bldg}) + G_{win} \cdot A_{win} \cdot I_{g,win} + \dot{Q}_v + \dot{Q}_{int} + \dot{Q}_{hc} \end{aligned}$$

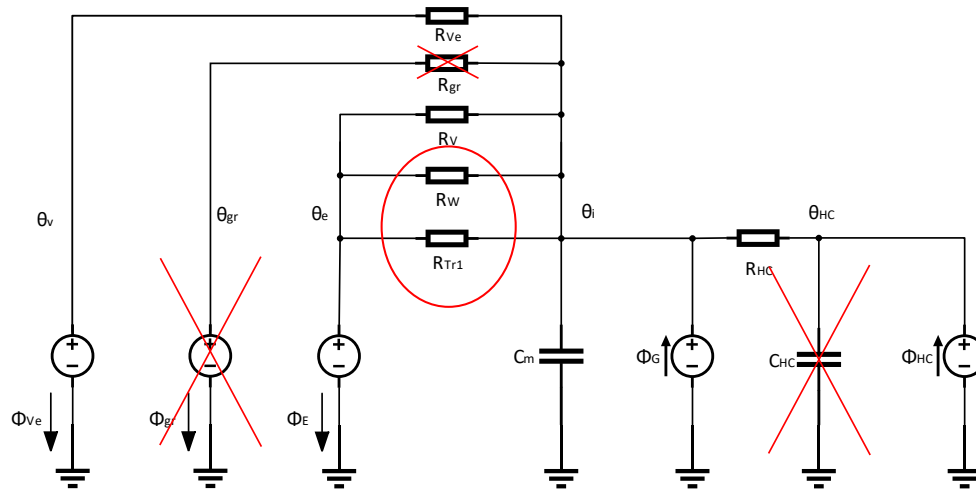
$$cap_{hc} \cdot \dot{T}_{hc} = \dot{m}_{hc} \cdot c_{fluid} (T_{flow} - T_{ret}) - \dot{Q}_{hc}$$

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

# Building Models

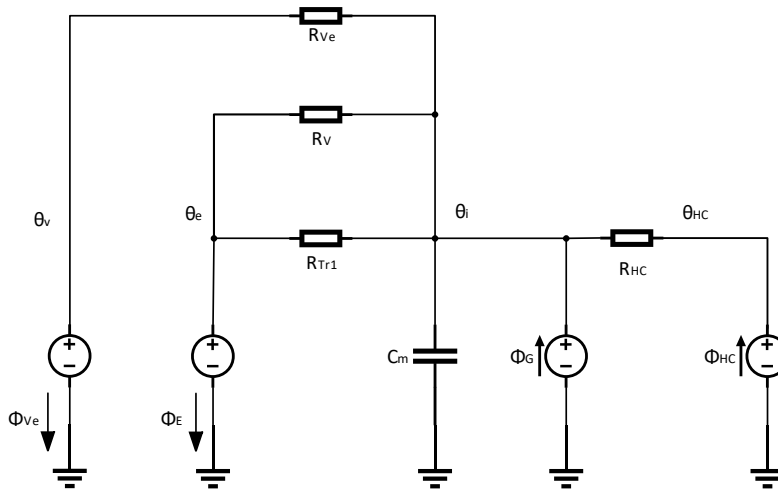
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# Building Models



## Subscripts

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# Building Models

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

$HG$  ... *heat gains*

$HL$  ... *heat losses*

$M \cdot C_p$  ... *building capacity*

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

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

$WWR$  ... *window wall percentage*

$SHGC$  ... *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:

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

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

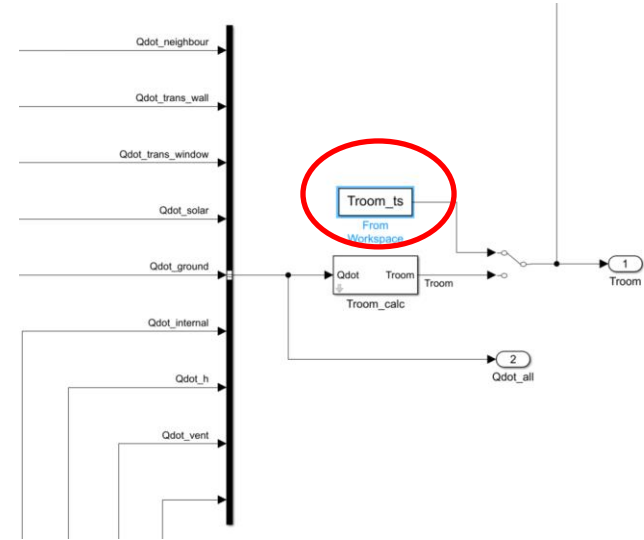
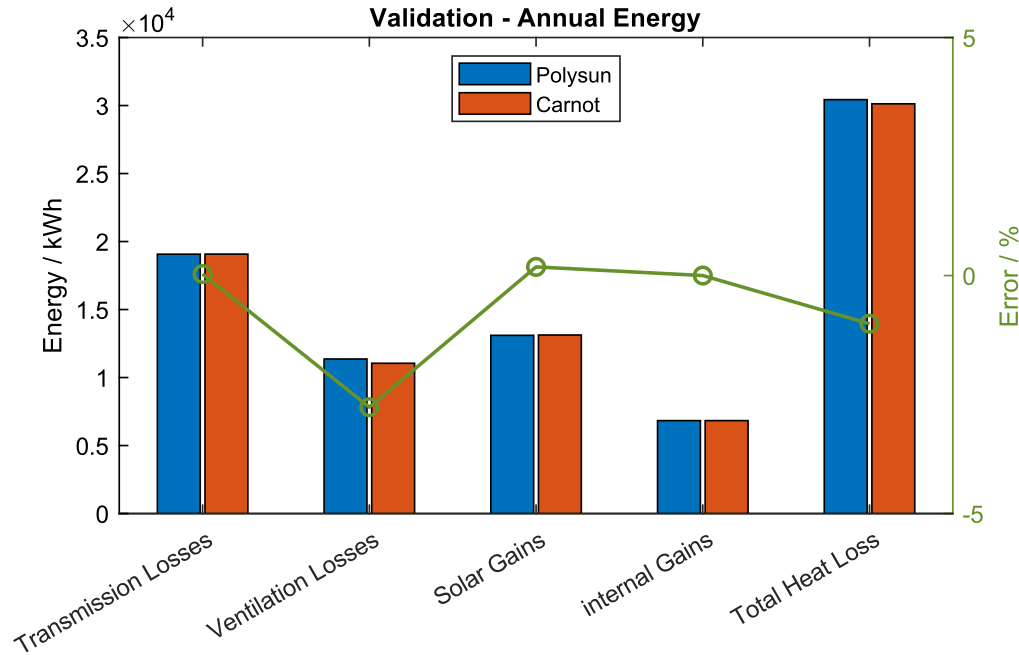
$$C_m = 750 \frac{kJ}{m^2 K} \rightarrow \text{spec. heat capacity}$$

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

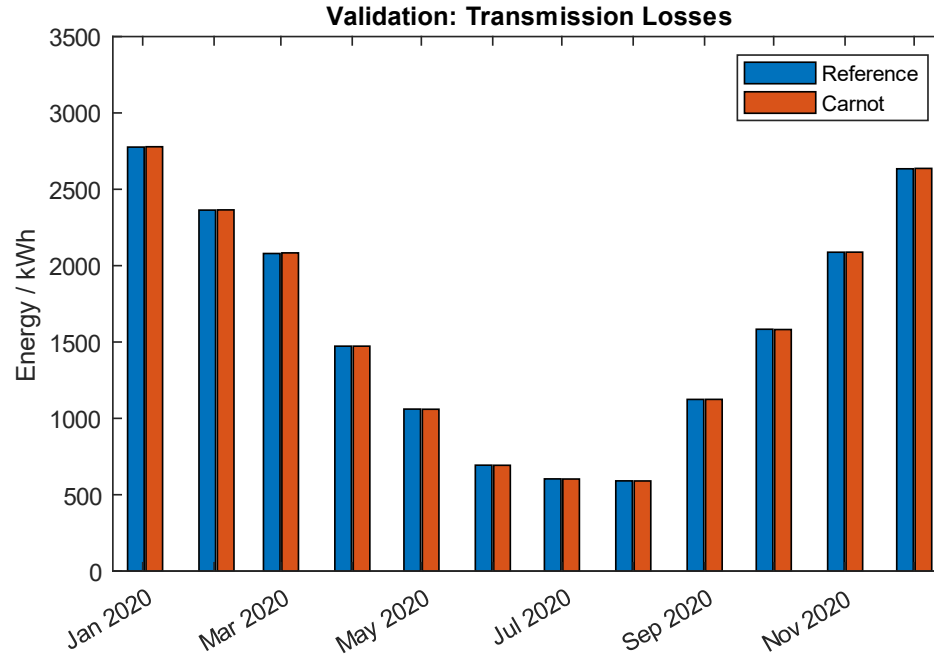
Carnot Results are way off when Polysun dataset is used !

- $U_{trans}$  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

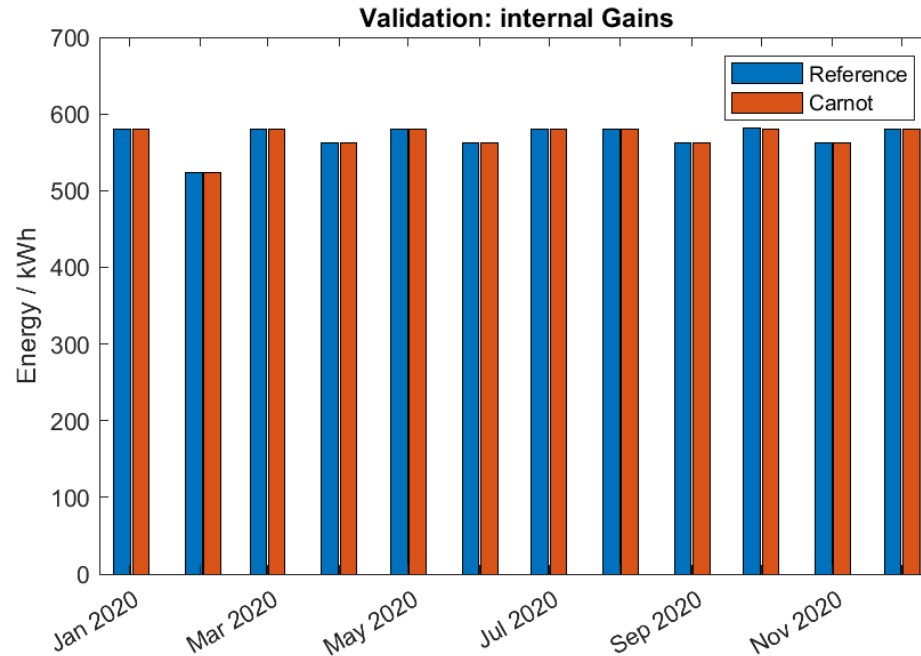
# Validation Results – fixed Troom



# Validation Results – fixed Troom

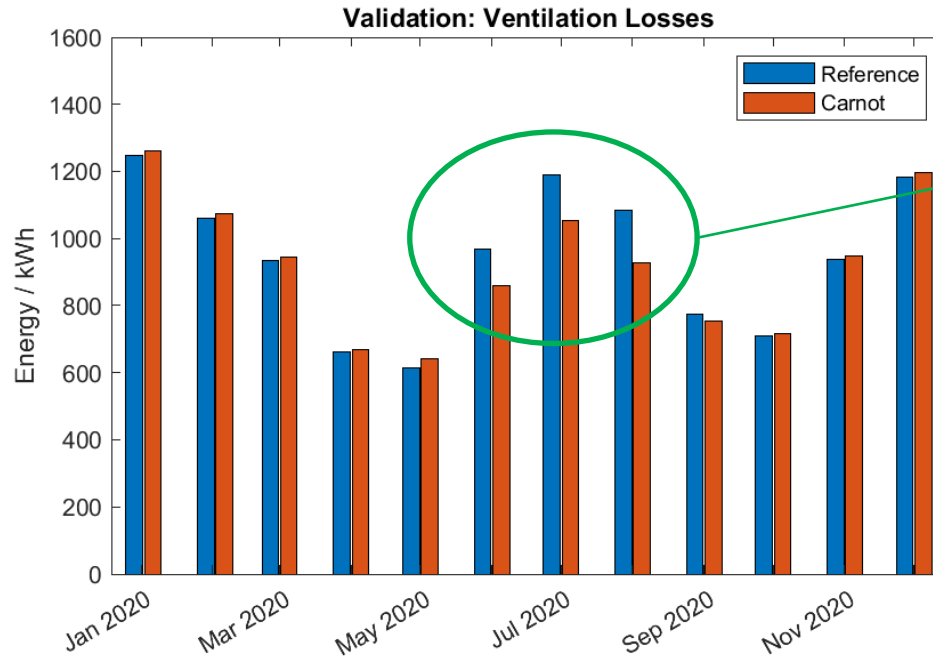


# Validation Results – fixed Troom





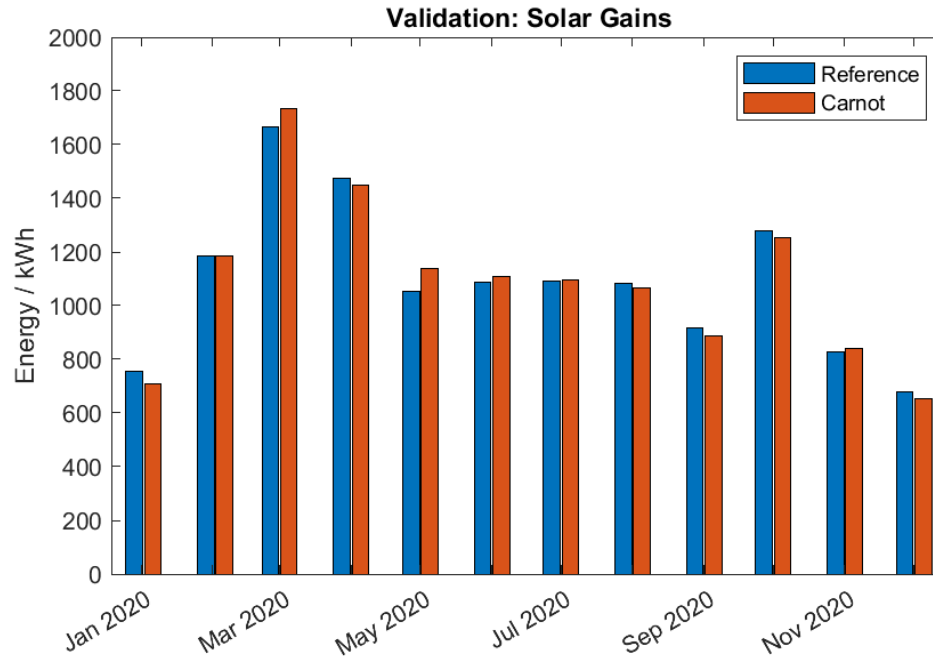
# Validation Results – fixed Troom



➤ difference in  $\rho \cdot c_p$ ?

➤ 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 readability
  - hardly any runtime penalties in accelerator mode

# Carnot Ground Loss Model - Update

Block Parameters: ground\_loss\_carnot

Heat Transfer to Ground ISO 13370 (mask)  
Ground heat transfer for a floor "SLAB ON GROUND" according to ISO 13370:2007.  
Use function fitSineToTamb to find the weather parameters.

Parameters

Heat Transfer General

Average thickness of walls including all layers [m]  
0.4

Conductivity of ground [W/(m\*K)]  
2.0

Time shift where outside temperature sine-curve shows a minimum [s]  
319\*3600

Capacity of ground [J/(kg\*K)]  
800

Density of ground [kg/m^3]  
2500

Total heat transfer of slab to ground [W/m^2/K]  
0.183

Total heat transfer of floor to basement [W/m^2/K] 0.2

Total heat transfer of wall above ground [W/m^2/K] 0.2

Level of basement floor below ground [m] 2.5

Level of 1st floor above ground [m] 0

ventilation rate [1/h] 0

OK Cancel Help Apply

Block Parameters: ground\_loss\_carnot

Heat Transfer to Ground ISO 13370 (mask)  
Ground heat transfer for a floor "SLAB ON GROUND" according to ISO 13370:2007.  
Use function fitSineToTamb to find the weather parameters.

Parameters

Heat Transfer General

ground coupling mode slab on ground

Width of slab in m  
15

Length of slab in m  
9

Linear thermal transmittance associated with wall/floor junctions [W/mK]  
0

Mean annual inside temperature [°C]  
22.5

Annual amplitude of inside temperature [°C]  
5

Mean annual outside temperature [°C]  
10.4

Annual amplitude of outside temperature [°C]  
11

OK Cancel Help Apply



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

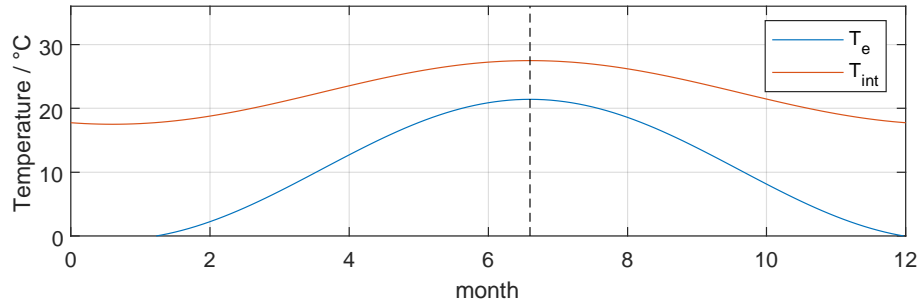
**Validation with PHPP t.b.d.**

# 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:**

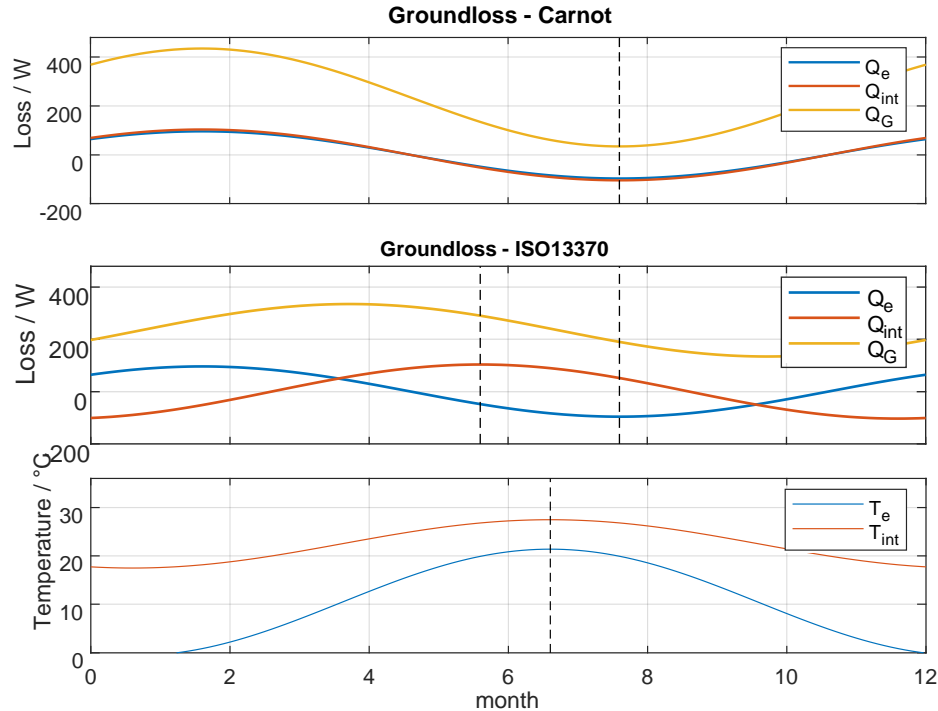
$$\Phi_m = H_g(\bar{\Theta}_{int} - \bar{\Theta}_e) - H_{pi}\hat{\Theta}_{int}\cos\left(2\pi\frac{m - \tau + \alpha}{12}\right) + H_{pe}\hat{\Theta}_e\cos\left(2\pi\frac{m - \tau - \beta}{12}\right)$$

**Carnot Model:**

$$\Phi_m = H_g(\bar{\Theta}_{int} - \bar{\Theta}_e) + H_{pi}\hat{\Theta}_{int}\cos\left(2\pi\frac{m - \tau - \alpha}{12}\right) + H_{pe}\hat{\Theta}_e\cos\left(2\pi\frac{m - \tau - \beta}{12}\right)$$



# Carnot Ground Loss Model - Update



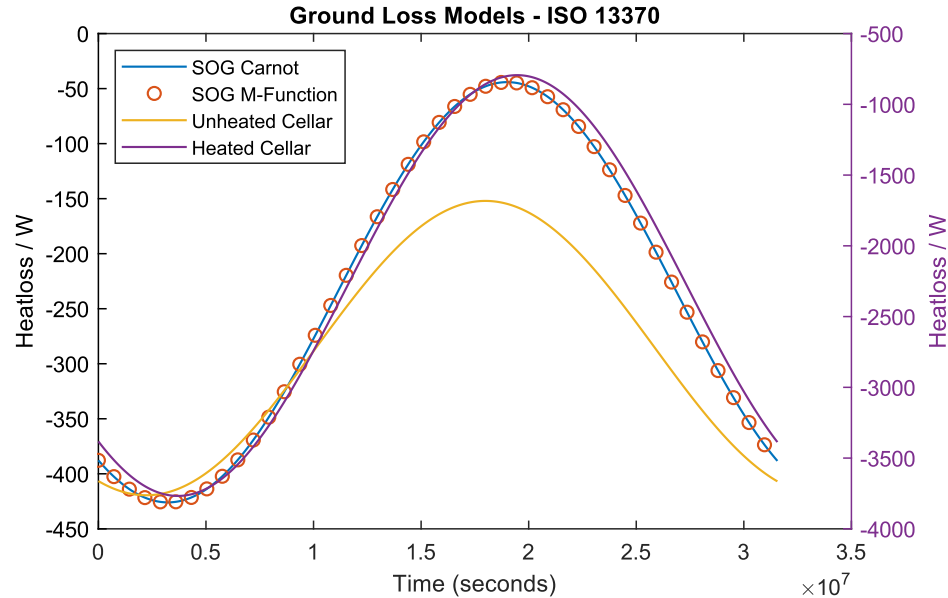
$$\alpha = 1$$

$$\beta = 1$$

$$\tau = 0.6$$

Ground Loss in phase with  
internal temperature correct ?

# Carnot Ground Loss Model - Update





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# Thank you for your attention