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Numerical Analysis of the Adaptive Solar Façade

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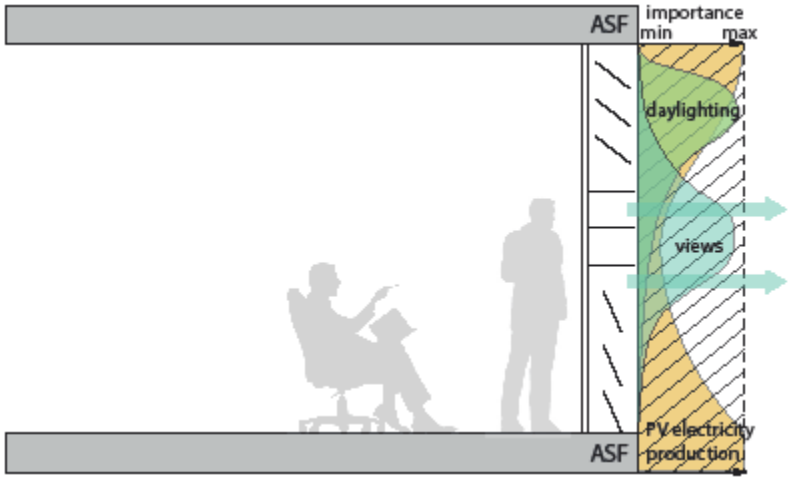
The Adaptive Solar Façade (ASF)

- Individually Actuated Panels

- Combines Dynamic Shading with PV-Electricity Production



- Needs to be Optimized for Cooling, Heating, Lighting, Actuation and PV-Electricity Production

Overview

- Introduction
- Problem Description
- Methodology
- Results and Discussion
- Conclusions and Outlook

Problem Description

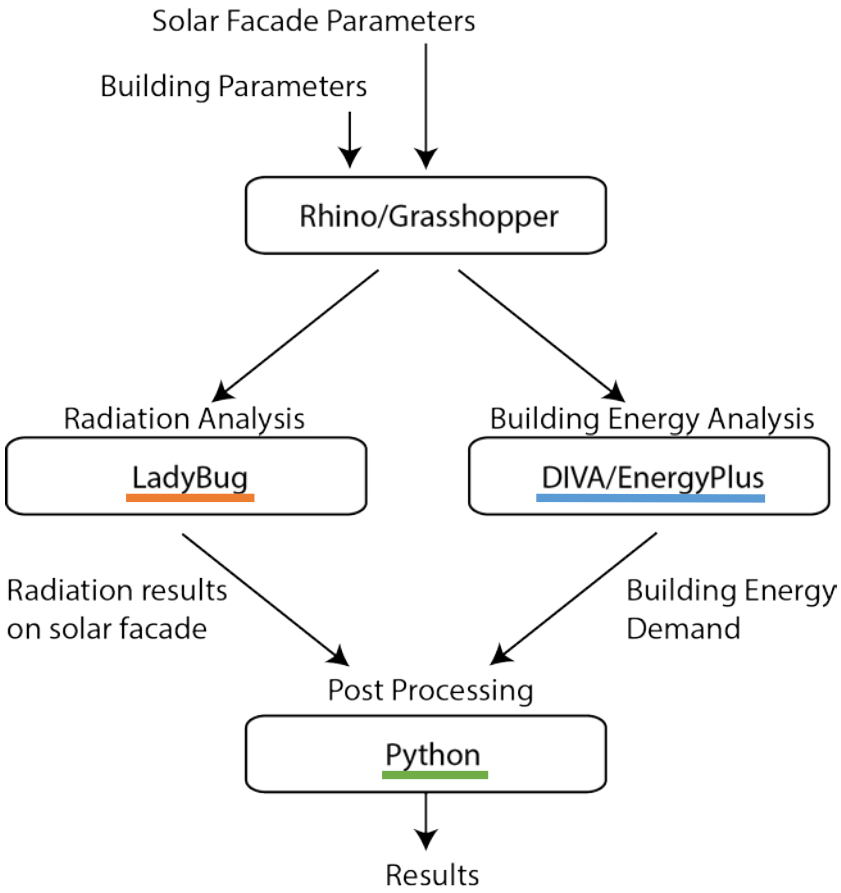
Optimization Problem

Minimize: $\mathrm{C} + H + L + A - PV$

$\mathrm{C} = Cooling\ Energy$
$\mathrm{H} = Heating\ Energy$
$L = Lighting\ Energy$
$A = Actuation\ Energy$
$PV = PV\ Electricity\ Production$

Methodology

Combination Of Different Tools To Achieve Optimal Results



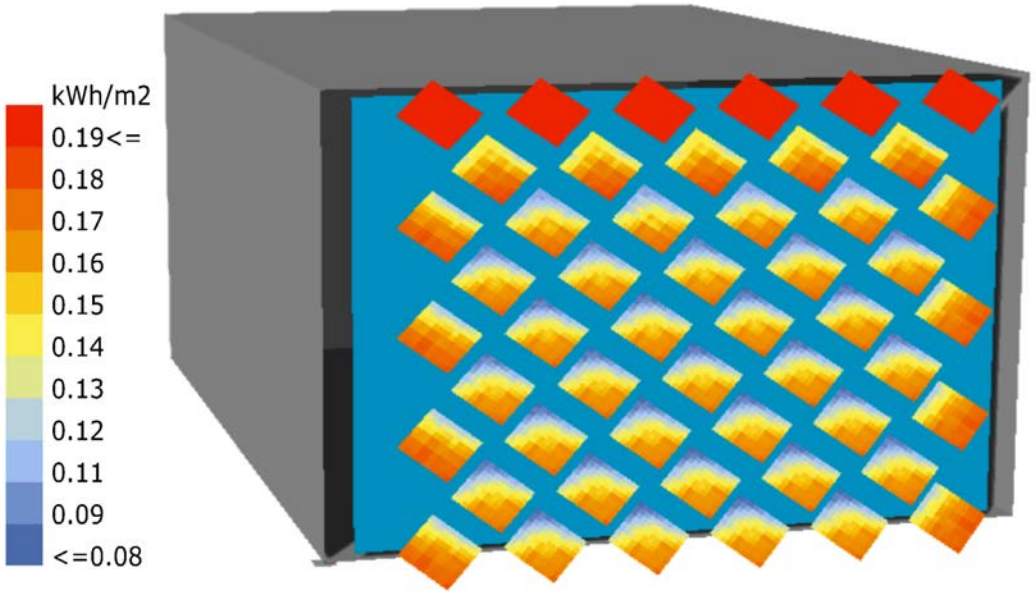
Minimize: $C + H + L + A - PV$

Case Study

- Single Zone Office
- Simulation for One Year
- Weather File for Geneva

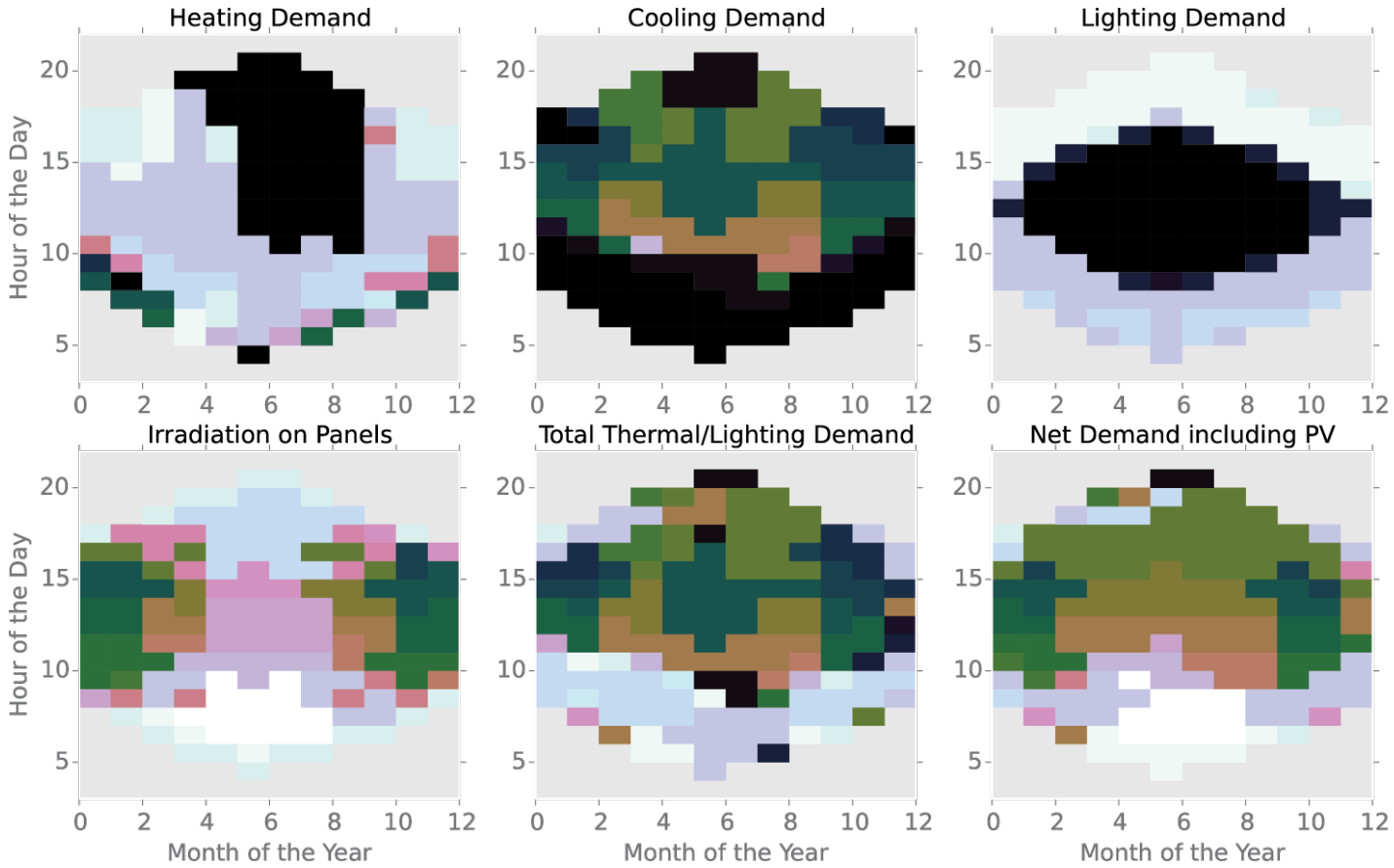
Radiation on Panels (Collaboration with Johannes)

- Radiation Analysis with Ladybug
- Includes Self-Shading



Insolation from 11:00-12:00 on June 16

Optimum Orientation of Panels



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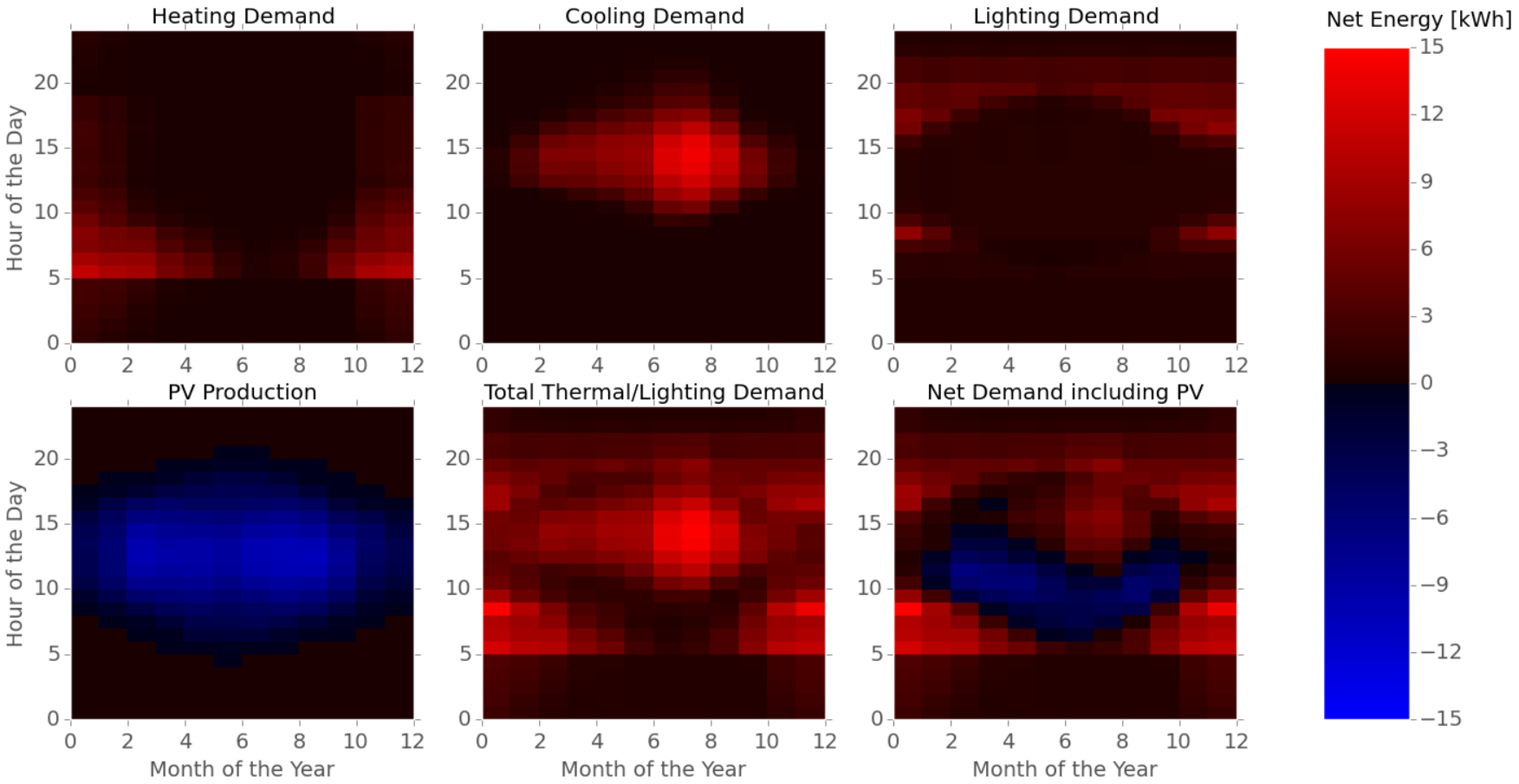
Net Energy Demand at Optimum Orientation



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Conclusions

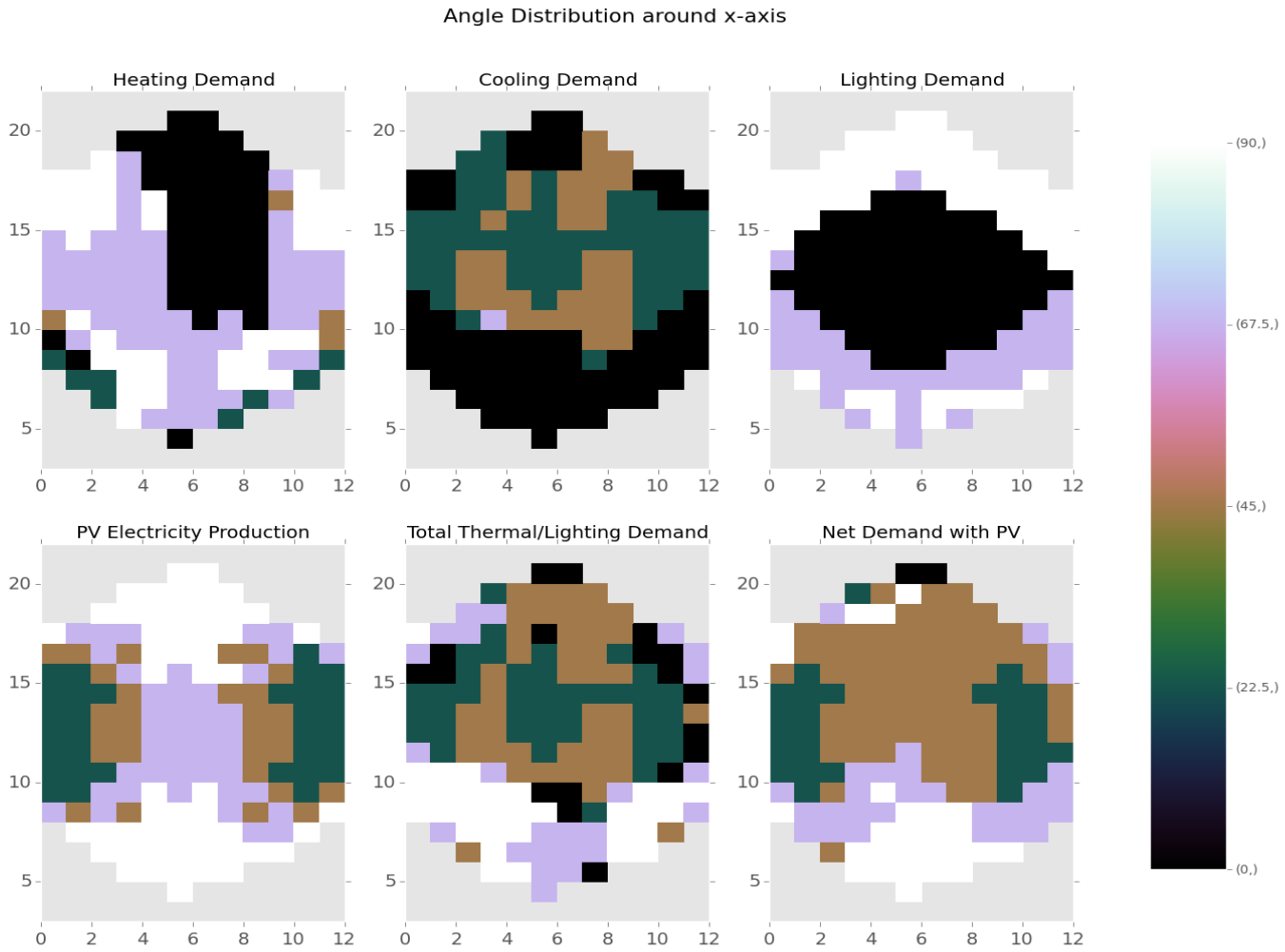
- Developed Simulation Framework for the ASF
- Successfully combine PV-Electricity Production with Building Energy Demand
- Optimal Angles for Single Cluster Found

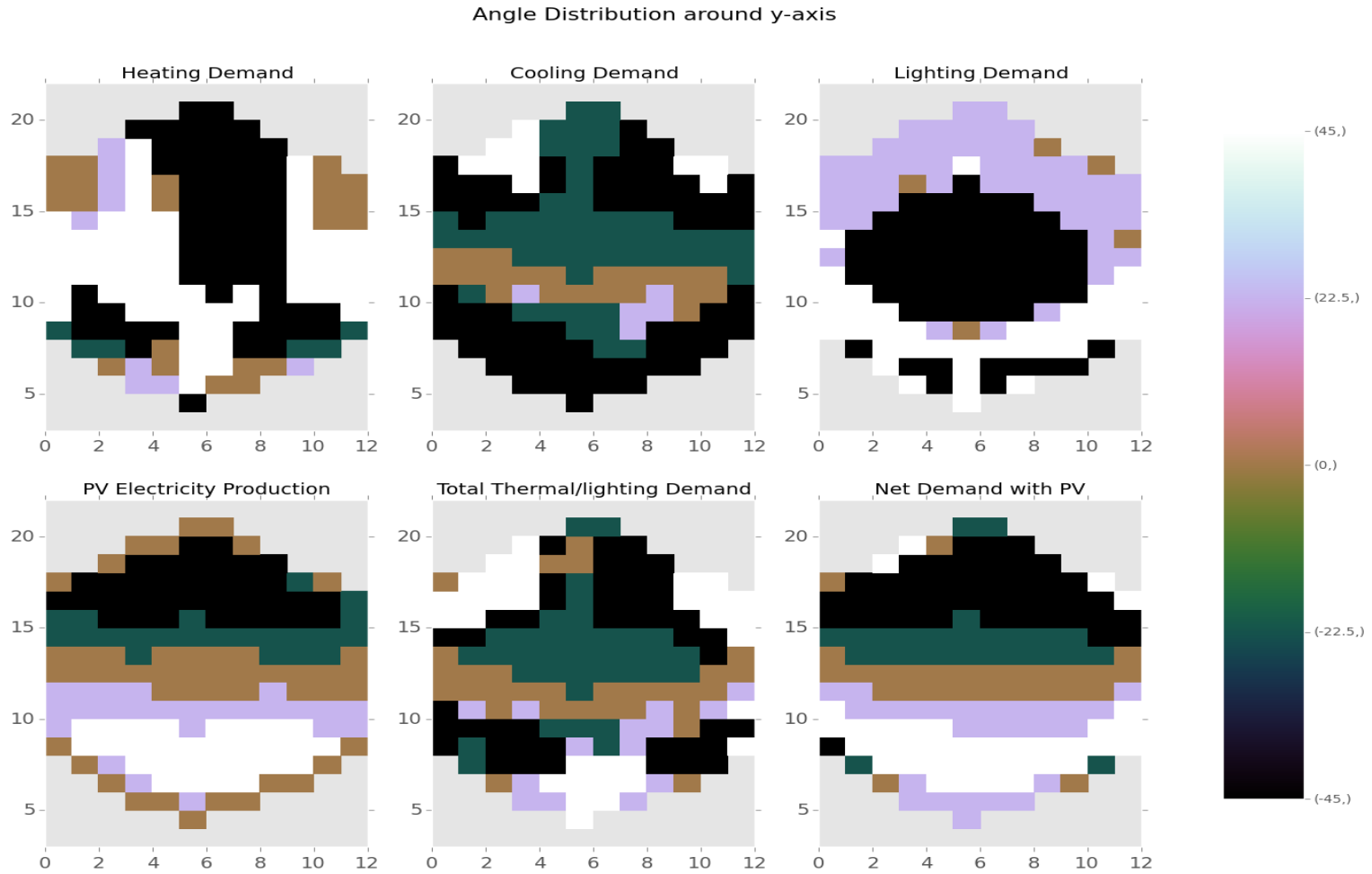
Outlook

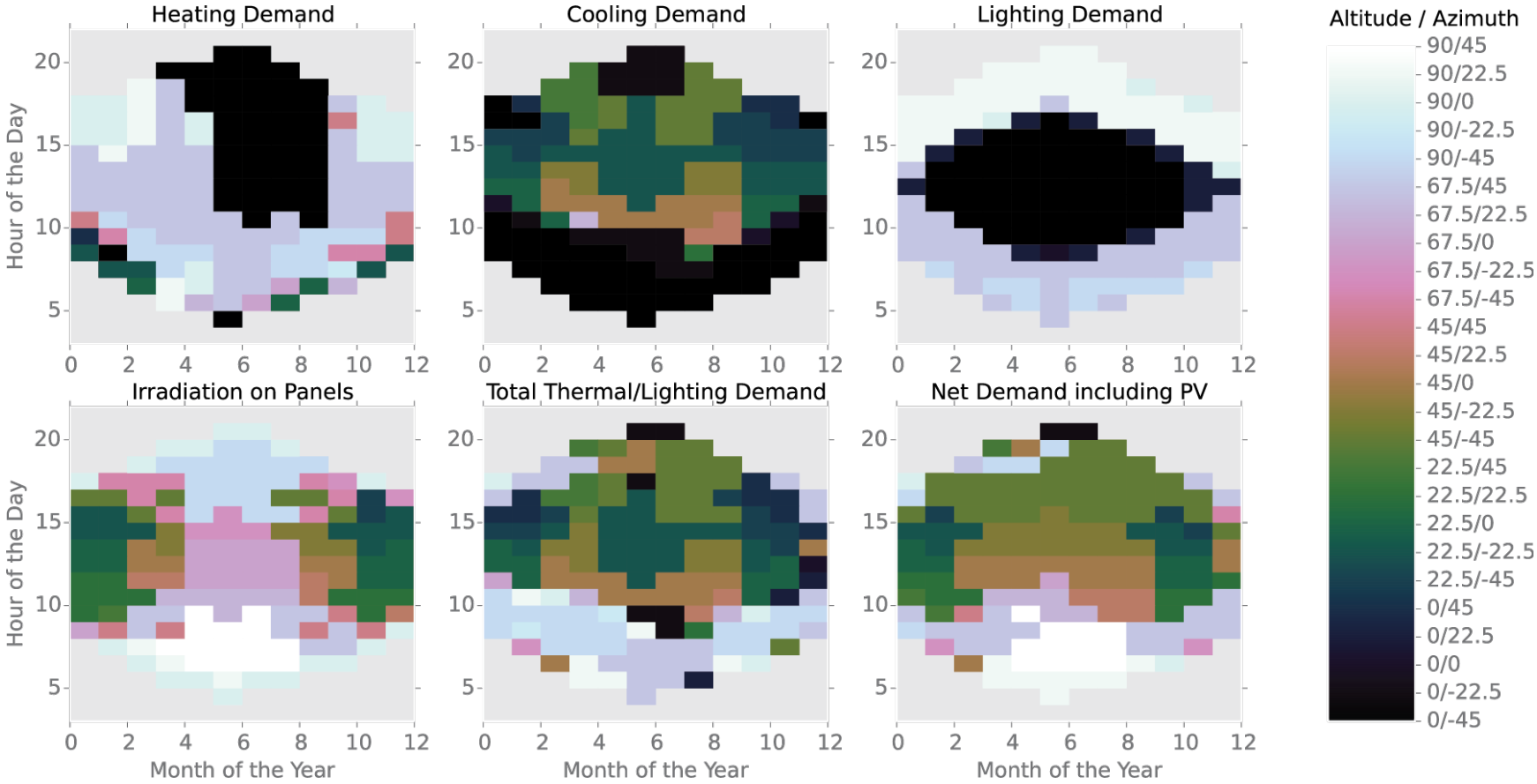
- Development of RC-Building Energy Simulation Tool
  (Collaboration with Mario and Amr)
- Include detailed Efficiency Analysis of PV-Electricity Production
  (Collaboration with Johannes)
- Include Energy-Use for Actuation in Simulation
- Analyze Results for different Regions and Building Typologies
- Use Multiple Clusters of PV-Panels

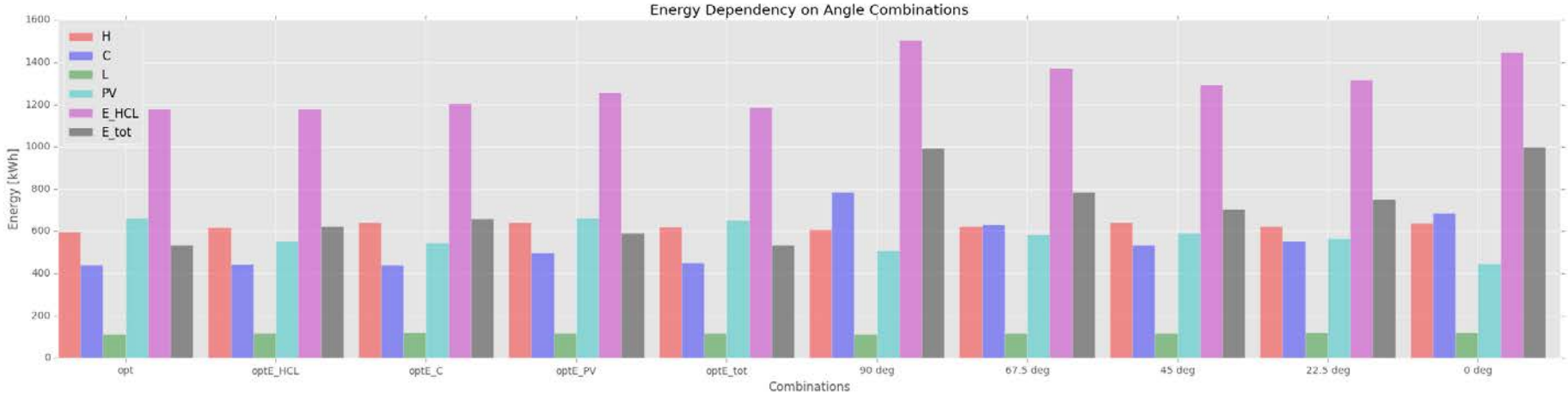
Questions?

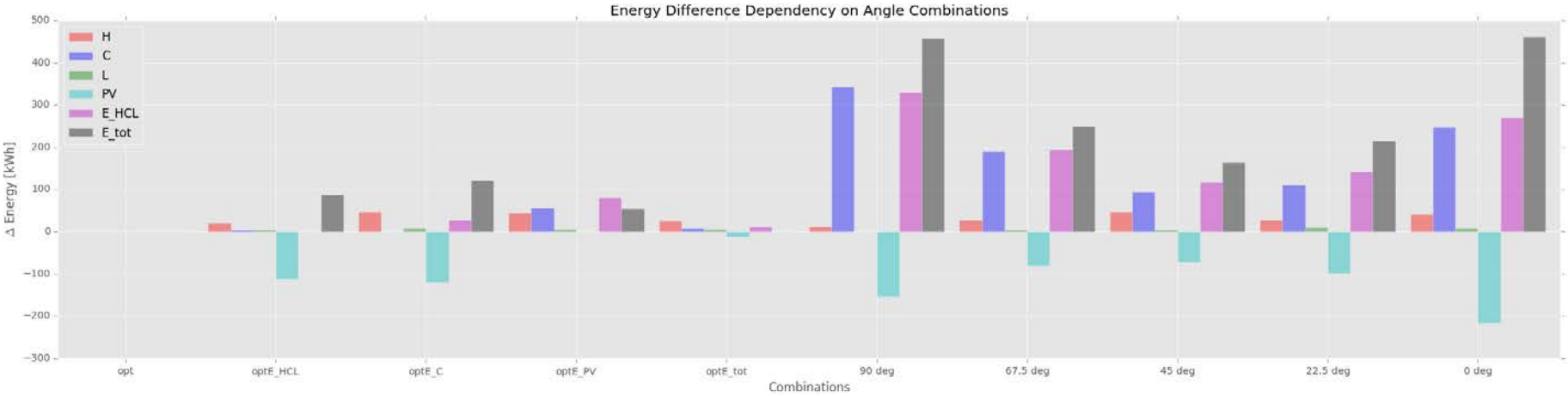
https://github.com/architecture-building-systems/ASF_Simulation


Angle Distribution around x-axis
Heating Demand
Cooling Demand
Lighting Demand
PV Electricity Production
Total Thermal/Lighting Demand
Net Demand with PV
(90,)
(67.5,)
(45,)
(22.5,)
(0,)

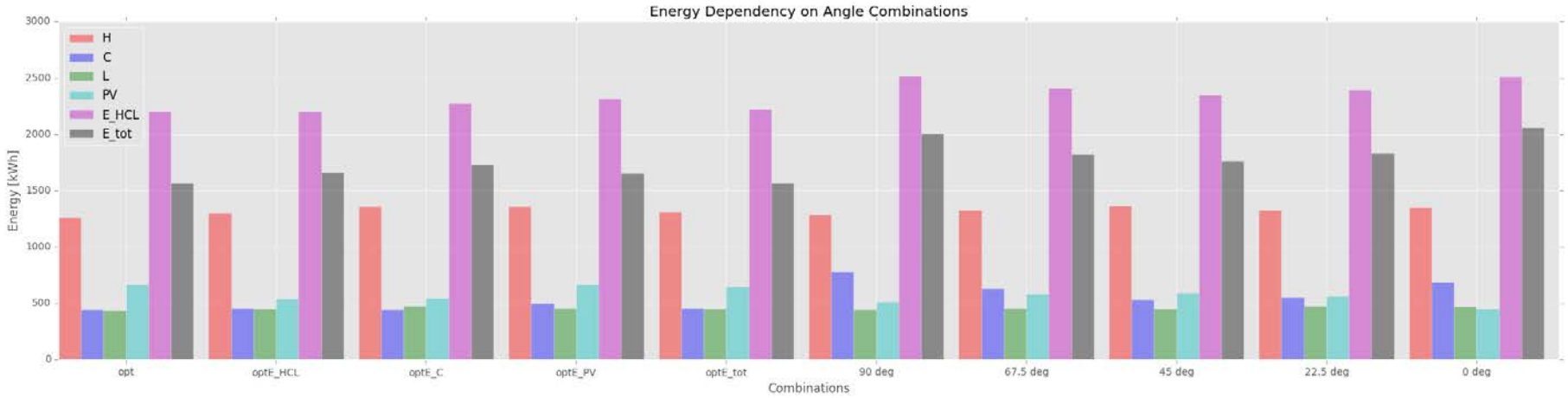

Angle Distribution around y-axis
Heating Demand
Cooling Demand
Lighting Demand
PV Electricity Production
Total Thermal/lighting Demand
Net Demand with PV
(45,)
(22.5,)
(0,)
(-22.5,)
(-45,)

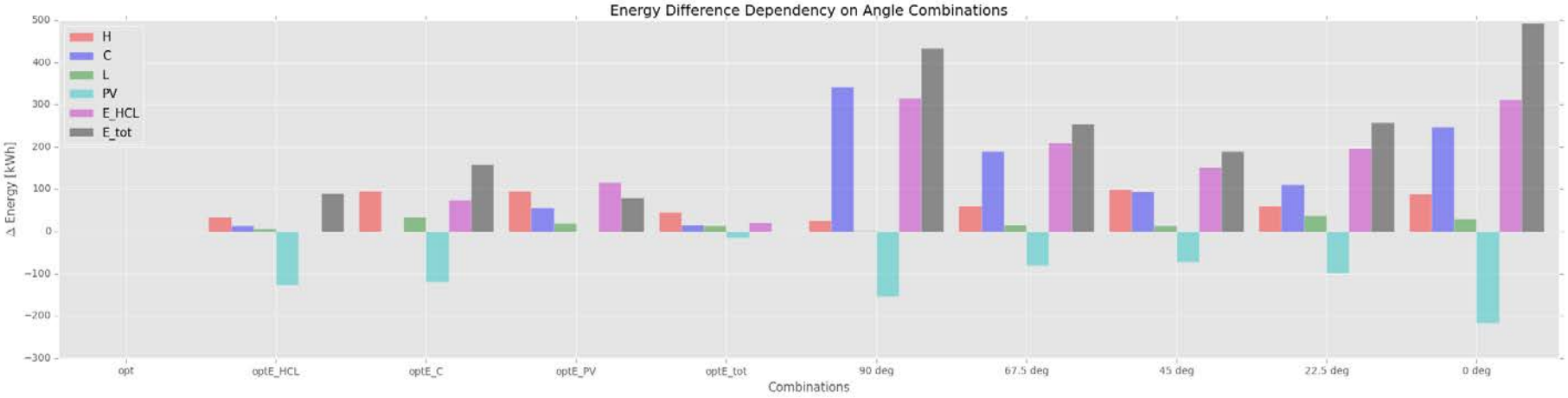

Heating Demand
Cooling Demand
Lighting Demand
Irradiation on Panels
Total Thermal/Lighting Demand
Net Demand including PV
Hour of the Day
Month of the Year
Altitude / Azimuth
90/45
90/22.5
90/0
90/-22.5
90/-45
67.5/45
67.5/22.5
67.5/0
67.5/-22.5
67.5/-45
45/45
45/22.5
45/0
45/-22.5
45/-45
22.5/45
22.5/22.5
22.5/0
22.5/-22.5
22.5/-45
0/45
0/22.5
0/0
0/-22.5
0/-45





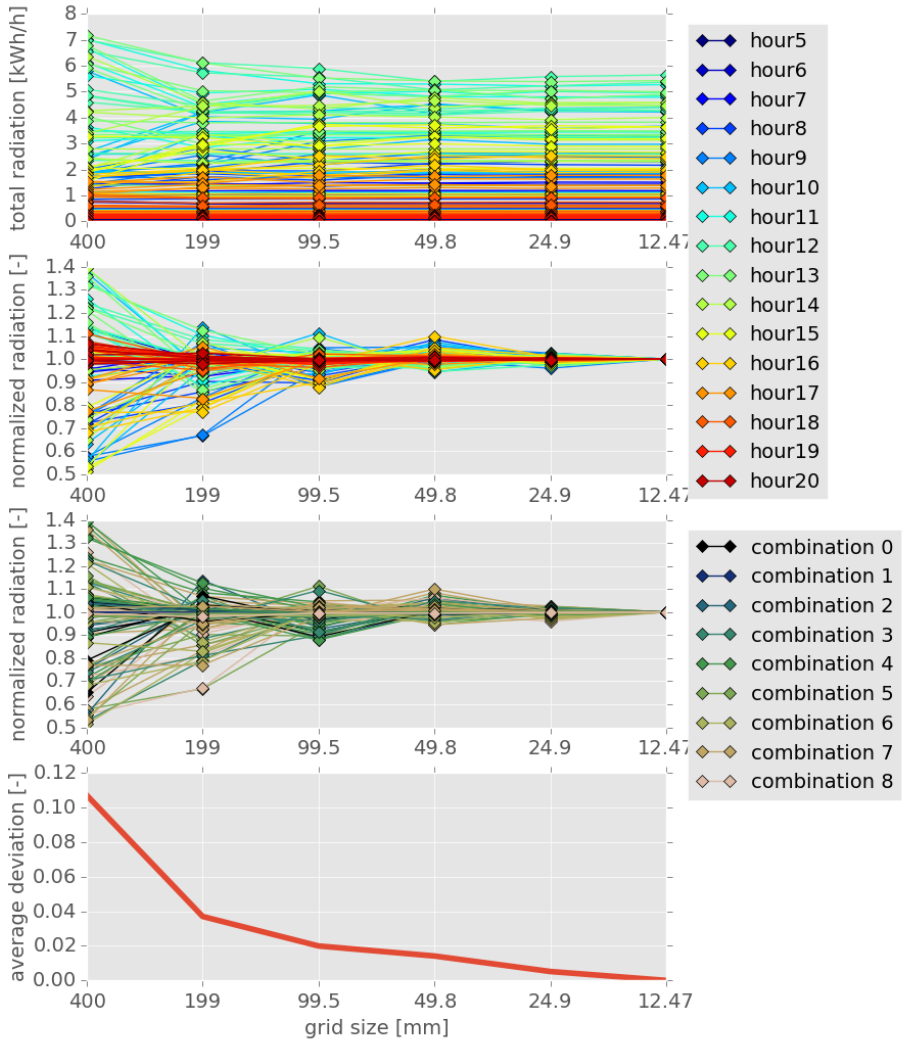
Heating COP = 3 Cooling COP = 3 Lighting = 3 W/m2 PV-efficiency = 0.072

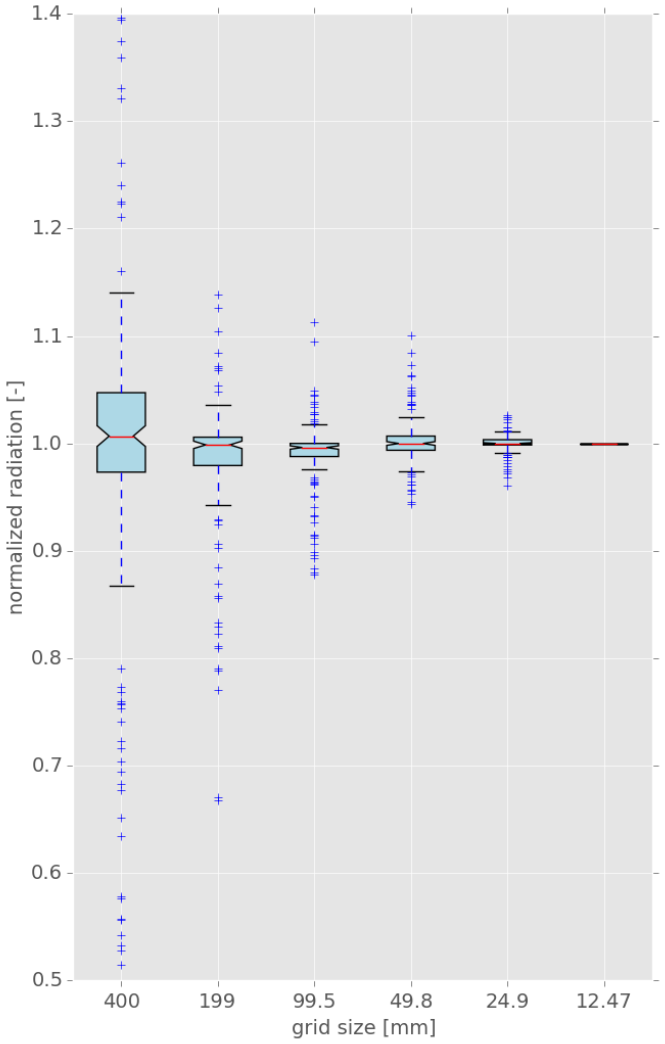




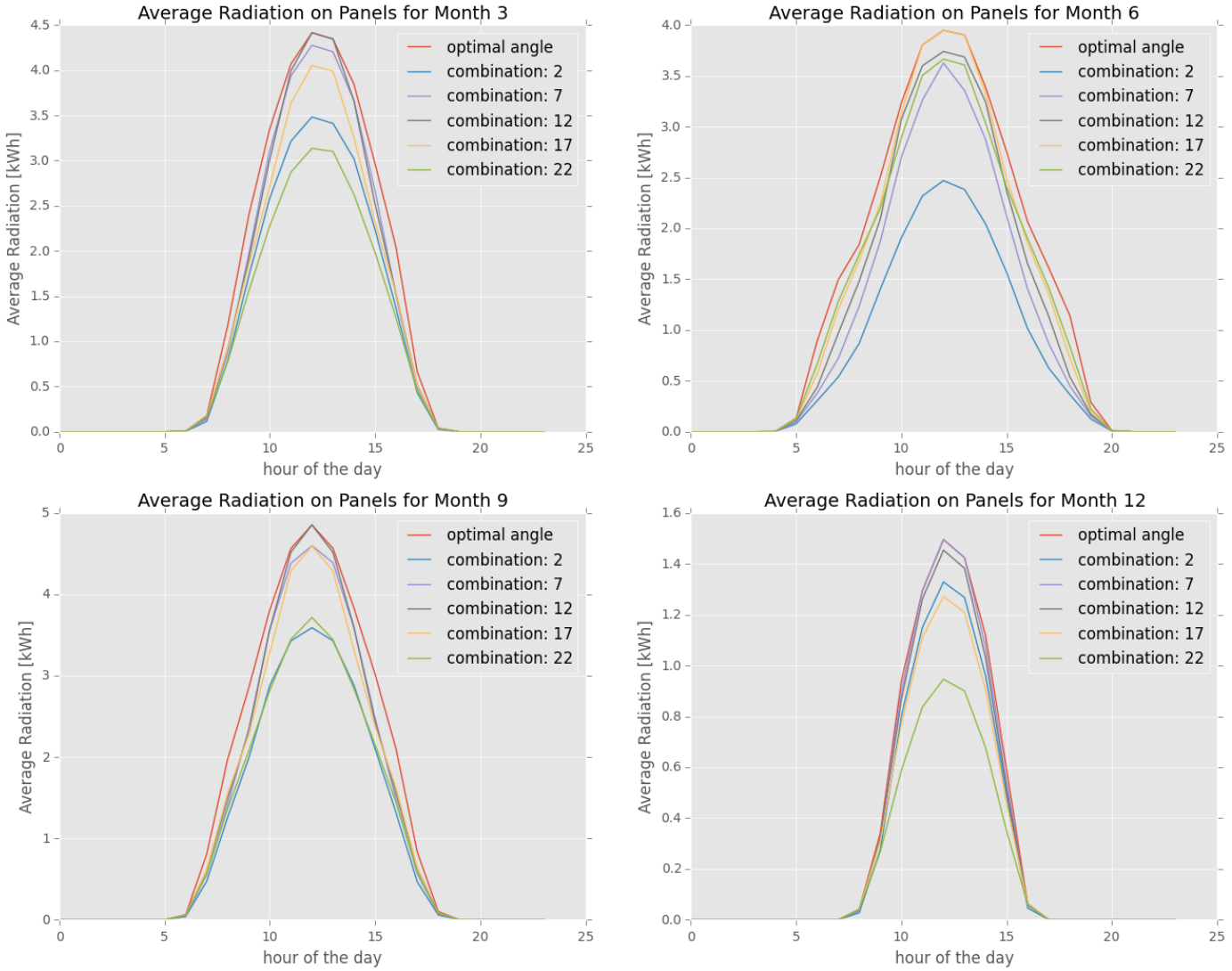
Heating COP = 0.85 Cooling COP = 3 Lighting = 11.74 W/m2 PV-efficiency = 0.072

Grid Convergence





Average Radiation on Panels



Total Radiation on Panels