AEE INTEC

ENERGY OPTIMIZATION OF A BAKERY

Jana Reiter, Mira Hönigmann, Julia Papst and Jürgen Fluch

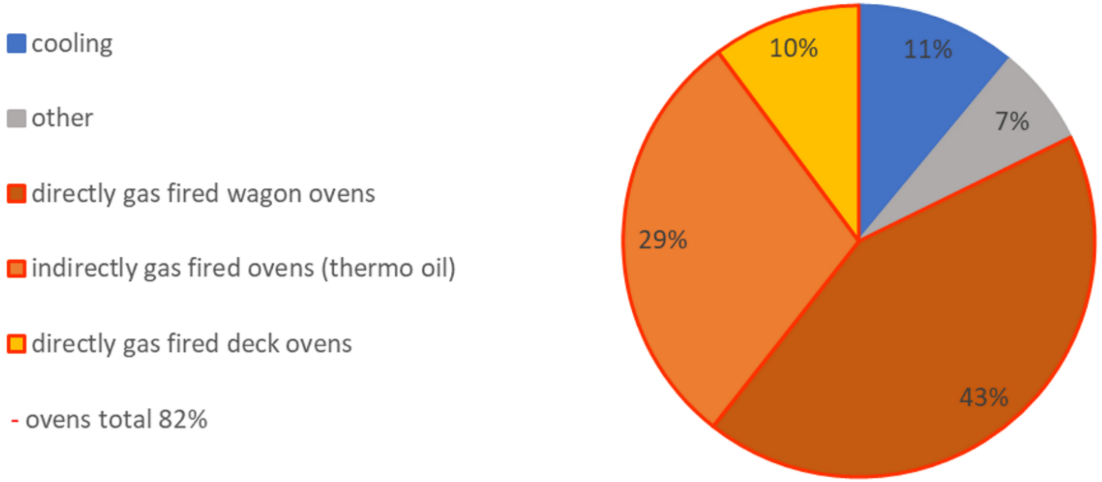
Background: DSM_Opt

- **Goal:**
  Demand **S**ide **M**anagement **D**ecision **S**upport **S**ystem **Toolbox**

- **2 case studies:**
  – steel mill
  – bakery

Analysis of the Production Process
Finding Possibilities for Flexibility

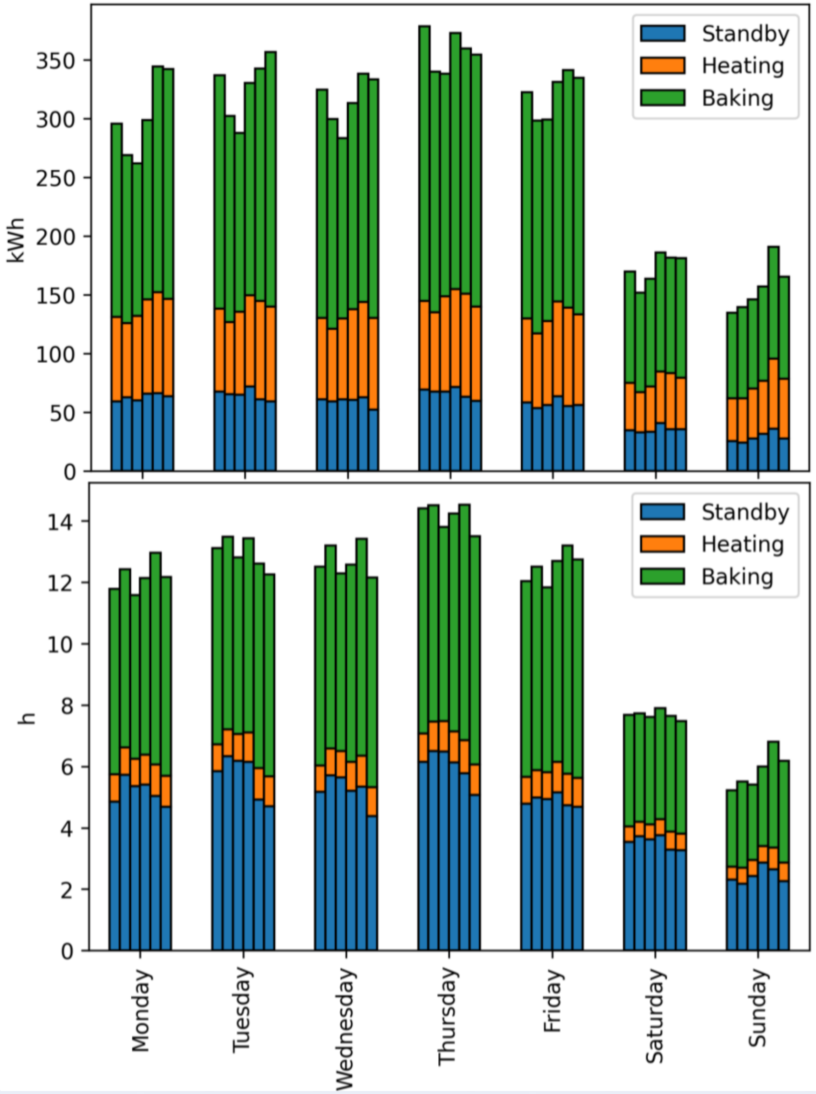
energy usage in the bakery



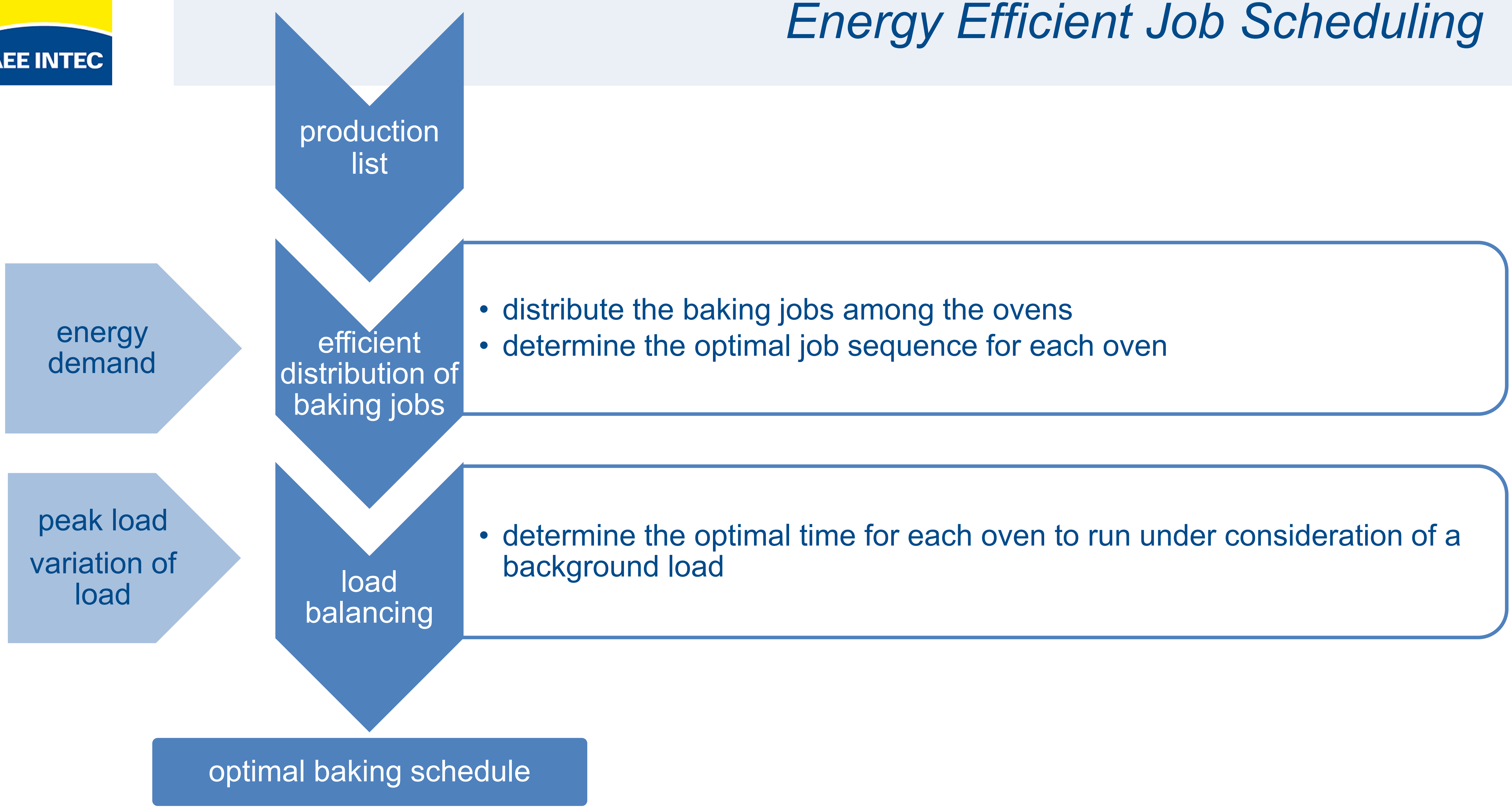
energy consumption

directly gas fired ovens

baking time



Optimization of Production Planning
Energy Efficient Job Scheduling

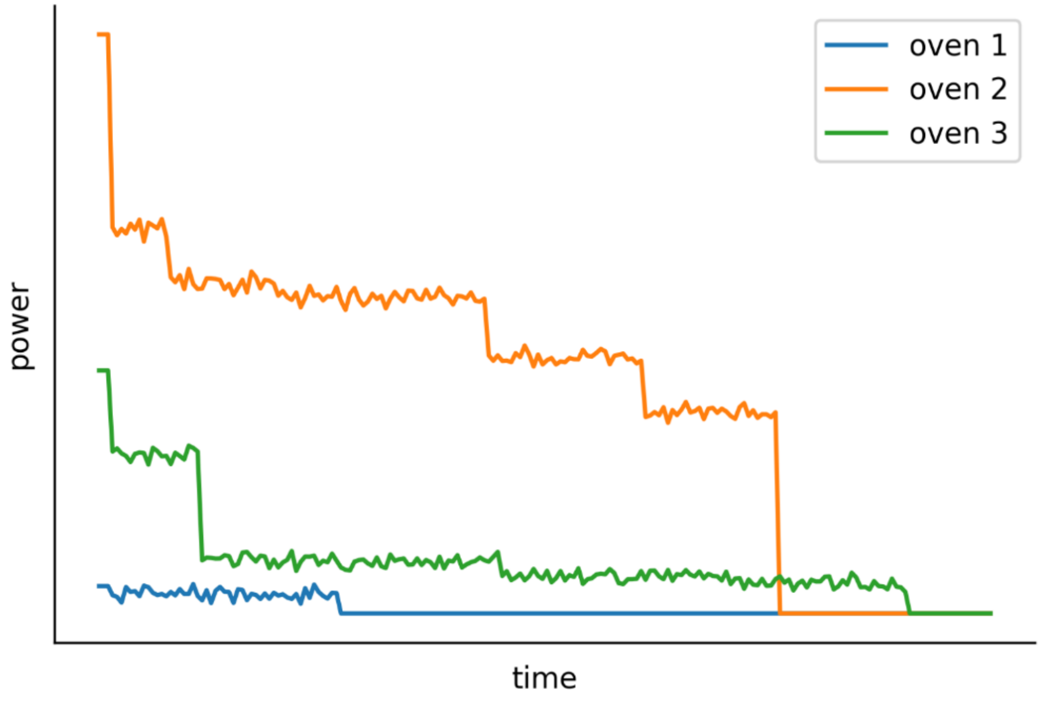


Step 1:
Integer Optimization for Distribution of Baking Jobs

- **Python library PuLP[1] for integer programming**
- **surrogate load profiles for developement process**
- **formulation of the optimization problem:**

$$E_{tot}(x_{ij}) = \sum_{j}^{N} \sum_{i}^{n} x_{ij}\, E(o_j, p_i)$$

+ constraints

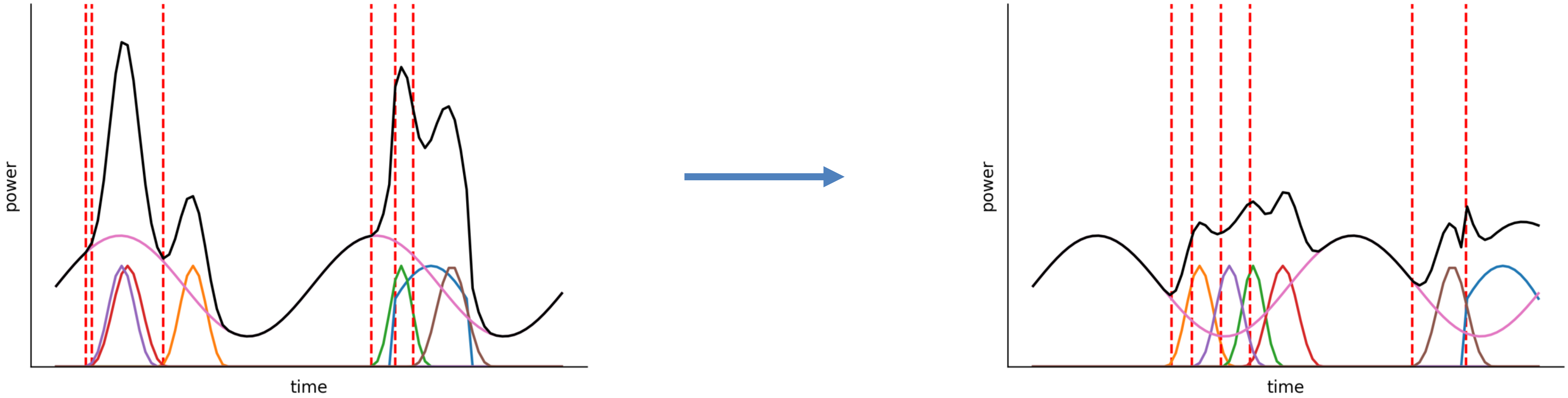


[1]J.-S. Roy and S. A. Mitchell, “https://github.com/coin-or/pulp,” [Online]. [Accessed 2022].

Step 2:
Non-linear Optimization for Load Balancing

- **Python SciPy[2] implementation of the Nelder-Mead method for non-linear optimization**
- **surrogate load profiles for developement process**
- **formulation of the optimization problem:**

$$p_{tot}(t, \boldsymbol{t_{start}}) = p_{bg}(t) + \sum_{j}^{N} p_j\left(t + t_{start}^{j}\right) \qquad \mathrm{C}(\boldsymbol{t_{start}}) = \alpha\left(p_{tot}(t_{i+1}, \boldsymbol{t_{start}}) - p_{tot}(t_i, \boldsymbol{t_{start}})\right)^2 + \beta \max_i p_{tot}(t_i, \boldsymbol{t_{start}})$$



[2]P. Virtanen, et al. , “SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python,” *Nature Methods*, 2020.

Conclusions and Outlook

Flexibility and opportunity to save energy:

timing of the baking jobs

Recommendation:

Employing an energy efficient baking schedule

Solution:

Two-stage baking job scheduling optimization procedure

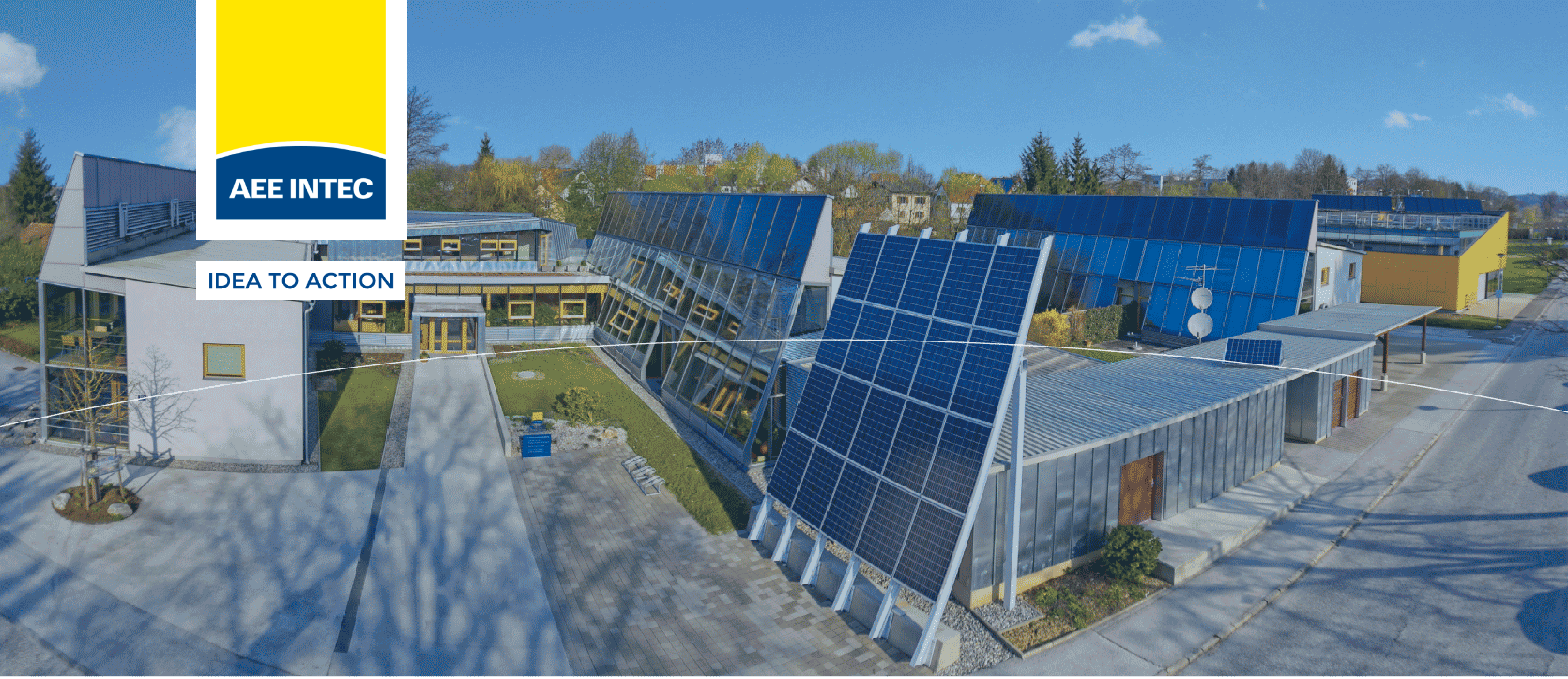
implementation of measuring equipment in the bakery

next steps

- realistic load profiles to replace the surrogate profiles
- validation experiments

further research interests

- economic parameters to promote better acceptance
- integration of volatile renewable energy sources



AEE – Institute for Sustainable Technologies (AEE INTEC)
8200 Gleisdorf, Feldgasse 19, Austria

Website: www.aee-intec.at
Twitter: @AEE_INTEC

Jana Reiter
j.reiter@aee.at