*Model Calibration at Building Stock Level with Machine Learning**

Paula van den Brom

* Based on: P. van den Brom., L. Itard, H. Visscher. (2019). *Calibration of building energy simulation models on a building stock level using actual energy consumption data – making building energy simulations a more reliable tool for policymakers.*

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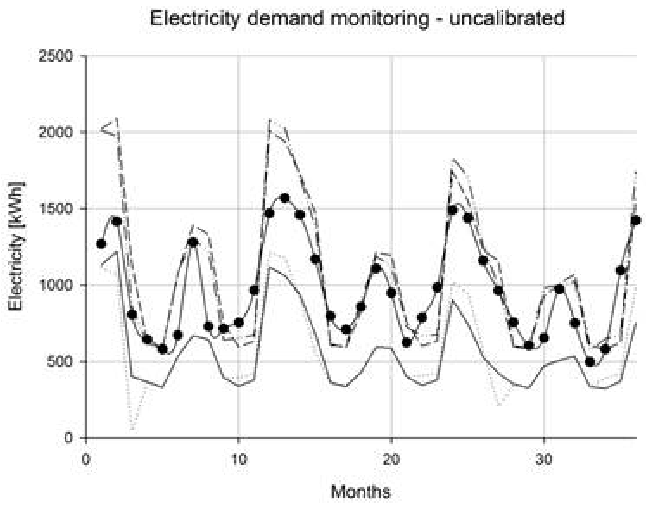
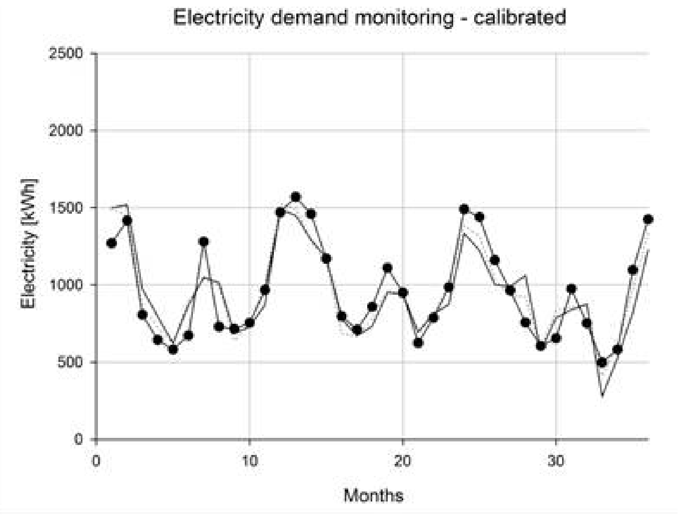
Calibration Building Energy Simulations





Source: Manfren, M.; Nastasi, B. Parametric Performance Analysis and Energy Model Calibration Workflow Integration—A Scalable Approach for Buildings. *Energies* **2020**, *13*, 621.

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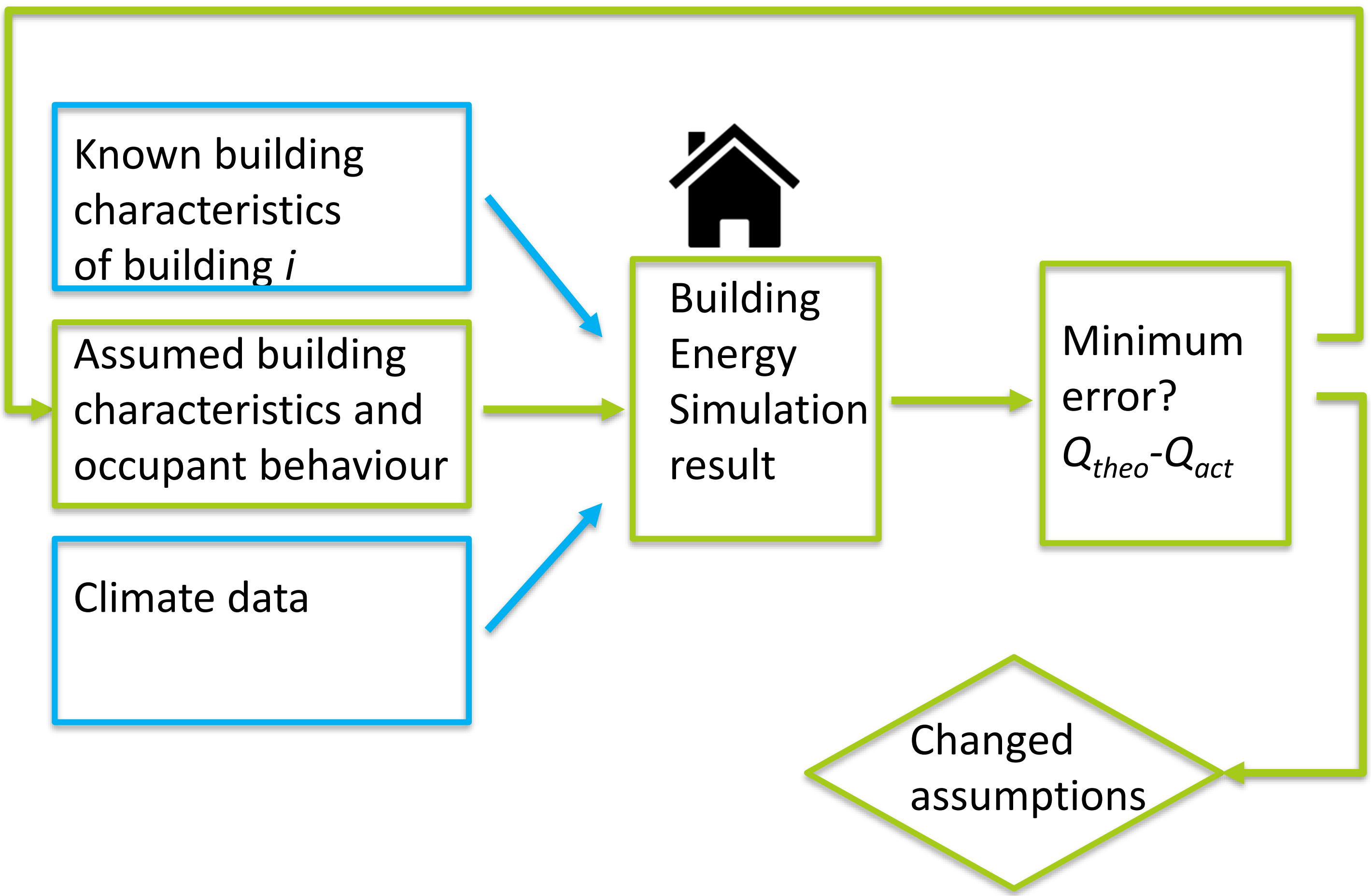

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Calibration parameters

- Indoor temperature
- Assumed U-values
- Ventilation rates
- Infiltration rates
- Occupant Presence
- Domestic hot water

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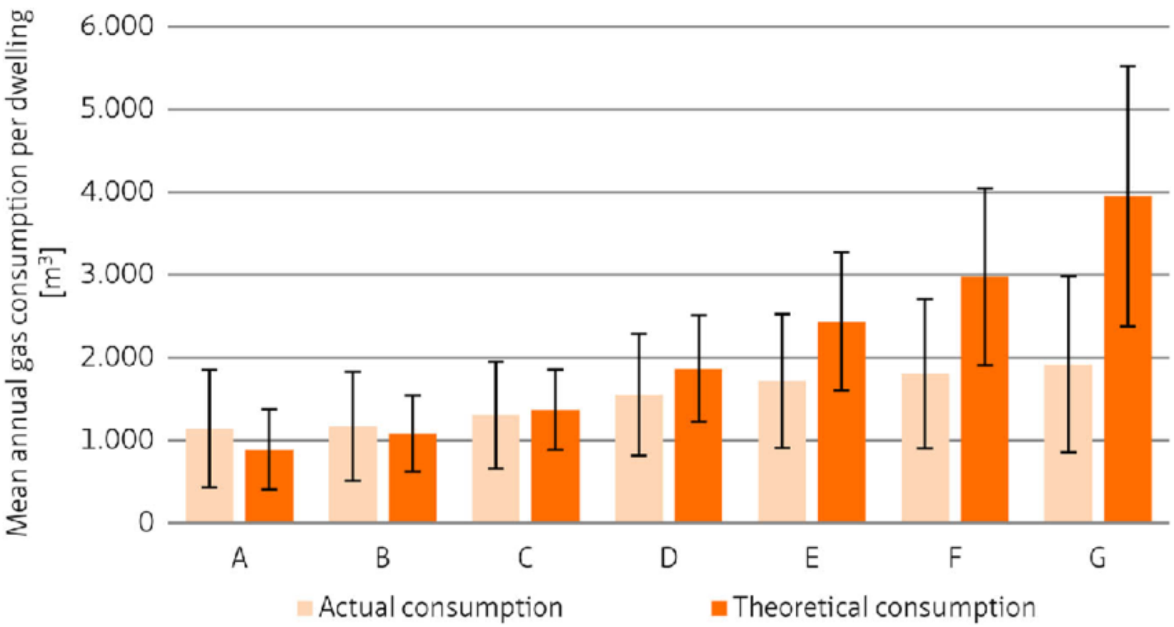
Energy Predictions on Buildings Stock Level



Source: Majcen, D., Itard, L., & Visscher, H. (2013a). Actual and theoretical gas consumption in Dutch dwellings: What causes the differences? *Energy Policy*, *61*, 460–471. doi: 10.1016/j.enpol.2013.06.018

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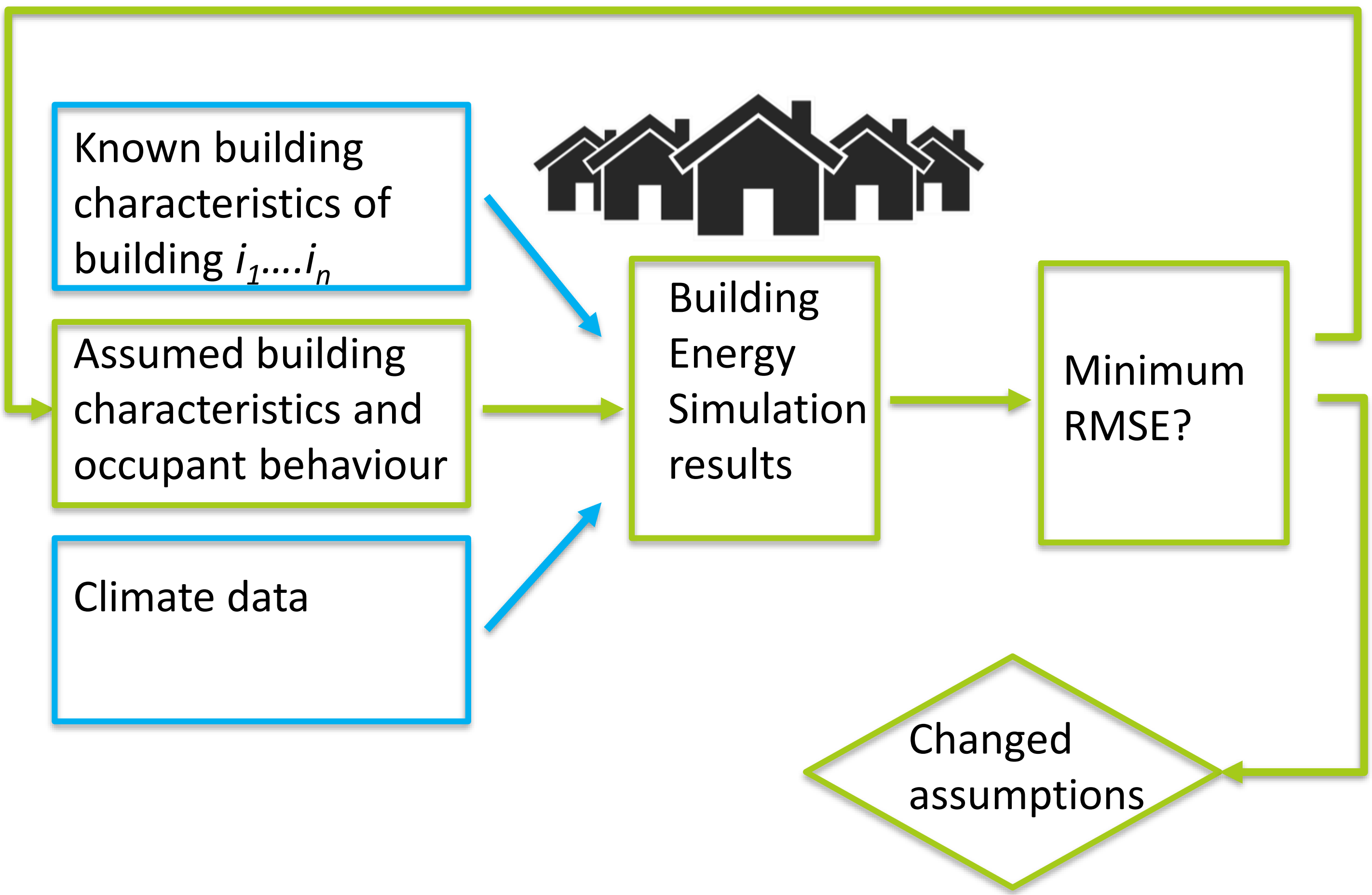
Calibration Building Energy Simulations

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Q_{theo_i} - Q_{act_i})^2}{n}}$$



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Calibration parameters

	Lower bound	standard values according ISSO 82.3	Upper bound
Indoor temperature setting	15°C	18°C	28°C
Rc value façade [units]			
Before 1965	0.19	0.19	1.3
Between 1965-1975	0.19	0.43	1.3
Between 1975-1988	0.43	1.3	2
Between 1988-1992	1.3	2	3
After 1992	1.3	2.3	3.5
Air change rate			
Natural ventilation	-90%	0%	+300%
Mechanical exhaust ventilation	-90%	0%	+300%
Mechanical exhaust ventilation demand based	-90%	0%	+300%
Balanced ventilation system with heat recovery	-90%	0%	+300%
Domestic hot water consumption			
dhw floor area <50m2	-39%	0%	286%
dhw 50< floor area <75 m2	-55%	0%	182%
dhw 75< floor area <100 m2	-65%	0%	142%
dhw 100 < floor area <150 m2	-67%	0%	133%

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Machine Learning Techniques

- Particle Swarm
- Surrogate model

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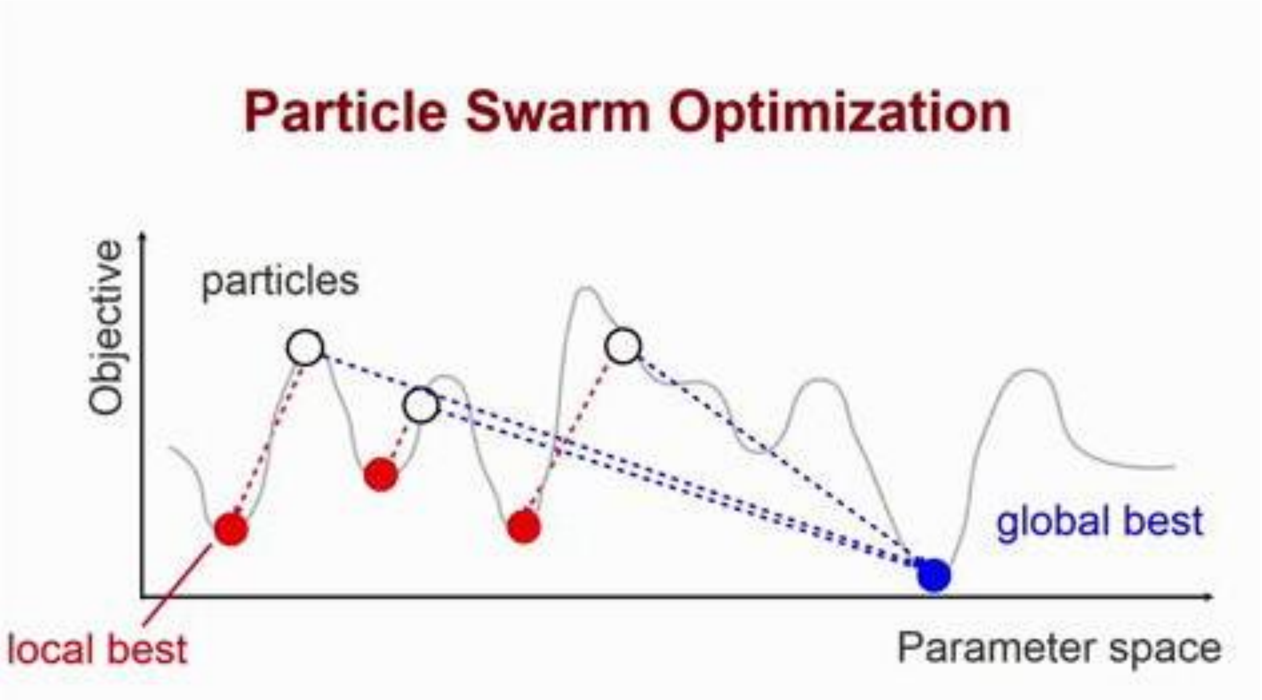
Machine Learning Techniques

- Particle swarm



Edgar Peña *et al* 2017 *J. Neural Eng.* **14** 016014

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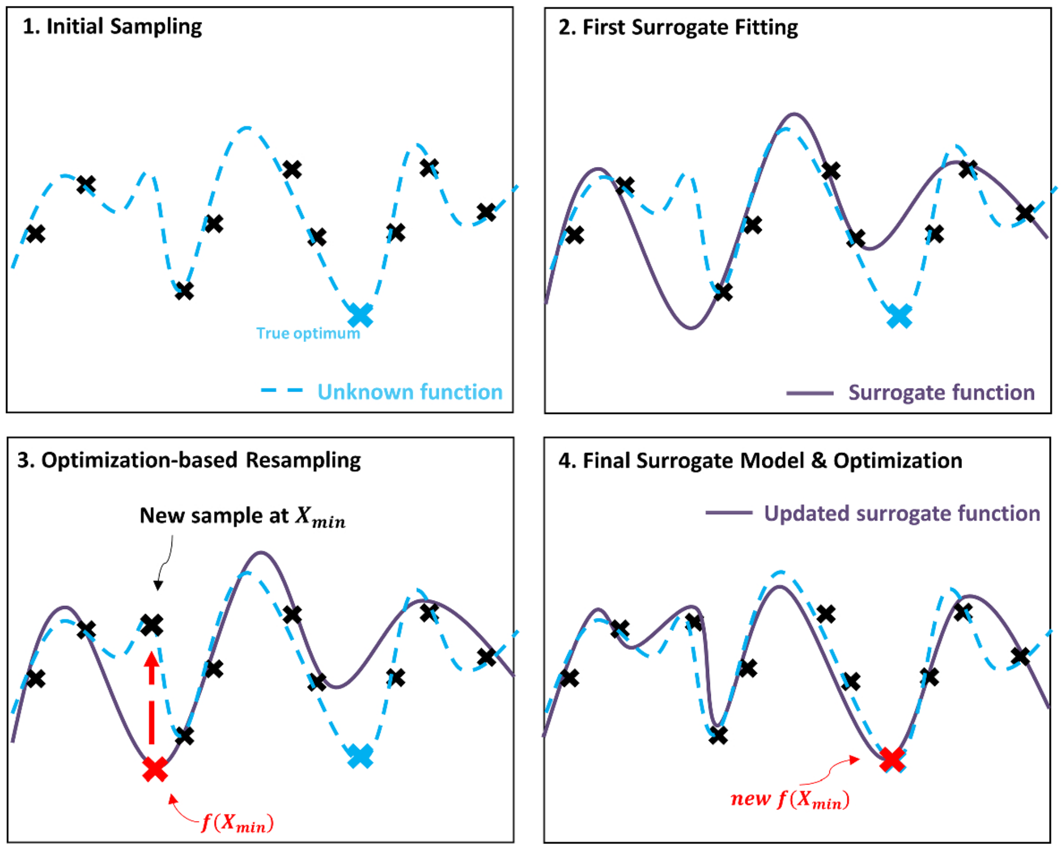
Machine Learning Techniques

- Surrogate model



Kim, S.H. & Boukouvala, F. Optim Lett (2019). https://doi.org/10.1007/s11590-019-01428-7

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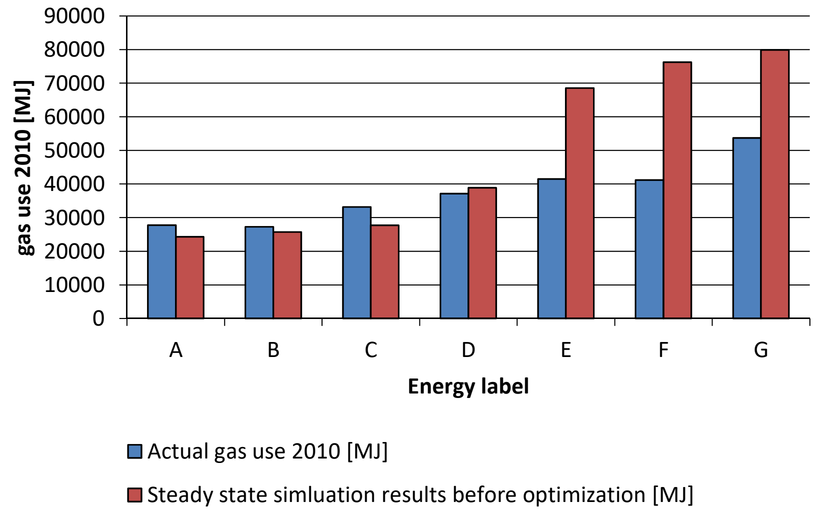
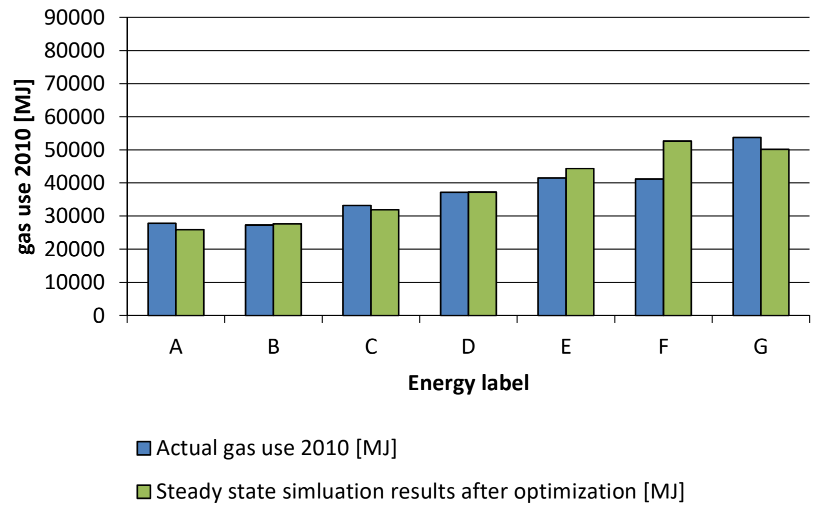
Reduction of Energy Performance Gap





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Conclusion and Recommendations

- Make sure that there are enough cases per optimization parameter
- Make sure that the group is representative
- Prevent overfitting
- Avoid influential outliers because they will have a significant influence on the end result
- This method does not aim to reduce the gap between predicted and actual energy consumption on an individual building level but only on a building stock level.

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