EABSS Workshop 2023

Co-Creation of Agent-Based Social Simulation Models

Case Study (Zhang et al 2010)

Modelling Office Building Energy Consumption

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

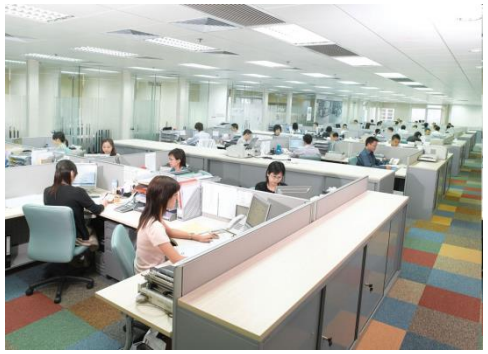
Related Project: "Future Energy Decision Making for Cities: Can Complexity Science Rise to the Challenge?"

- Project research question: How do city level energy policy interventions (technological; behavioural; organisational) impact on overall energy consumption and energy user behaviour?

- Collaboration between several universities (researchers from different domains)
  - https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/G059780/1
  - https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/G05956X/1

- Task: Developing models to help decision makers define their current energy situation and then reach balanced decisions in their future energy planning to implementing UK sustainability targets

Case Study: Context



- Office building energy consumption
  - We focus on modelling electricity consumption
  - Organisational dilemma
    - Need to meet the energy needs of staff
    - Need to minimise its energy consumption through effective organisational energy management policies/regulations

- Objective
  - Test the effectiveness of different electricity management strategies, and solve practical office electricity consumption problems

Case Study: Modelling

- Electricity consumption
  - Base electricity consumption: security devices, information displays, computer servers, shared printers and ventilation systems.
  - Flexible electricity consumption: lights and office computers.

- Current electricity management technologies
  - Each room is equipped with light sensors
  - Each floor is equipped with half-hourly metering system

- Strategic questions to be answered
  - Automated vs. manual lighting management
  - Local vs. global energy consumption information

Case Study: Modelling

- We distinguishing base appliances and flexible appliance
  - Examples for **base appliances**
    - Security cameras
    - Information displays
    - Computer servers
    - Refrigerators
  - Examples for **flexible appliances**
    - Lights
    - Desktop computers
    - Printers

Case Study: Modelling

- The mathematical model
  - Ctotal = Cbase + Cflexible
    - where Cflexible = β1*Cf1+ β2*Cf2+ … + βn*Cfn
    - and Cf1 …Cfn = maximum electricity consumption of each flexible appliance
    - and β1 … βn = parameters reflecting the behaviour of the electricity user
      - β close to 0 = electricity user switches flexible appliances always off
      - β close to 1 = electricity user leaves flexible appliances always on
  - Ctotal = Cbase + (β1*Cf1+ β2*Cf2+ … + βn*Cfn)

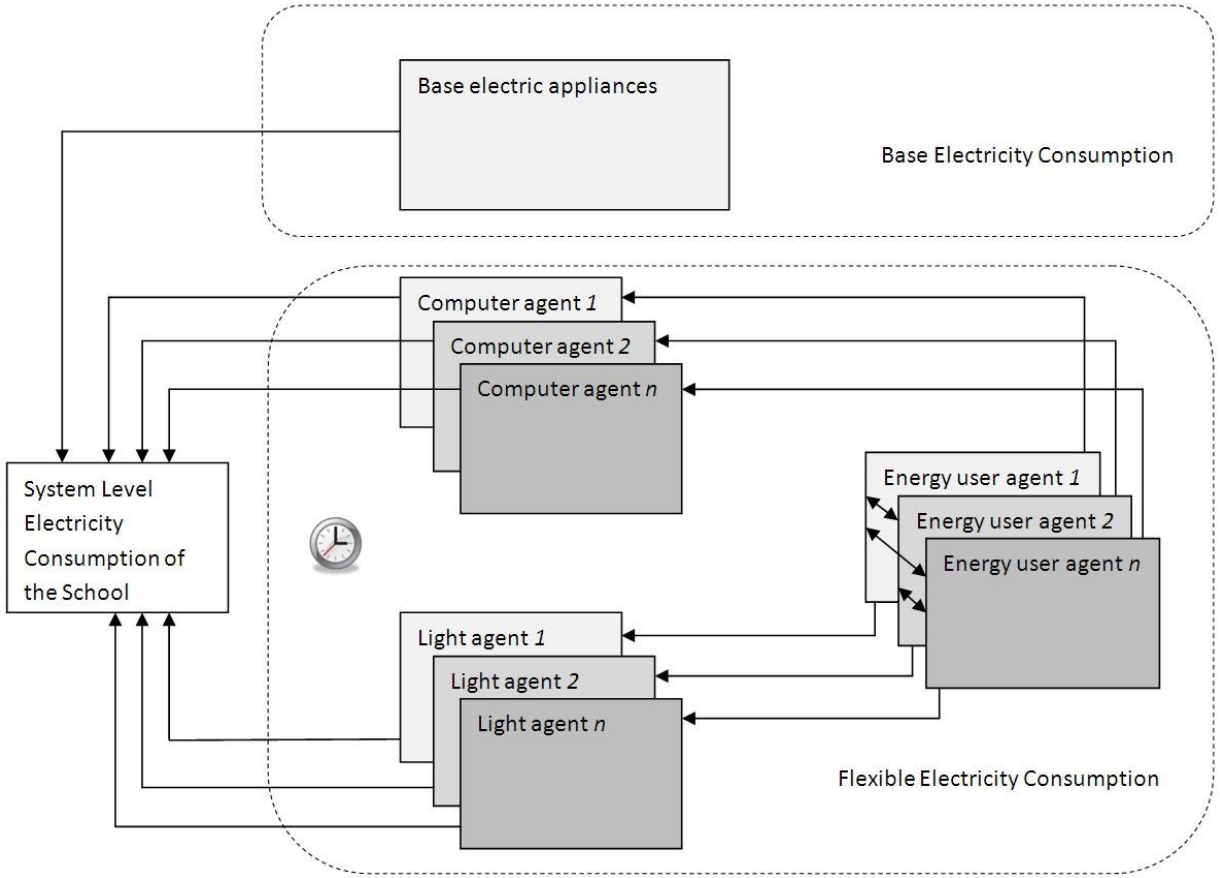
Case Study: Modelling

- Knowledge gathering
  - Consultations with the school's director of operations and the university estate office
  - Survey amongst the school's 200 PhD students and staff on electricity use behaviour (response rate 71.5%)

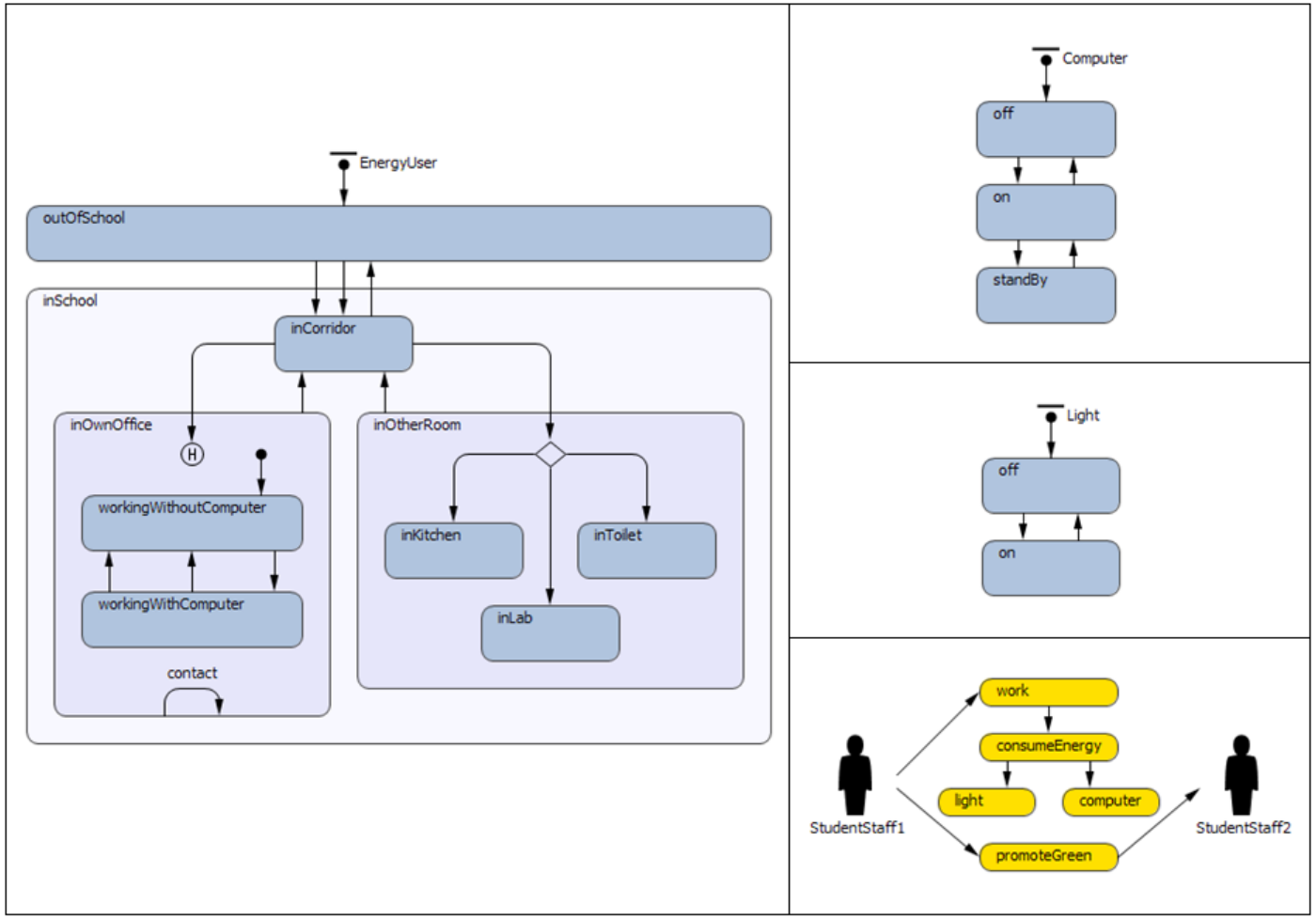
- User stereotypes
  - Working hour habits
    - Early birds, timetable compliers, flexible workers
  - Energy saving awareness
    - Environment champion; energy saver; regular user; big user

Case Study: Modelling

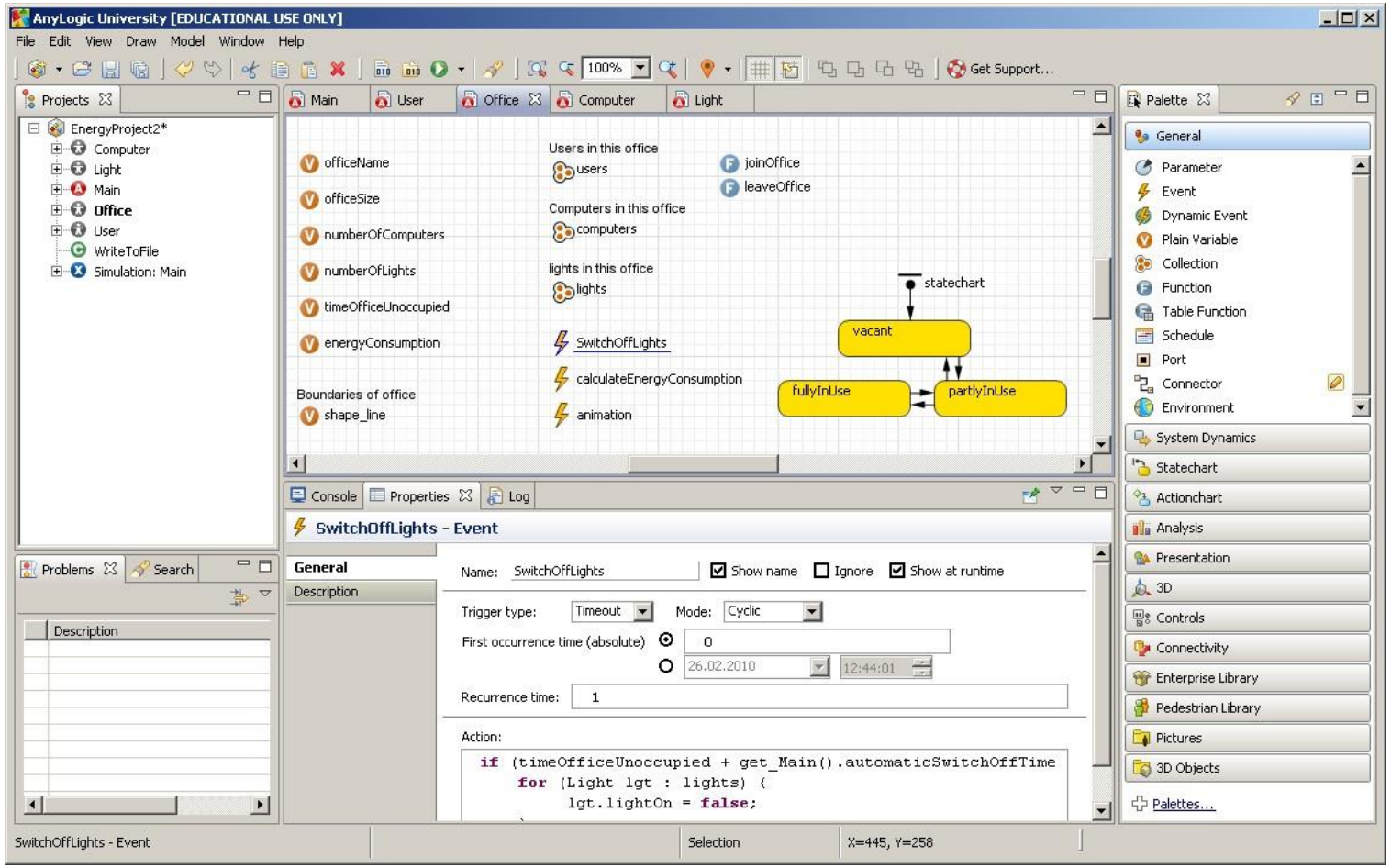
- Conceptual model



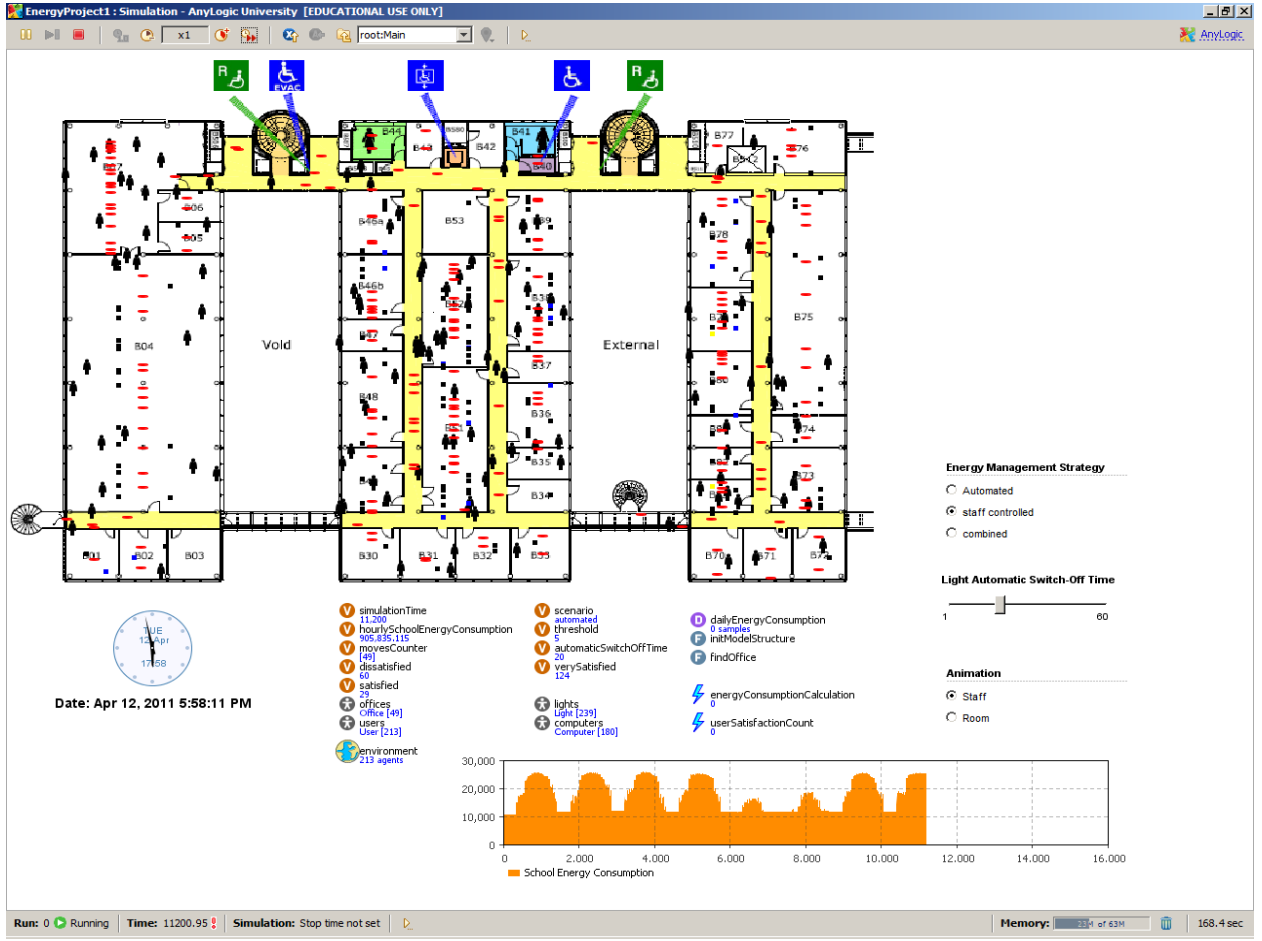
Case Study: Modelling



Case Study: Implementation

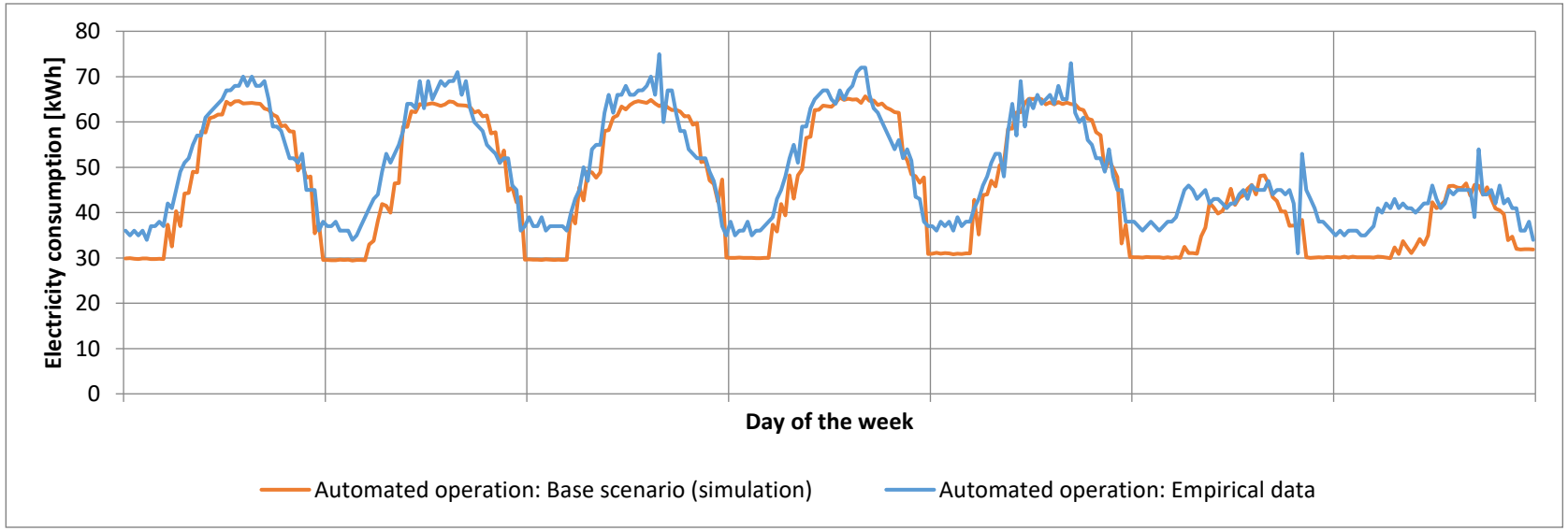


Case Study: Experimentation



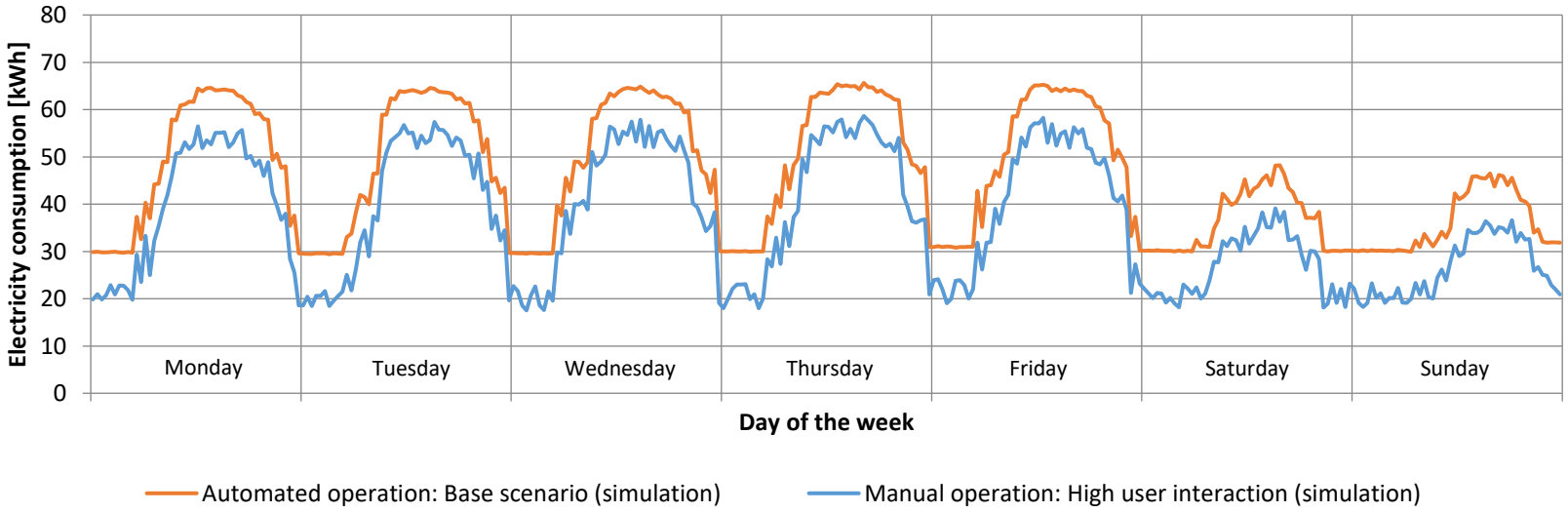
Case Study: Experimentation

- Validation
  - Comparing **simulation** and **empirical results**



Case Study: Experimentation

- Scenario #1
  - Comparing **automated** and **manual operation** (high user interaction)



Any Questions?

References & Related Publications

- References
  - Zhang T, Siebers PO and Aickelin U (2010) 'Modelling Office Energy Consumption: An Agent Based Approach'. In: Proceedings of the 3rd World Congress on Social Simulation (WCSS2010), 5-9 September, Kassel, Germany
- Related Publications
  - Zhang T, Siebers PO and Aickelin U (2011) 'Modelling Electricity Consumption in Office Buildings: An Agent Based Approach'. Energy and Buildings, 43(10) pp. 2882-2892
  - Zhang T, Siebers PO and Aickelin U (2012) 'A Three-Dimensional Model of Residential Energy Consumer Archetypes for Local Energy Policy Design in the UK'. Energy Policy, pp. 102-110
  - Zhang T, Siebers PO and Aickelin U (2016) 'Simulating User Learning in Authoritative Technology Adoption: An Agent Based Model for Council-led Smart Meter Deployment Planning in the UK'. Technological Forecasting and Social Change, 106, pp.74-84
  - Siebers PO and Klügl F (2017) 'What Software Engineering has to offer to Agent-Based Social Simulation'. In: Edmonds B and Meyer R (Eds). Simulating Social Complexity: A Handbook - 2e