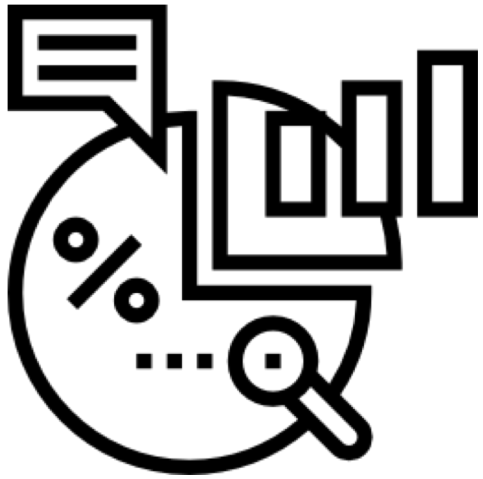
Karlsruhe Institute of Technology

Behavioral Studies in Energy Economics: A Review and Research Framework

Institut für Informationswirtschaft und Marketing & Institut für Regelungs- und Steuerungssysteme



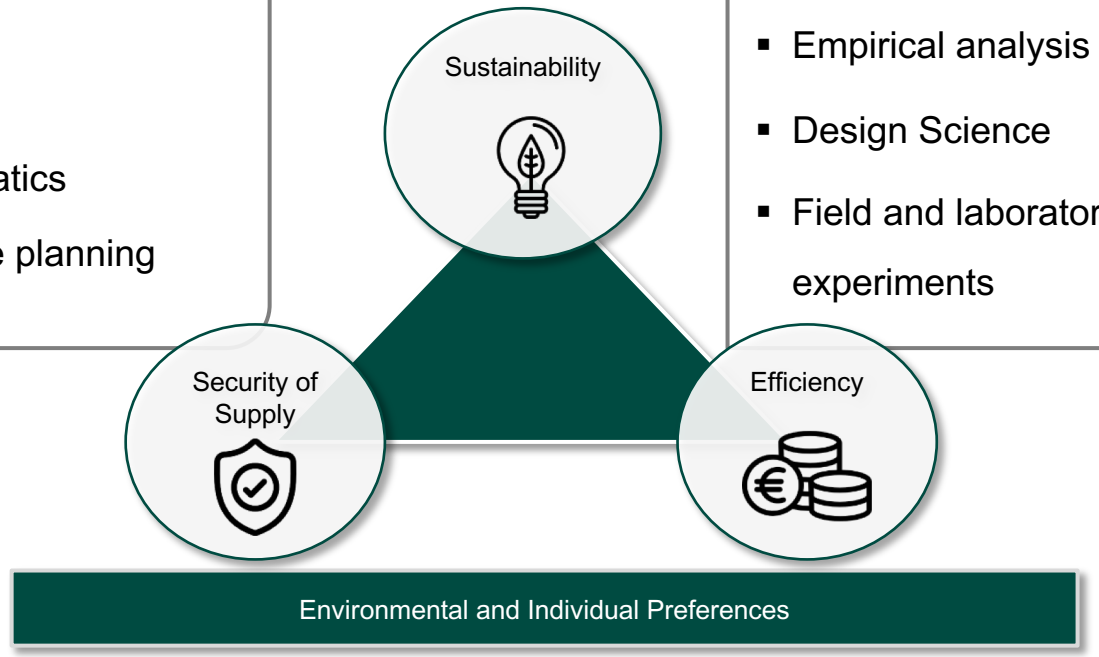
Smart Grids and Energy Markets

Research Focus

- Market design and architecture
- Demand side management
- Tariff design
- Energy trading
- Energy informatics
- Energy service planning

Methods

- Models, simulation and prototypes
- Optimization
- Empirical analysis
- Design Science
- Field and laboratory experiments



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Energy and Transmission Market Design

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Energy Regulations & Social Impact

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Smart Tariff Design

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E-Mobility & Charging Infrastructure

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Sector Coupling

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Motivation: Behavior in energy systems

Individual behavior

Economic behavior	Energy usage	Investment decisions
Economic efficiency	Consumption behavior	Energy infrastructure
Strategic bidding	Consumption decision	Decision process
Market power	Knowledge of energy usage	

Motivation: Behavior in energy systems

Individual behavior

Economic behavior

Energy usage

Investment decisions

The main objective is the motivation and formalization of behavioral research in the energy domain.

Strategic bidding

Consumption decision

Decision process

Market power

Knowledge of energy usage

Characteristics of behavior in the energy system

Consumption behavior

Low elasticity

Low flexibility

Costs Benefits of a conscious decision not meaningful

- Taking into account all information is not possible
- Cost of a decision are too high
- Sum of individual decisions (day/year) have a low impact
- Sum of all decisions of all individuals becomes relevant factor

Increasing share of EVs

Increasing demand

Sector linkage (heat)

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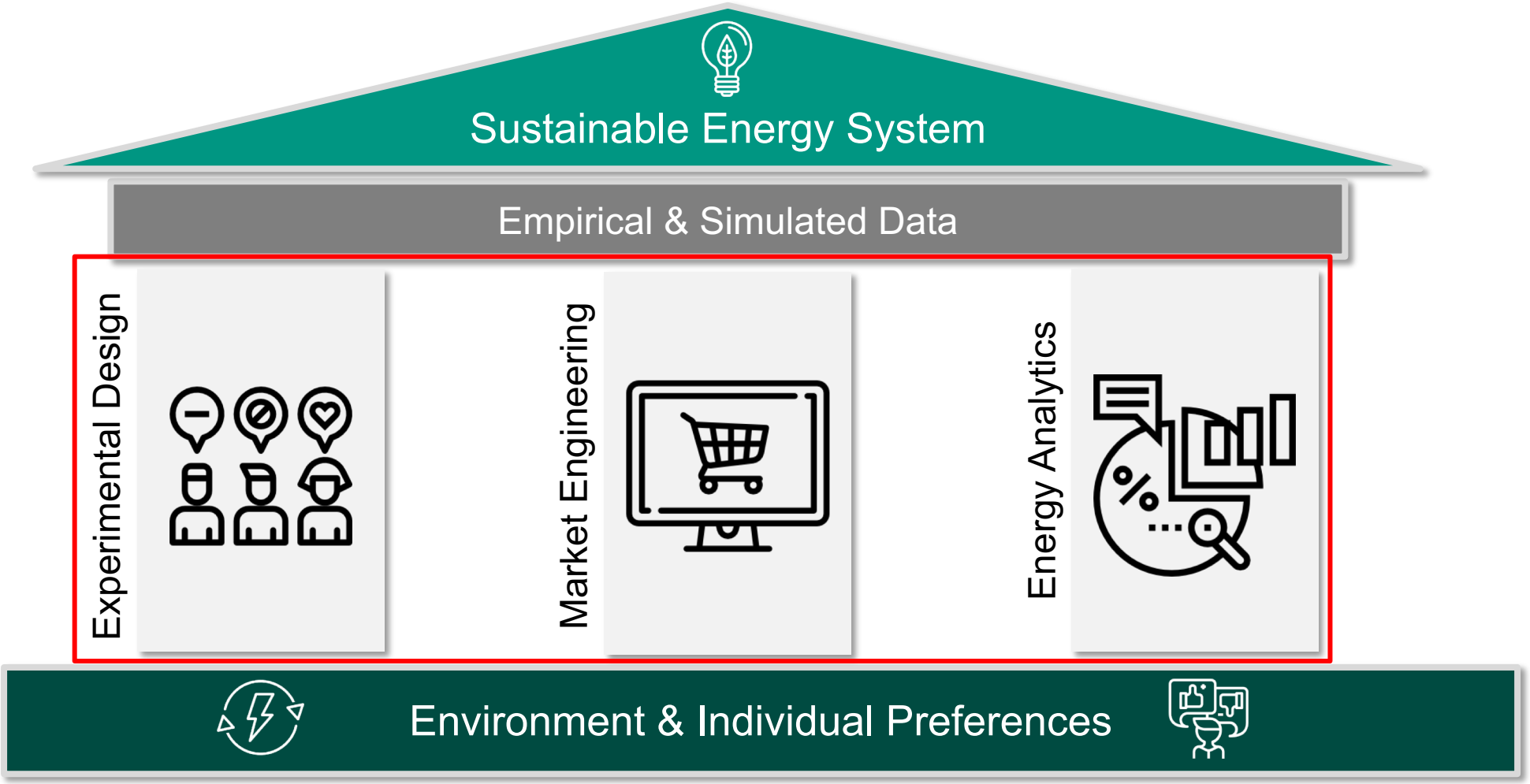
Research Framework for Behavioral Studies in Energy Economics



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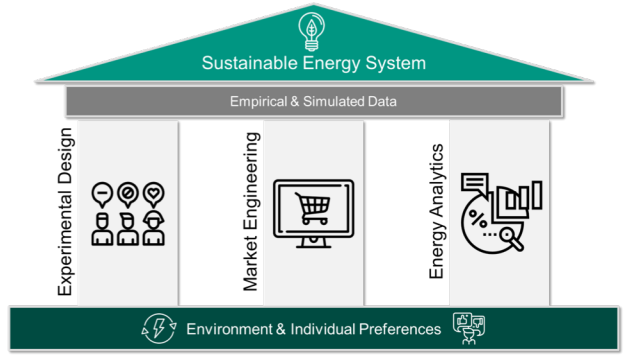
Market Engineering

Market Engineering

Design of efficient and effective mechanisms

- **Financial incentives**
- **Non-financial incentives**
- **Regulatory interventions**

Change behavior taking individual preferences and the social and legal environment into account.



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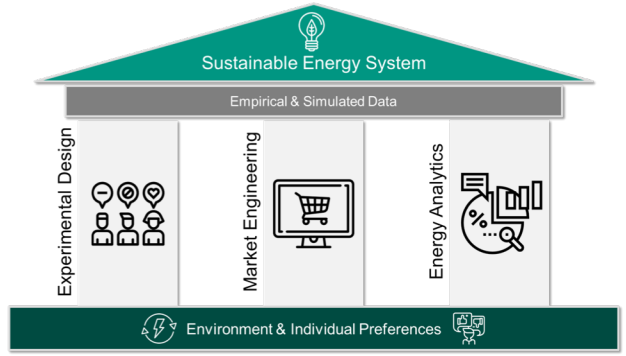
Experimental Design

Experimental Design

Initial mechanism design needs to be tested in its intended environment through experiments

- **Field experiments**
- **Lab experiments**
- **Surveys**

intended to find weaknesses of the developed approach and collection of empirical data



Energy Analytics

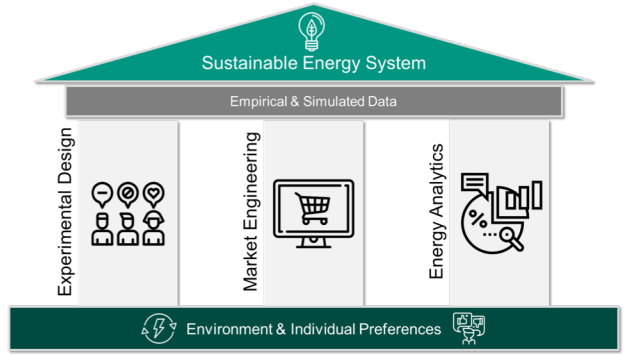
Energy Analytics

creation of empirical knowledge that can be used for the design of experiments or mechanisms

evaluation of generated empirical data

- **Performance evaluation**
- **Market efficiency**
- **Effect of policies**

provides further input for the creation/improvement of the original mechanism



Research process

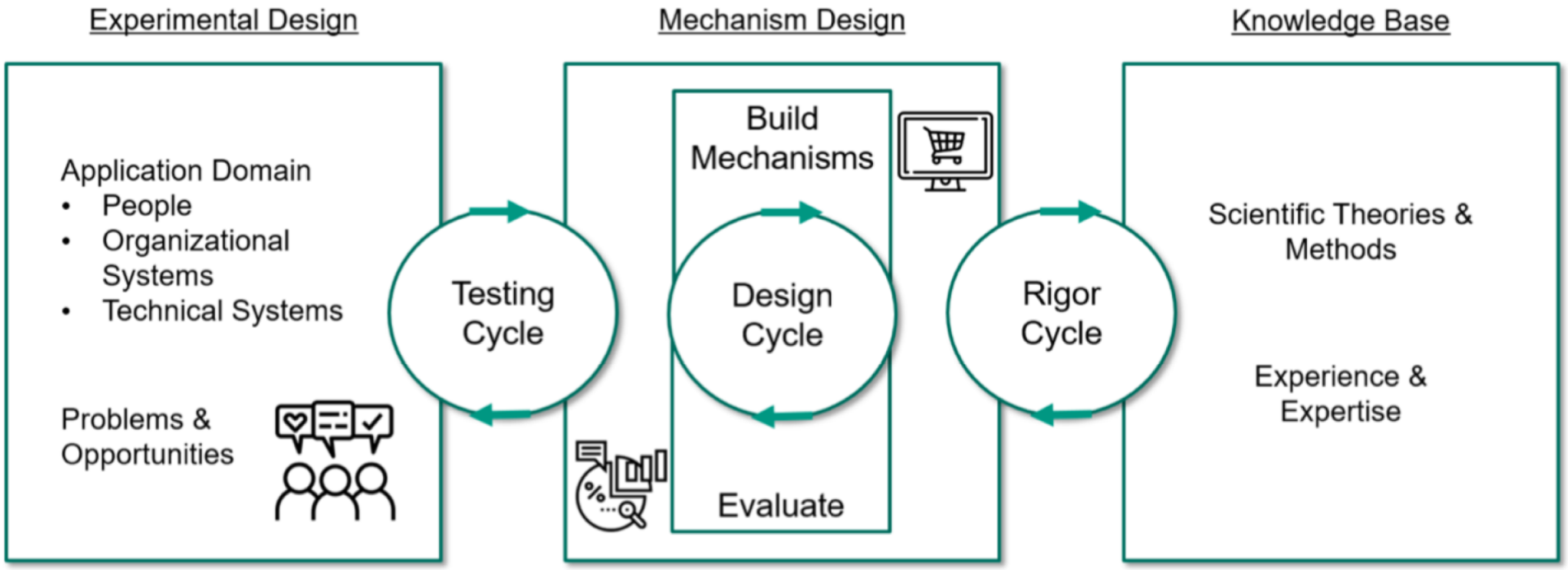


Figure 2: Research process based on the design science research cycle

Case Studies

- Local Energy Markets
- Tariff Design
- Range Anxiety
- Distribution Grid Congestion

Case study *Tariff Design* – Market Engineering

- Market Engineering: Design of time-of-use tariffs

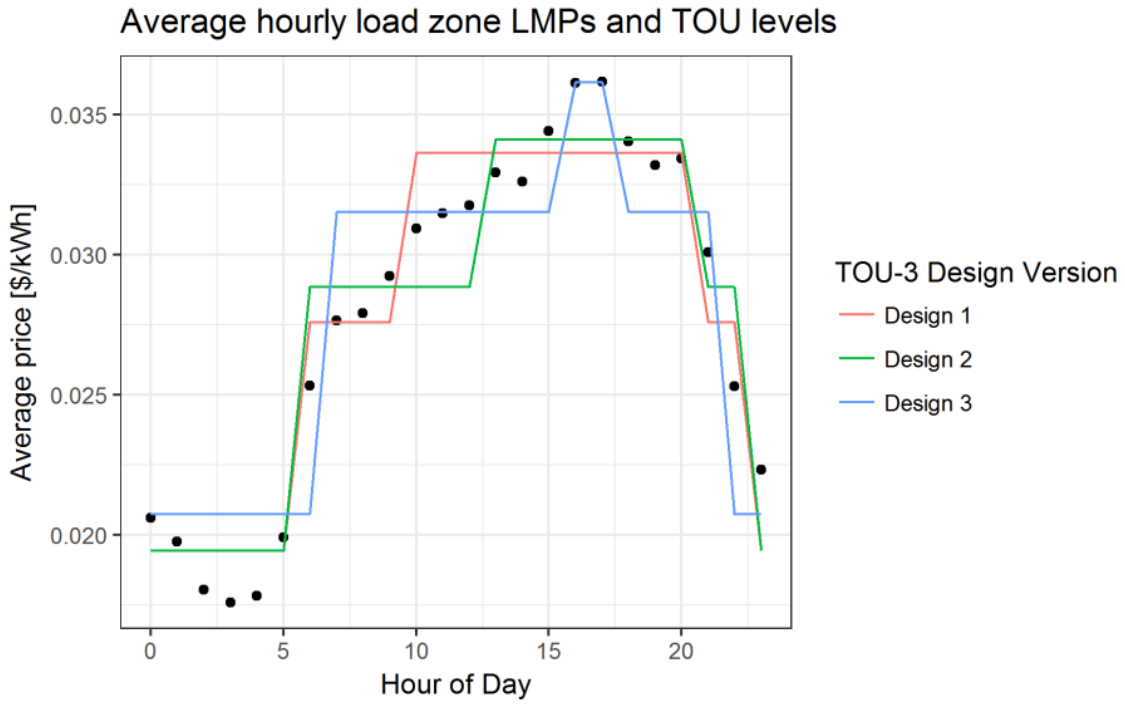
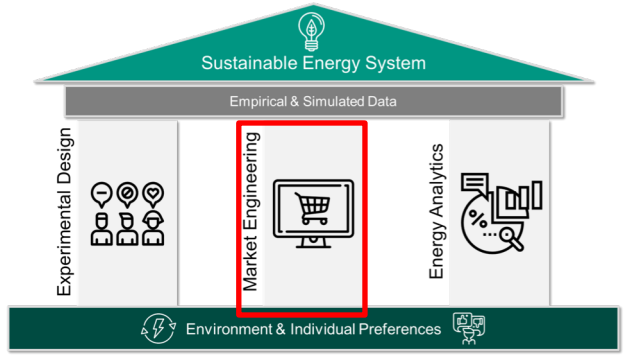


Fig. 1. Average hourly ComEd load zone LMPs in 2016 and derived 3-level TOU prices.



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Case study *Tariff Design* – Energy Analytics

- Energy Analytics: Data-driven evaluation of tariffs

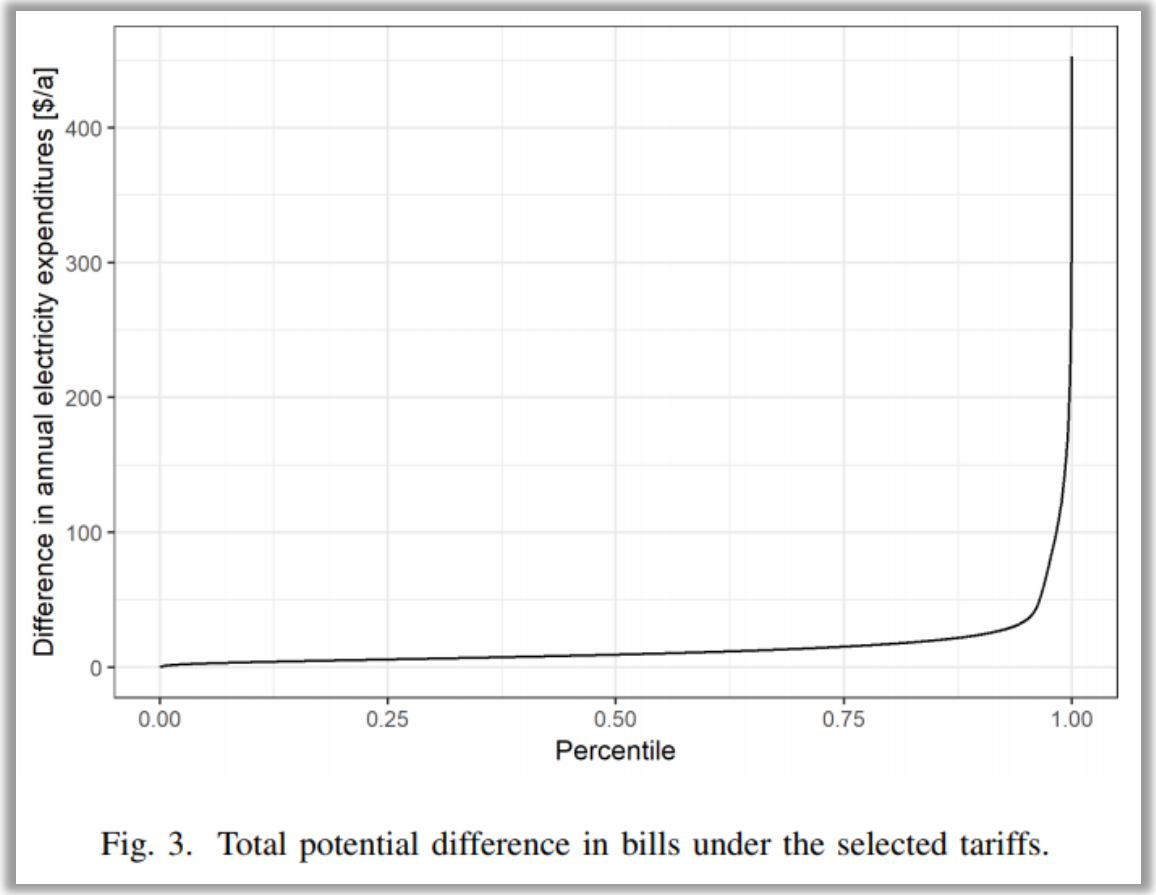
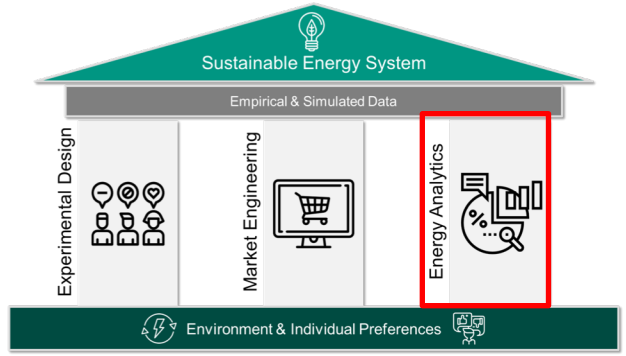


Fig. 3. Total potential difference in bills under the selected tariffs.

TABLE I
PROBABILITIES OF TARIFF CONFUSION

	Best annual tariff						
Best monthly tariff	Flat	TOU-3a	TOU-3b	TOU-3c	TOU-24	RTP	Total
Flat	0.1435	0.0130	0.0076	0.0083	0.1930	0.0398	**0.4051**
TOU-3a	0.0006	0.0082	0.0005	0.0006	0.0303	0.0080	0.0482
TOU-3b	0.0024	0.0016	0.0026	0.0003	0.0266	0.0072	0.0408
TOU-3c	0.0027	0.0014	0.0002	0.0020	0.0140	0.0034	0.0238
TOU-24	0.0187	0.0066	0.0029	0.0022	0.0602	0.0092	0.0999
RTP	0.0954	0.0191	0.0085	0.0082	0.1996	0.0513	**0.3822**
Total	**0.2634**	0.0500	0.0223	0.0216	**0.5238**	0.1189	1.000



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Case study *Tariff Design* – Market Engineering

- Market Engineering: Design of time-of-use tariffs

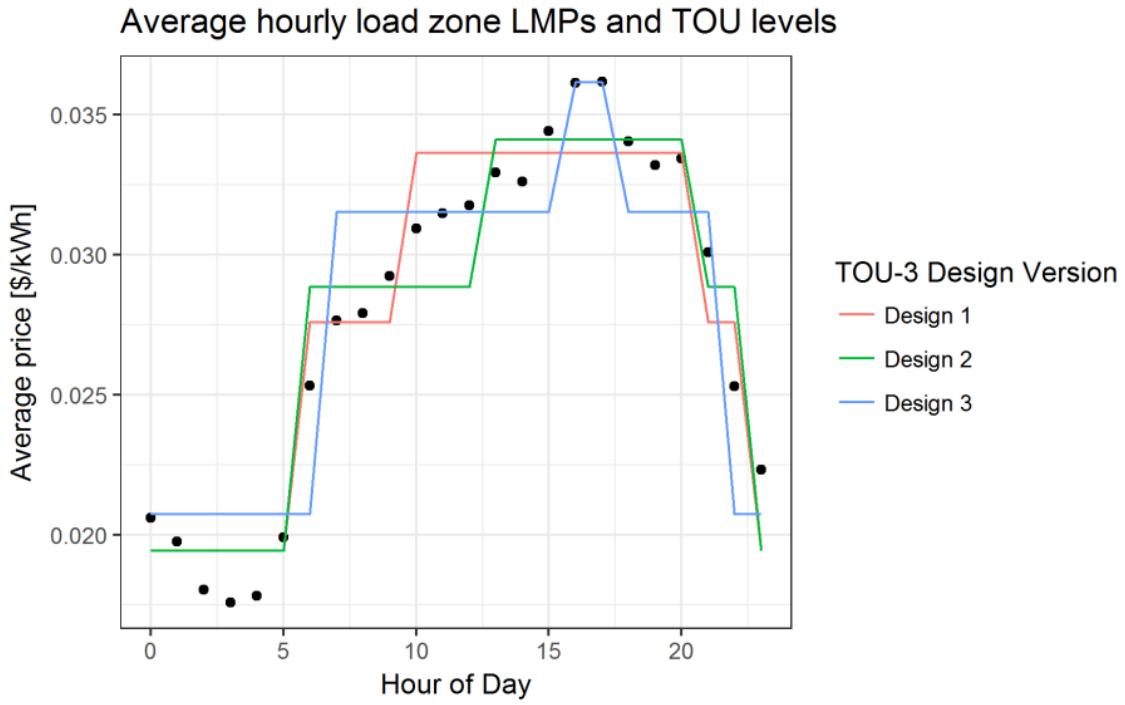
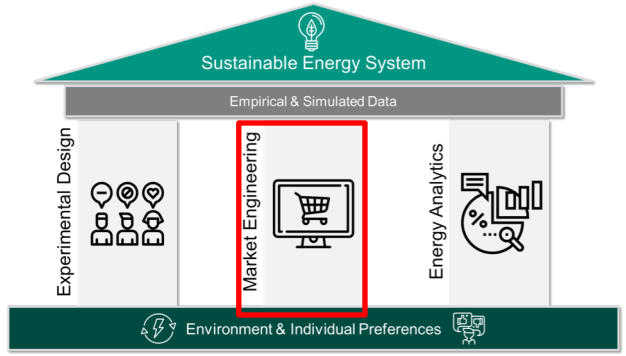


Fig. 1. Average hourly ComEd load zone LMPs in 2016 and derived 3-level TOU prices.

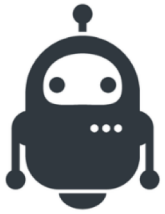
Question:
Individual has to choose optimal tariff?

Consumers can be unable or unwilling to select the tariff which is most cost-effective for them (Bundesnetzagentur and Bundeskartellamt, 2018; M. L. Nicolson, 2018)

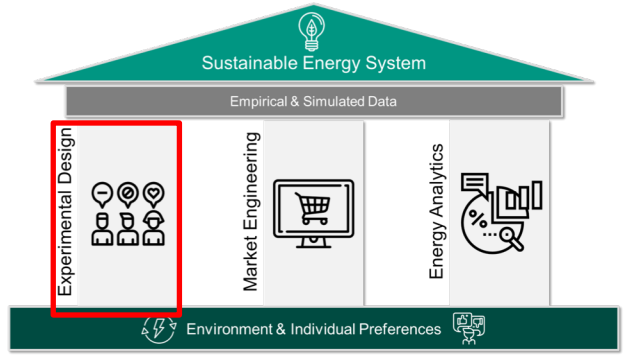


Tariff Design

- → Empirical experiments are needed to drive the analytical findings towards applicability
- Approach: Transfer learnings from *robo-advisor* research to the field of electricity tariffs (Jung, Dorner, Glaser, et al., 2018; Jung, Dorner, Weinhardt, et al., 2018)
- Controlled lab experiment, with representative sample panel
- → "Can a *tariff robo-advisor* support self-selection of people into beneficial time-varying tariffs?"



Support mechanism



Thank you for your attention