



**conect**

Conference of Environmental  
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# **Multiplayer game for energy communities**

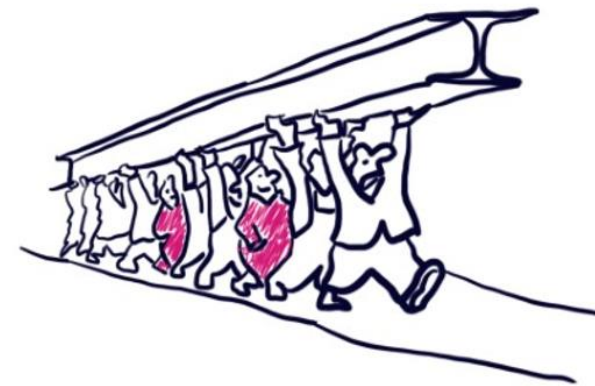
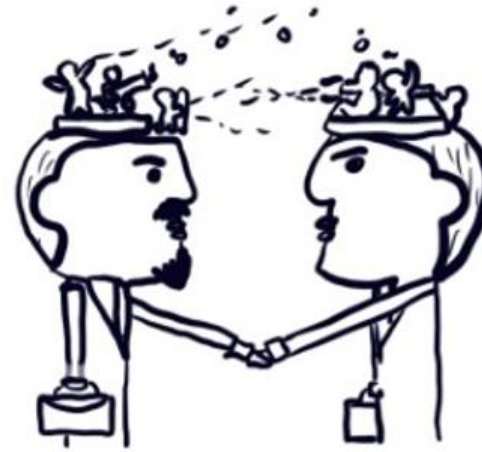
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**Riga Technical university**

**12.05.2022.**


# Social dilemma: Prisoner's dilemma

- the tension between individual selfish behavior and collective interest, where everyone, pursuing the former, achieves an overall lower welfare than cooperation would instead ensure
- prisoner's dilemma tends to arise in strategic interactions
- free rider problem arises when considering public and common goods





# Example: Dinner's dilemma game

**Round 2**  
Total Cost 70

**You choose lobster** 


$$\frac{\text{Quality } 400}{\text{Cost } 23.33} = \text{DP } 17.1429$$


**Player 2 choose hot dog** 

**Player 3 choose lobster** 

**UI1** **Total DP**  
29.1429

**Turn 1 - Round 3**  
Please make your choice

  
Quality 200  
Cost 10  
**Choose hot dog**

  
Quality 400  
Cost 30  
**Choose lobster**

Jiang T, Fang H (2020) The influence of user interface design on task performance and situation awareness in a 3-player diner's dilemma game. PLOS ONE 15(3): e0230387. <https://doi.org/10.1371/journal.pone.0230387>  
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0230387>

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# Energy community as social dilemma

Theory of interaction:

- Social dilemmas and collective decision-making with **common interests**:
  - Collective action
  - Instability of common choice
- Bargaining over **conflicting interests**
- Autarky and autonomy issues in energy communities



# Bridging the carbon neutrality gap in energy communities: social sciences and humanities meet energy studies (BRIDGE)



<https://twitter.com/Prusis/status/1267433323095379980>



# The goal of the project

to develop a policy simulation tool for policy makers

to study alternative business models for carbon neutral urban neighborhood energy communities by considering different psychological and social behavior aspects

in small-scale cooperatively organized energy systems



Market survey about energy saving and RES practices



Game 1:  
**Laboratory**  
Single player



Game 2:  
**Design studio**  
Single player



Game 3:  
**Practice ring**  
Multi player

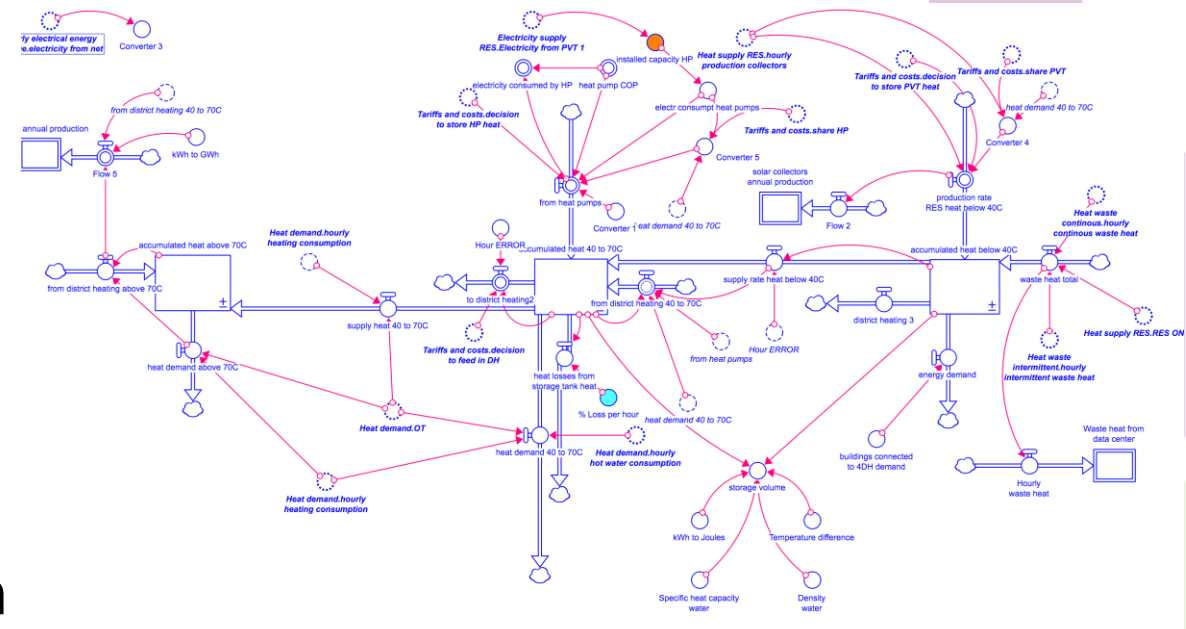


Game 4:  
**Negotiation table**  
Multi player

Decision making and policy simulation tool

# The model

- System Dynamics model: time step 1 day
- Stella Architect software
- Internet based single/multi player game
- Interactive Learning Environment
- User's behaviour tracking
- Three sectors:
  - Energy demand
  - Energy production
  - Transportation
- Decisions for investments and operation
- Tailor made for particular energy community





# The model

## Energy demand

- Increasing thermal resistance of building envelope
- Changing energy consuming technologies

## Energy production

- PV: roofs and walls
- PVT
- Heat pumps
- Energy accumulation: heat and electricity
- Business models: P2P, net metering, etc.

## Transportation

- Changing cars
- Transport sharing
- Business models

- Detailed data about each:
  - building
  - energy production technology
- Investment costs from Danish Energy Agency database and other sources



# Decision making indicators

- Payback time
- Total investment
- Specific investment: EUR/m<sup>2</sup> or EUR/apartment
- Quality of life?
- Reduction of CO<sub>2</sub> emissions?
- Quality of life/payback time?





# Single player game: The first prototype



## ENERĢĒTIKAS KOPIENA PILSĒTAS KVARTĀLĀ

talak

**LŪZDU, VEICIET UZLABOJUMUS KATRĀ NO SEKTORIEM, LAI SASNIEGTU MĒRĶI!** SAKOTNĒJAS VĒRTĪBAS PABEIGT UZDEVUMU

**ENERĢIJAS TAUPIŠANA**

Mainīti laģi, %

Nomainītās elektroiekārtas, %

Siltinātā platība, %

Enerģijas ietaupījums, %

Iet uz enerģijas taupīšanu

**ENERĢIJAS RAŽOŠANA**

Saules enerģijas tehnoloģijām izmantotā jumtu platība, %

Saules enerģijas tehnoloģijām izmantotā fasāžu platība, %

Kvartālā saražotā siltumenerģija, % no patēriņa

Kvartālā saražotā elektroenerģija, % no patēriņa

Uz enerģijas ražošanu

**TRANSPORTS**

Automobiļu skaita samazinājums, %

Benzīna auto, %

Elektroauto, %

Koplietošanas transports, %

Velo un skūteru skaits, %

Uz transportu

**ENERĢIJAS TAUPIŠANA** ? Atriesties kopējā lapā

Subsidijas ēku siltināšanai, %

0 25 50 75 100

Kultūrvēsturiskās ēkas

Vērtīgā apbūve

Pārējā apbūve

ĀRSIENU SILTINĀŠANA NO ĀRPUSES

ĀRSIENU SILTINĀŠANA NO IEKŠPUSES

JUMTA SILTINĀŠANA

LOGU MAIŅA

IEKĀRTU NOMAINA UZ ENERĢOEFEKTĪVĀKĀM

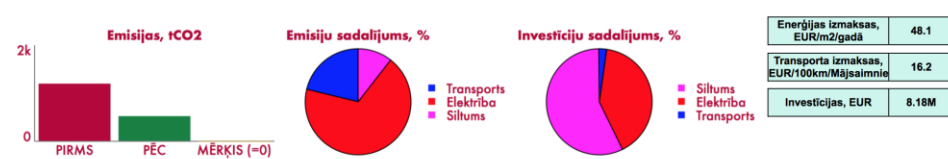
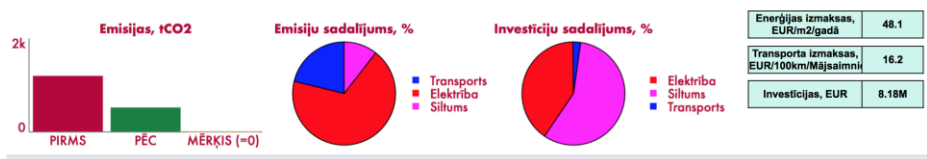
PAGRABA SILTINĀŠANA

Mainīti laģi, %

Nomainītās elektroiekārtas, %

Siltinātā platība, %

Enerģijas ietaupījums, %



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Powered by isee systems, inc.



# Single player game: The first prototype

- Tested in three user groups
- Positive feedback
- Feedback integrated in the second prototype:
  - Tailor made model for a community
  - Three levels of users:
    - Simple
    - “Informed school teacher”
    - Experts and advanced users



# Multiplayer game: the first prototype

### USER INPUTS

Room temperature, C: 18 22 26

Stairwell:  Floors:

Water consumption, m3/p/yr:  Electricity consumption, kwh/m2/yr:

#### ENERGY PRODUCTION

Photovoltaic panels, %:

Production area, %:

#### ENERGY CONSUMPTION

Wall insulation thickness, cm:

Roof insulation thickness, cm:

Foundation insulation thickness, cm:

Replacement of electrical equipment:

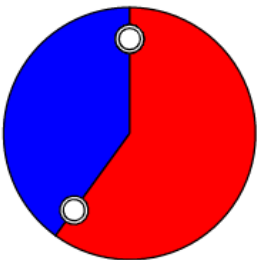
Window replacement:

#### TRANSPORT

Vehicle use, Days/Week:

Travel distance, km/day:

Car sharing proportion, %:

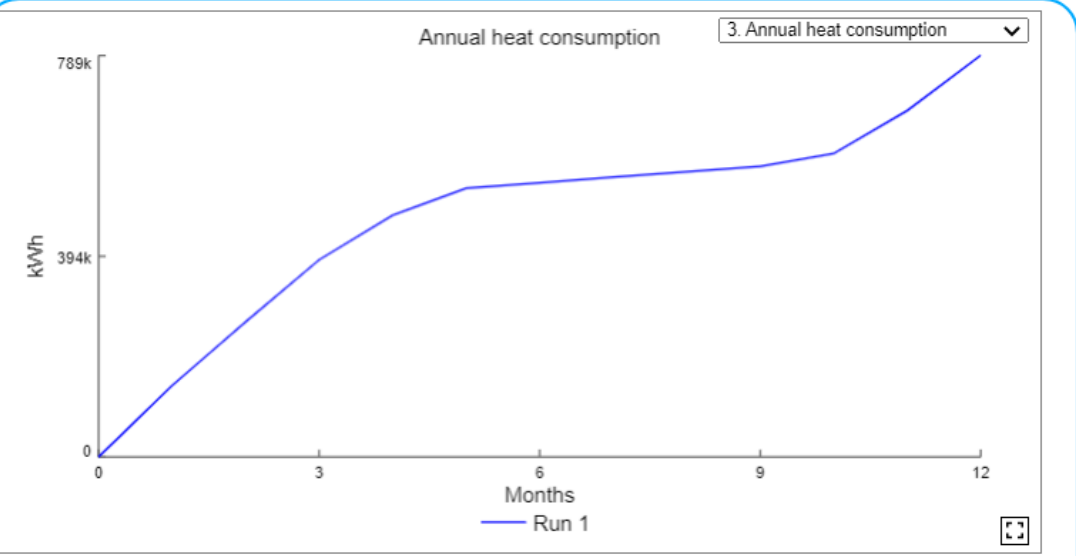


- Gasoline 40%
- Diesel 60%
- LPG 0%
- Electricity 0%

### APARTMENT MEASURES

### RESULTS

Annual heat consumption: 3. Annual heat consumption



kWh

Months

— Run 1

Financial gain, EUR/yr	NaN	Investments, EUR	0	Surplus electricity, kWh	0
Energy costs, EUR/yr	99,1k	Payback time, yr	0	Surplus heat, kWh	0
				Transport expenses, EUR/100km	13,2



# Conclusions

- Single player games as Laboratory and Design studio are developed and tested
- Positive feedback is received about game mechanics, interface and applicability
- The first prototype of multi player game is built and is under further construction



# Further activities

- Adding optimal solution as the starting point for the game
- Visualisation of past activities
- Visualisation of impact of potential measures
- Single and multi player game tests with building managers in the selected neighbourhood







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