ENERGY EFFICIENCY REGION ZLATIBOR

Evaluation and development of energy efficiency measures related to existing public building infrastructure through the application of Austrian technologies in the city of Užice, Zlatibor region

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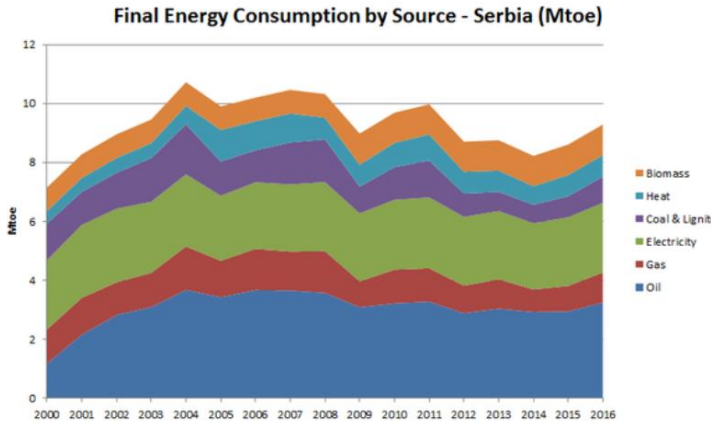
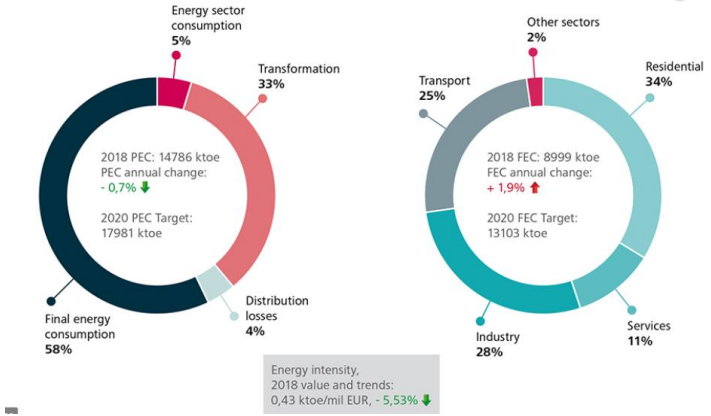
ENERGY USAGE / ENERGY EFFIENCY

- Renewable energies are still underpresented
- Around 1/3 of energy usage in residential and industry sector
  - high potential for optimisation

- 2 options to implement energy efficiency:

construction	energy saving = reduction of needs (thermal / electrical) + efficient engineering	energy requirements
operation	energy saving = adaptability (use / need) + communication of components	energy consumption





ENERGY EFFICIENCY IN PUBLIC BUILDINGS IN UŽICE

- Project 05/20-04/21
  - Aim to show possibilities to overcome market barriers & implement energy – efficiency measures in public buildings and
  - promote cooperation and business amongst Austrian companies and institutions

National Theater

Primary School

Swimming Pool

BASELINE & DETAILS
PUBLIC BUILDINGS IN UŽICE

METHODOLOGY, METHODS AND TOOLS

- Simulation-based evaluation of energy efficiency measures
  - Development of baseline simulation model
  - Calibration of baseline simulation model against monitoring data
  - Definition of energy efficiency measures
  - Simulation of energy efficiency measures
  - Comparison of energetic and ecological with conversion factors
  - Economic evaluation with the annuity method

Climate file — meteonorm

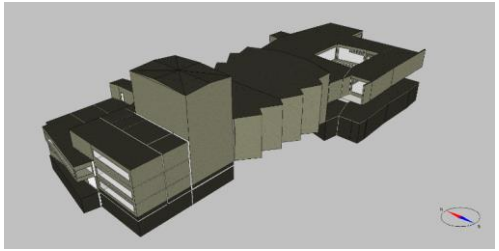
Dynamic building simulation — IDA ICE by EQUA

PV simulation — PVsites

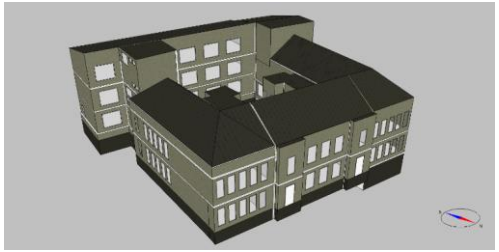
Economic evaluation — Excel, python

DETAILS OF THE BUILDINGS

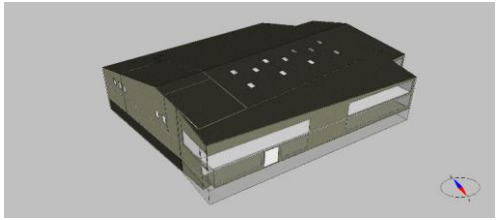
Theatre	Theatre - Narodno pozorište, Užice
Owner	Grad Užice \ Narodno pozorište Užice
Adress	Trg partizana 12, Užice
Heated Floor area	4,614 m^2
Average U-Value	1.20 W/(m^2K)
Heat delivery	Radiators



School	Primary school OS "Dušan Jerković", Užice
Owner	Grad Užice \ OŠ "Dušan Jerković", Užice
Adress	Trg Svetog Save 22, Užice
Heated Floor area	3,463 m^2
Average U-Value	1.42 W/(m^2K)
Heat delivery	Radiators



Swimming pool	Indoor pool – Gradski Bazen
Owner	Grad Užice \ JP "Veliki park", Užice
Adress	Nemanjina 150, Užice
Heated Floor area	5,063 m^2
Average U-Value	0.59 W/(m^2K)
Heat delivery	Floor heating



ASSUMPTIONS FOR THE SIMULATIONS

- Typical weather data for Užice generated with the software tool Meteonorm
- Construction properties from available documentation
- Internal loads and schedules from SIA 2024, adapted for energy demand to fit measured data
- Conversion factors

Energy carrier	gCO_2/kWh	Primary energy factor	Source
Electrical energy	1100	3.015	Client
District heating (Uzice)	290	1.563	Client
Natural gas	236	1.10	Serbian norm

DEFINITION OF BASELINE & ENERGY EFFICIENCY MEASURES

- **Theatre**
  - Improved insulation of the thermal envelope
  - Ventilation with heat recovery
  - Local Combined Heating and Power plant
  - PV System
    - Optimized area 56 kWp
    - Maximal area 82 kWp

Theatre	Final energy in MWh	CO2 emissions in tCO_2	Primary energy in MWh
Measured in 2019			
Electricity	67.6	74	204.0
District heating	90.4	26	141.2
Simulation results			
Electricity	74.4	82	224.3
District heating	126.3	37	197.4

DEFINITION OF BASELINE & ENERGY EFFICIENCY MEASURES

- **Elementary School**
  - Insulated exterior walls
  - Insulated exterior walls + improved windows
  - LED lighting
  - Ventilation with heat recovery
  - PV System
    - Optimized area 23 kWp
    - Maximal area 60 kWp

School	Final energy in MWh	CO2 emissions in tCO_2	Primary energy in MWh
Measured in 2019			
Electricity	67.6	74	203.7
District heating	335.8	97	524.8
Simulation results			
Electricity	65.8	72	198.5
District heating	375.8	109	587.4

DEFINITION OF BASELINE & ENERGY EFFICIENCY MEASURES

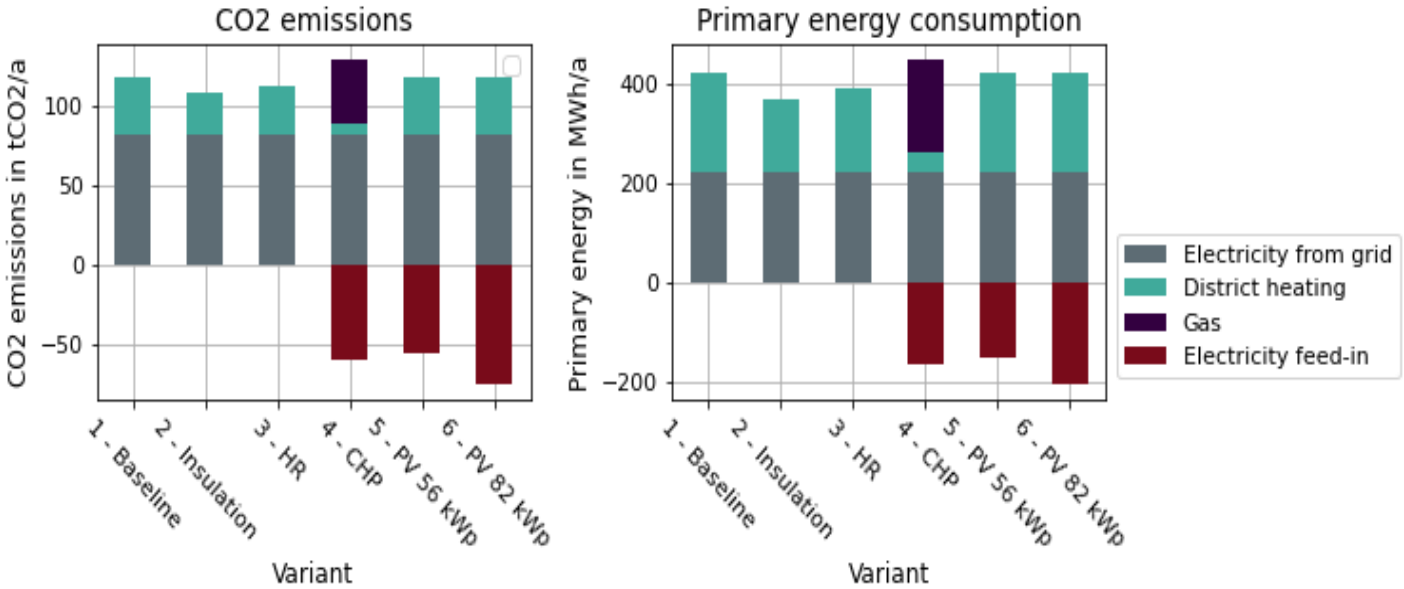
- **Swimming pool**
  - Air-to-water heat pump
    - Monovalent
    - Bivalent
  - Solar thermal system
  - PV system 90 kWp

Swimming Pool	Final energy in MWh	CO2 emissions in tCO_2	Primary energy in MWh
Measured in 2019			
Electricity	604.8	665	1823.5
District heating	877.2	254	1371.1
Simulation results			
Electricity	599.1	659	1806.3
District heating	912.2	265	1425.8

SIMULATION RESULTS

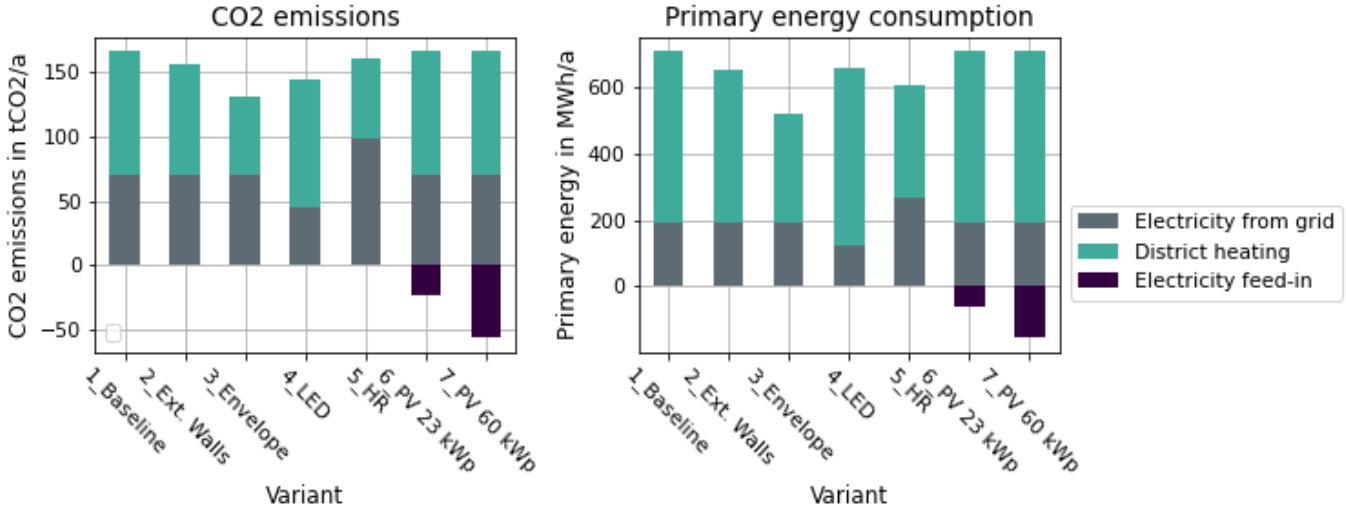
THEATRE BUILDING

- Insulation/heat recovery: moderate decrease in CO2 emissions
  - Heat demand in baseline already rather low
- CHP/PV: significant electricity production



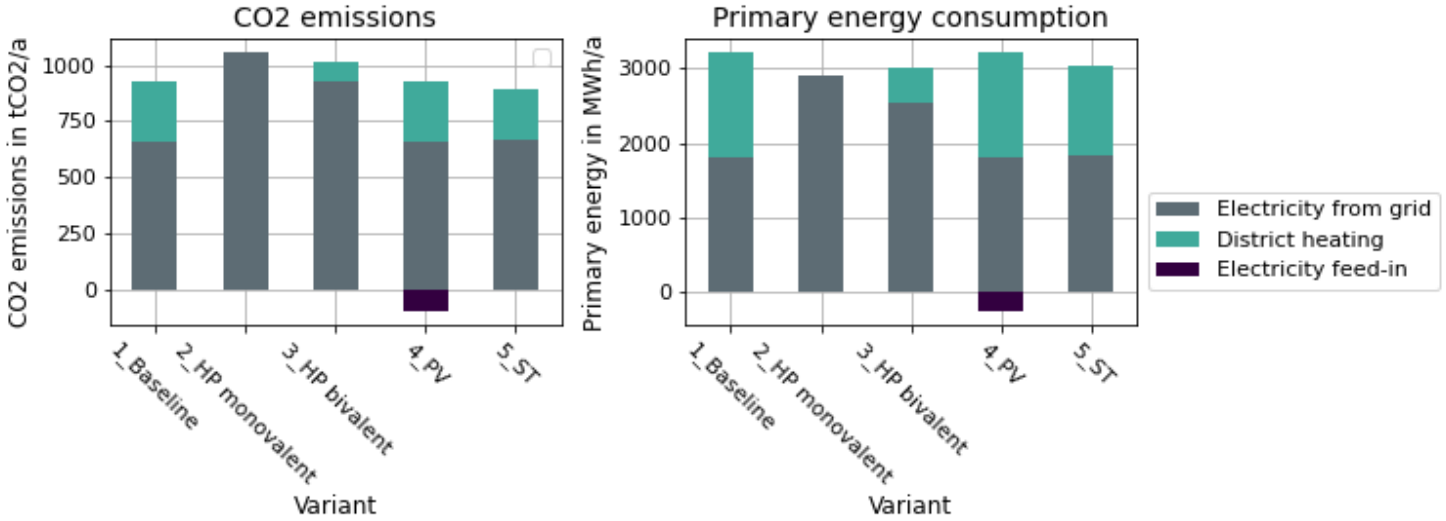
SCHOOL BUILDING

- Insulated exterior walls: 11% reduction of heat demand
- Insulated exterior walls + improved windows: 36% reduction of heat demand
- LED lighting: 36% reduction in electricity demand but 4% increase in heat demand
- Ventilation with heat recovery: reduction of heat demand but increase of electricity demand (but presumably better air quality)



SWIMMING POOL

- Air-to-water heat pump: decrease in primary energy consumption but increase in CO2 emissions
- Solar thermal system: -6% primary energy, -3.5% CO2 emissions
- PV system 90 kWp: -8% primary energy, -11% CO2 emissions



CONCLUSION

- variety of different energy efficiency measures simulated in three public buildings depending on the actual situation
- results show:
  - reduction of primary energy use and reduction of CO2 emissions due to the set efficiency measures
  - results are highly dependent on the building layout, consumption and loads
  - relatively high investment costs for the measures due to cheap energy and electricity prices
    - wide range of payback times for the various energy efficiency measures

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TOMORROW TODAY

THANK YOU!

ECONOMIC EVALUATION

ASSUMPTIONS FOR THE ECONOMIC EVALUATION

- Economic parameters

	Unit	Value
Calculation interest rate	%/a	1.5
Observation period (T)	Years	20
Price increase for energy	%/a	2.0

- Energy prices

	Feed-in price in 0.01 €/kWh	Electricity price in 0.01 €/kWh	Heat price in 0.01 €/kWh
Theater	8.8	8.8	4.1
Swimming pool	7.9	7.9	8.0
School	8.7	8.7	12.6
Assumed price: average	8.4	8.4	8.2

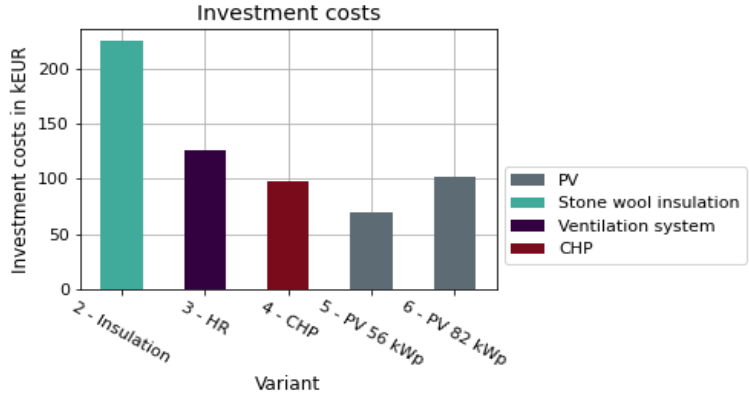
- Component investment costs

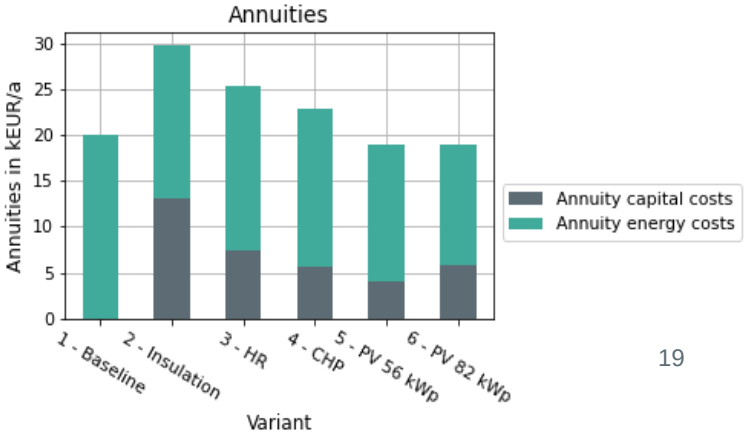
Component or system	Investment cost	Unit
Air-water heat pump (HP_AW)	600	€/kW
CHP plant around 75 kWel	1300	€/(kW)
PV system	170	€/m² module
Solar thermal swimming pool absorbers	120	€/m² collector
Stone wool insulation 10 cm thickness	100	€/m² wall
Triple pane windows	600	€/m² window

RESULTS OF ECONOMIC EVALUATION

Theater

- High investment costs to further reduce the (already low) heat demand
- Only PV system has payback under 20 years
- Other options could become viable if the building was to be used more often, or with a strong increase of energy prices, or justified by motivation to reduce CO2 emissions

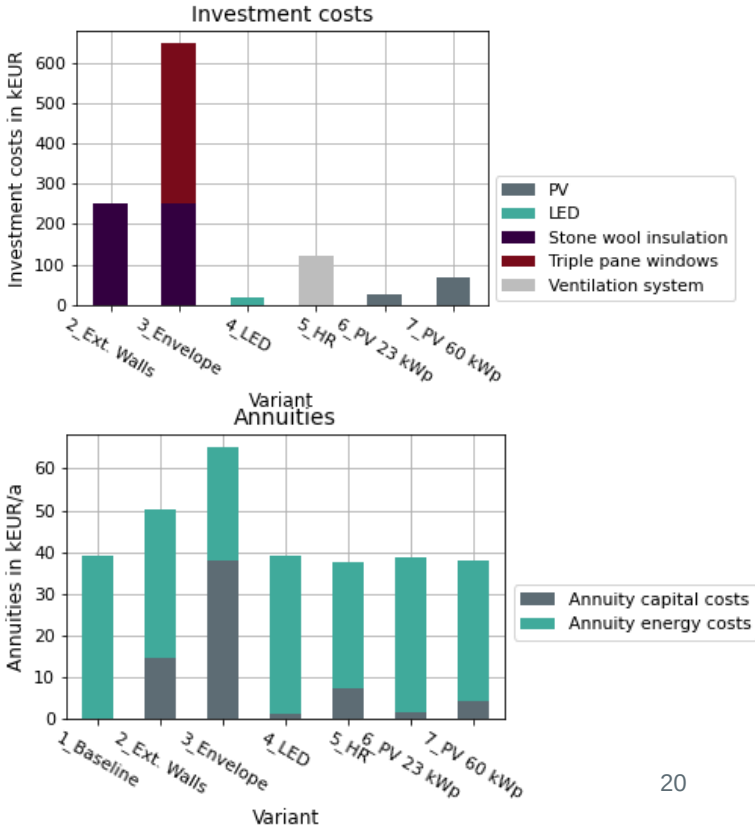




RESULTS OF ECONOMIC EVALUATION

School

- High investment costs for envelope refurbishment measures
- LED lighting and ventilation with heat recovery economically ~neutral over 20 years
- Shortest payback for small PV system
- Bundle of measures preferable for energy performance improvement



RESULTS OF ECONOMIC EVALUATION

Swimming pool

- All considered measures economically interesting
- Shortest payback time (under 2 years) with bivalent heat pump
- Lowest annuities with monovalent heat pump
- Payback time of solar thermal ~5 years
- Combinations could make it possible to achieve larger reductions in emissions and energy use with low payback time