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Impact of Microgrids concept on low voltage network reliability

Liang TAO
Christine SCHWAEGERL
Siemens AG
Germany

Nicolai HERRMANN
MVV Energie AG
Germany

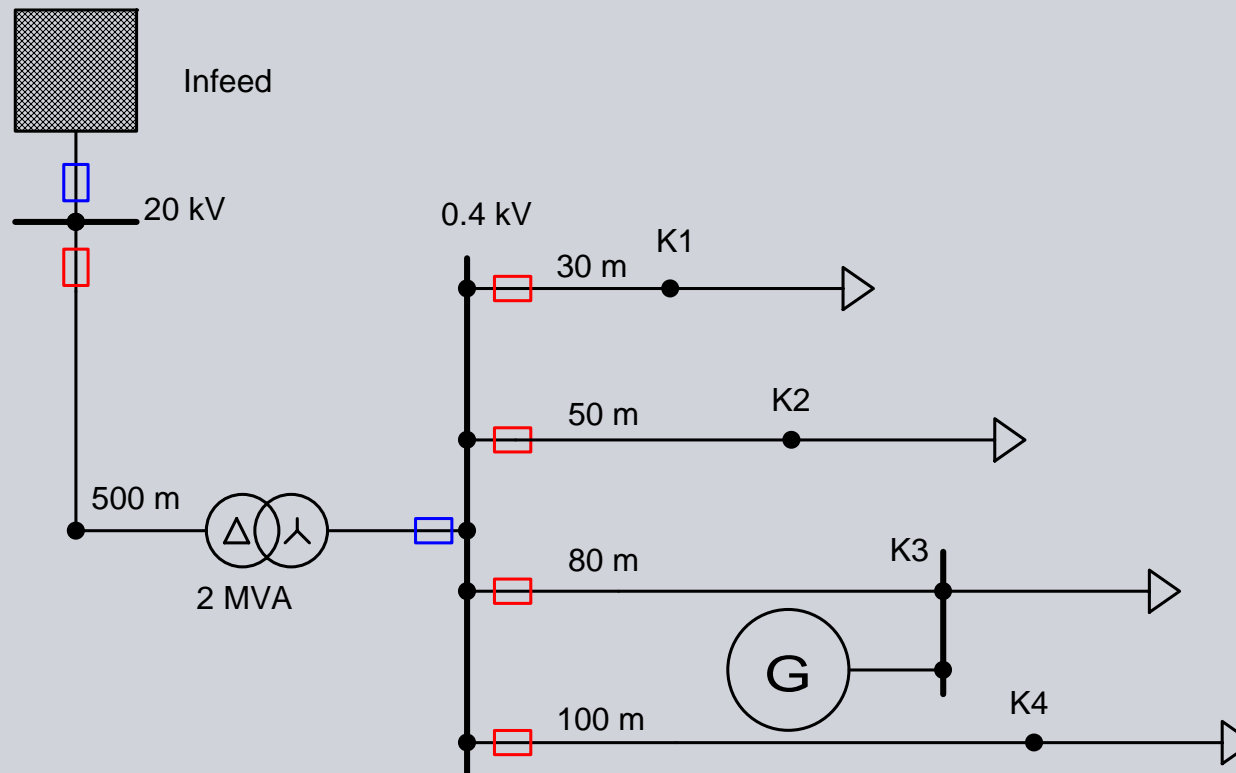


Reliability indices for stochastic outages

Symbol	Name	Unit
F_i	Frequency of supply interruption	1/a
D_i	Mean duration of supply interruption	h or min
Q_i	Unavailability	min/a
P_i	(Cumulated) Interrupted power	MVA/a
E_i	(Cumulated) Energy not supplied	MVAh/a
C_i	(Cumulated) Interruption cost	€/a



Test network to demonstrate effects of DG reliability impacts





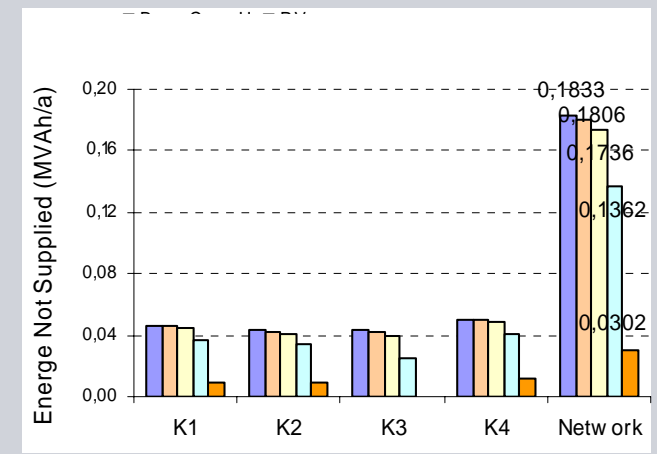
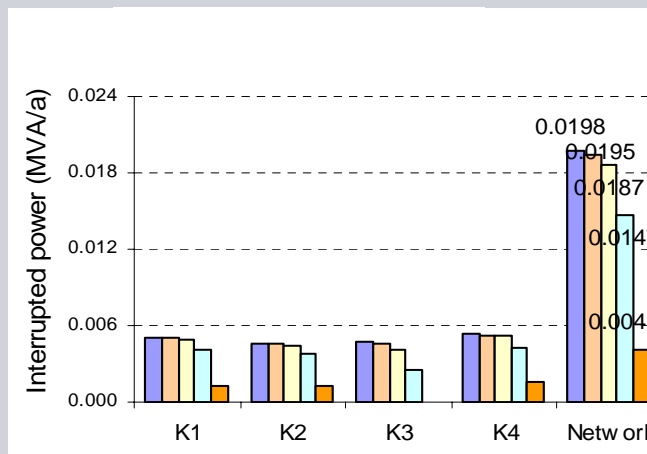
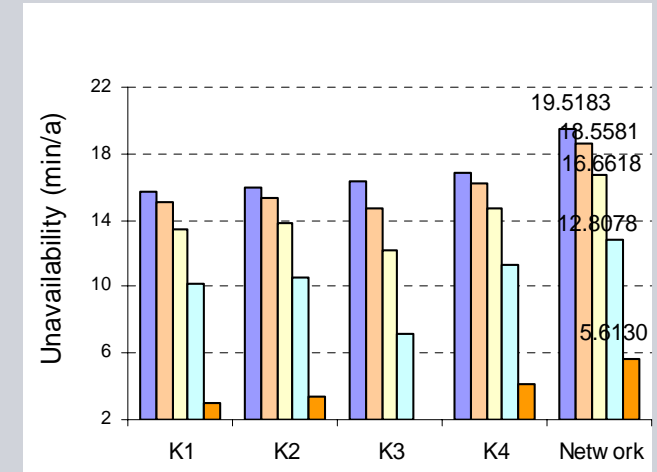
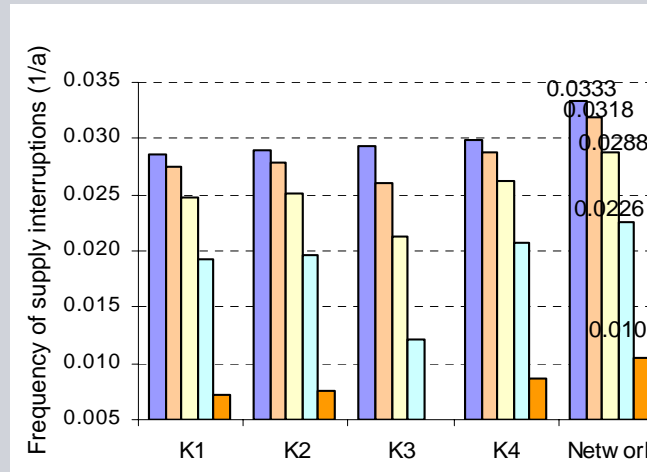
Comparison of reliability improvements by different DG types



➤ Reliability improvement increases with increasing full load generation hours of DG (highest for CHP, lowest for PV)

➤ Intermittency needs to be considered -> otherwise results are too good

- Without DG
- PV
- Wind
- CHP
- Non-intermittent DG



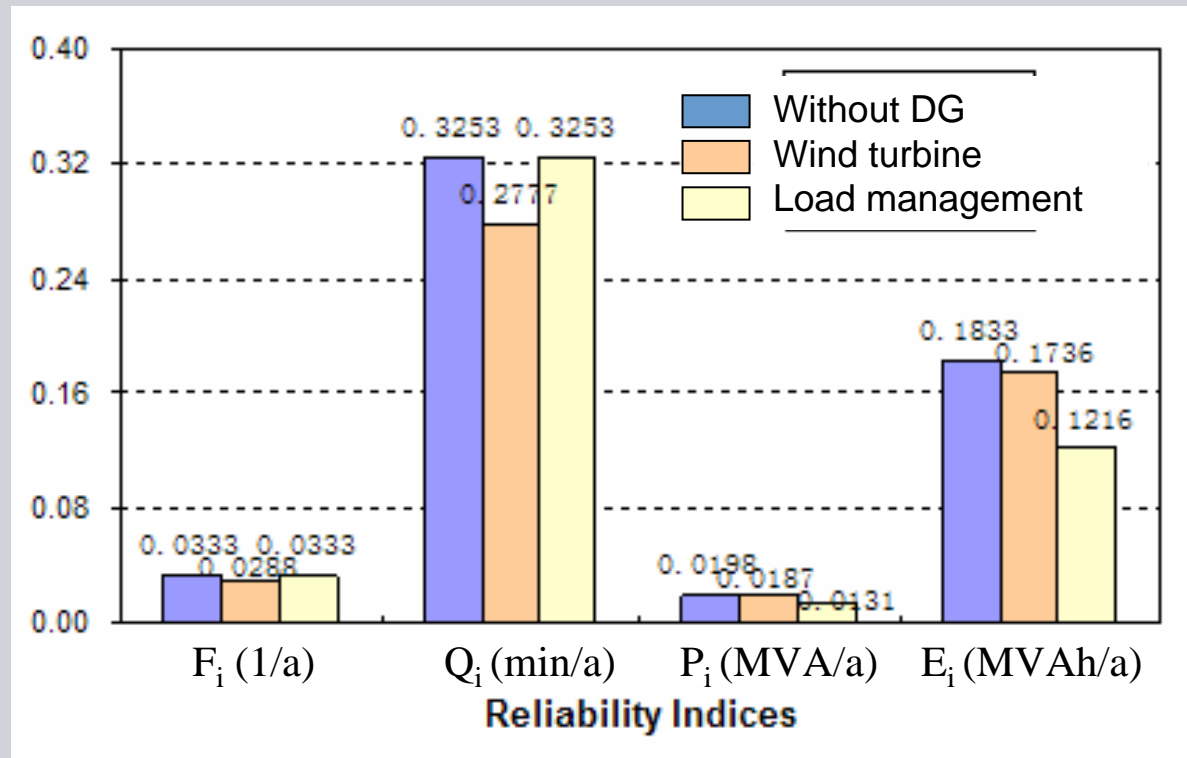
Assumption for figures:
Installed DER capacity equals total network load (100 % DG penetration)



Comparison of reliability impacts of DG connection and Demand Side Management

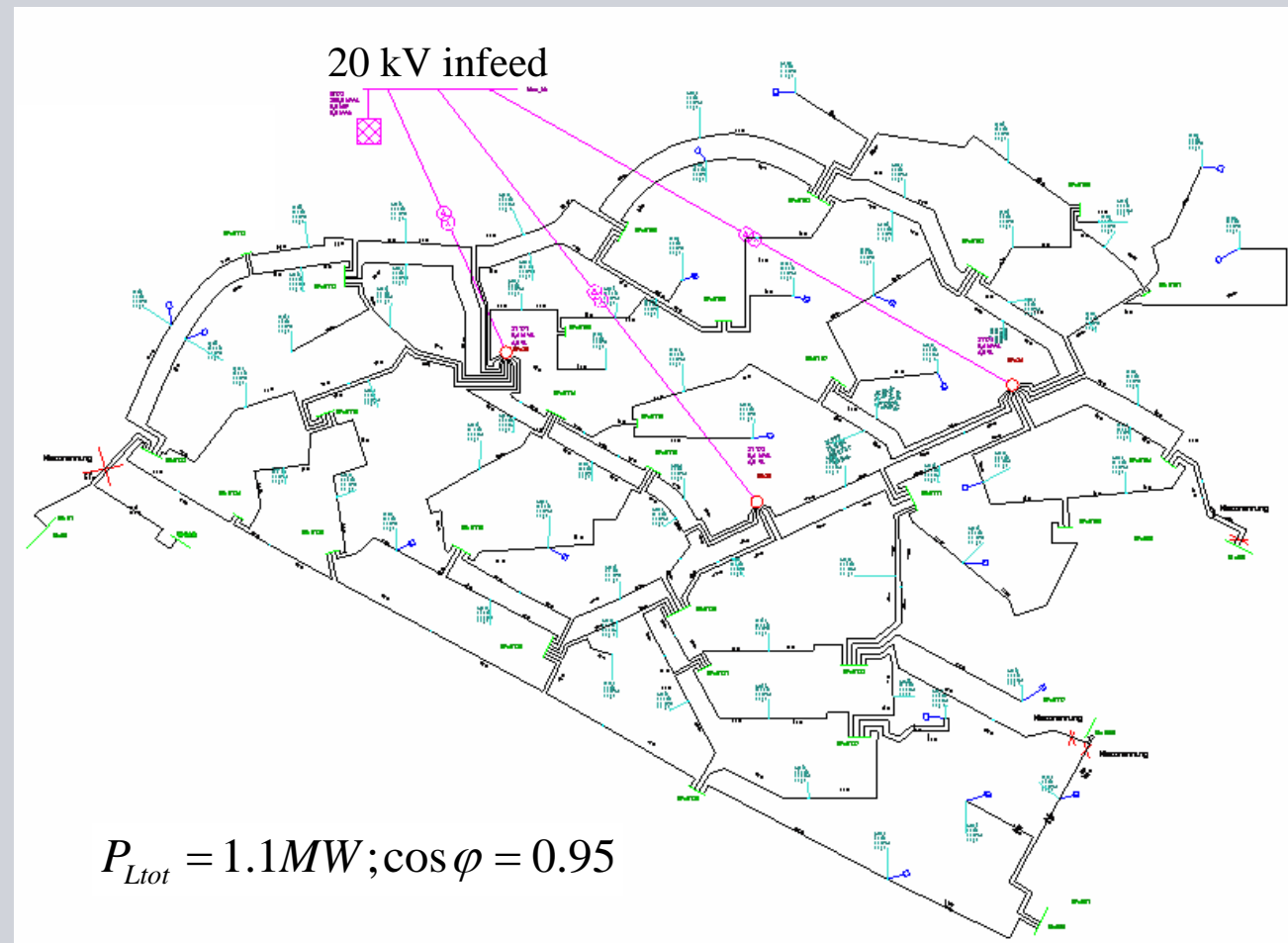


- Demand Side Management yields better P_i and E_i compared to intermittent DG
- DG units improve F_i and Q_i while Demand Side Management fails to do so





MVV, Mannheim, residential LV study network





Reliability results for case study network under various DG scenarios



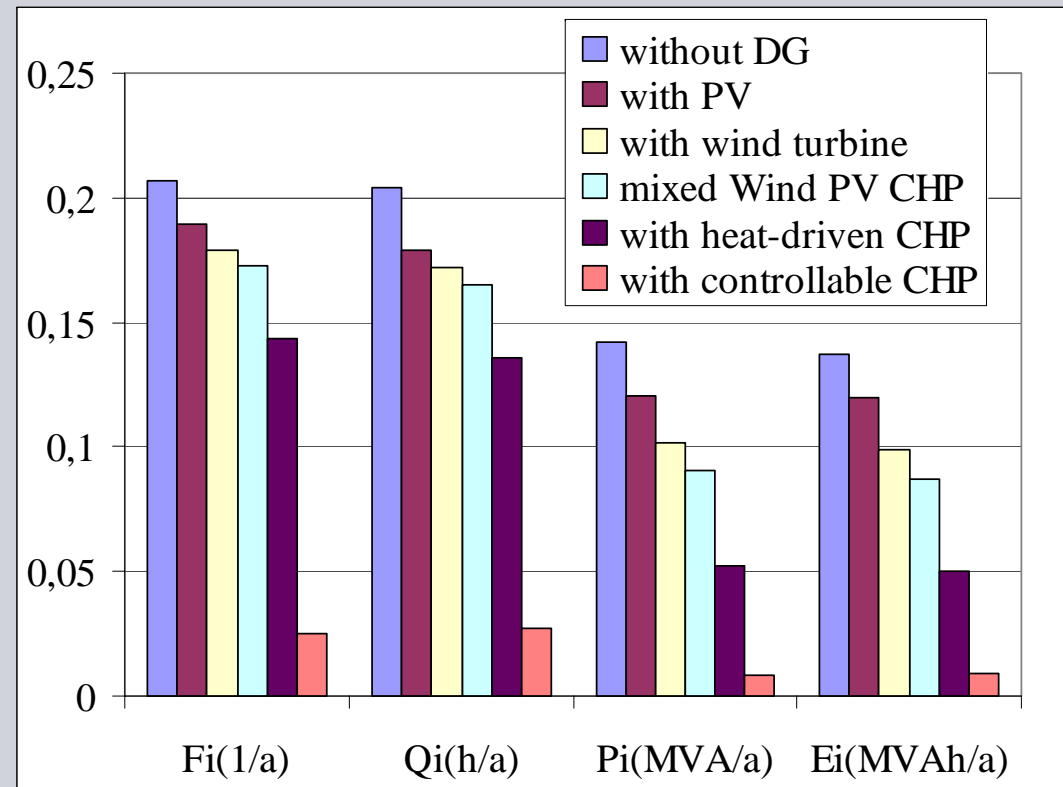
Assumptions:

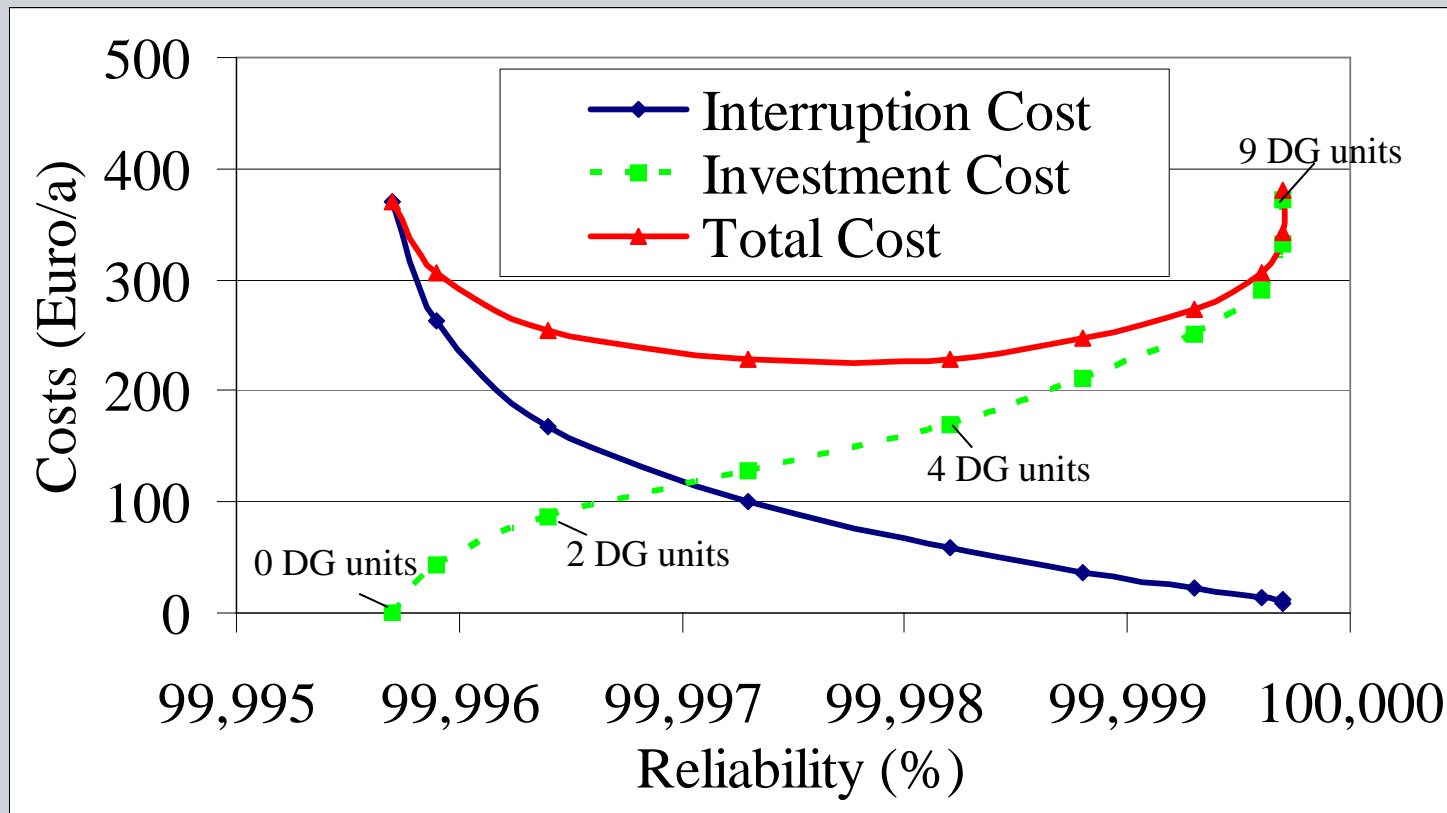
DG unavailability = 20 %

DG penetration level = 80%

Reliability evaluation results are consistent with those of simple test network:

PV < WT < CHP < Controlled DG





- A minimum total reliability cost exists when interruption cost and investment cost arrive at an optimized reliability index



Economic benefits from reliability improvement under Microgrid operation



Economic benefits are achieved when:

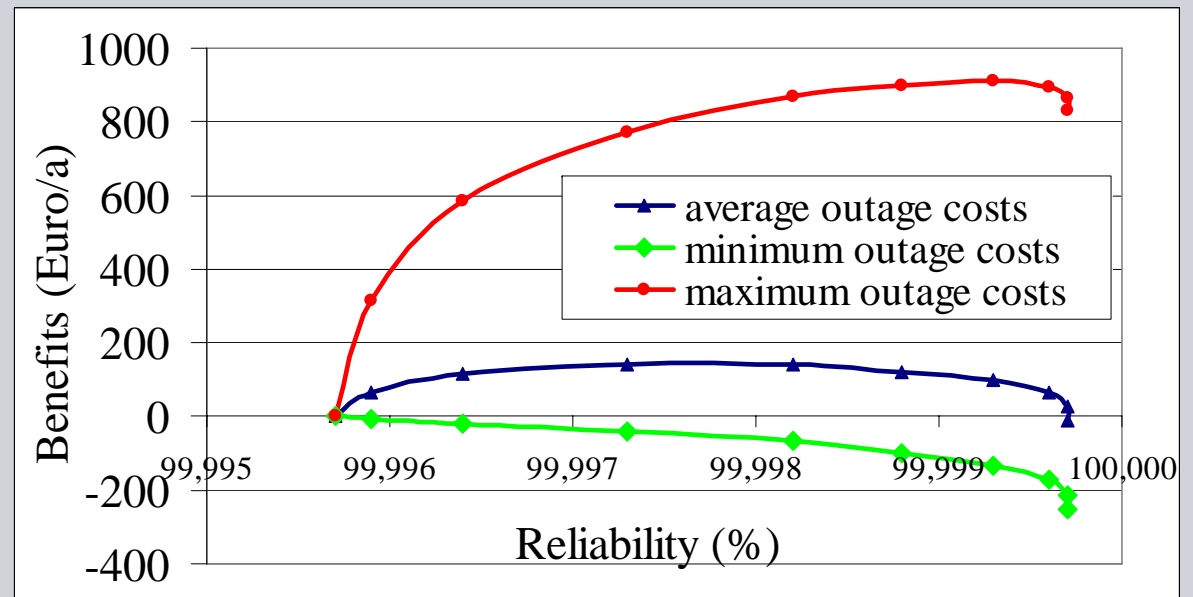
Installation and operation cost of protection and control devices
+ DG operation cost during outage
< savings in interruption costs

Maximum outage costs (5 €/kWh):

Nearly all Microgrid installations are economically beneficial

Minimum outage costs (0.5 €/kWh):

Microgrid operation is not economical from reliability point of view





- Renewable and non-controllable generation units contribute to reliability only if their intermittent output power is higher than simultaneous demand
- CHP plants contribute more to reliability improvement in comparison with intermittent PV or wind turbine units; conversion from heat-driven to electricity-driven mode enables island operation
- Economic benefits of the Microgrids approach concerning reliability rise with increasing outage costs, especially for commercial and industrial consumer segments



Thanks for your attention !