1. Introduction:
Heating electrification supplied by distributed renewable energy resources is considered among potential solutions towards mitigation of greenhouse gas emissions. In this thesis, roadmaps propose a wide deployment of heat pumps and photovoltaics in a residential sector in Vevey.

2. Objective:
The objective of this thesis focuses on developing practical and scalable methodologies for the Active Distribution Networks (ADN) planning, in order to safely integrate Heat Pumps (HPs) in the Low Voltage (LV) distribution network and at the same time increase the self-consumption of network customers, with making a particular reference to power curtailment strategy and the integration of Energy Storage Systems (ESSs) by the distribution system operators (DSOs).

3. Theory/Method:
An optimization tool has been developed in order to identify potential PV hosting capacity and battery location and size which is based on an Optimal Power Flow (OPF) algorithm that has a mixed integer linear DistFlow formulation [1] and taking into account the line shunt admittance. It is defined as a multi-objective optimization problem aiming at finding the optimal trade-off between technical and economical goals.

4. Hypothesis:
We have assumed in first the LV grid as a balanced radial distribution network so the study will be conducted regarding only one phase of the electric network. And second, we assumed that the grid is lossless in order to use the simplified Linear DistFlow formulation. Finally, we used critical weeks of the load demand and radiation profiles in order to sit a size PV instalations and ESSs.

5. Simulation results:
5.1. Nodal voltage magnitudes after integration of HPs (with and without ESSs):

By varying weights on the objective function we can find the optimal situation in terms of price/performance ratio. In our case study, we find that for a weight of battery cost equal to 0.7 and a fixed self-consumption weight equal to 0.9, we have a high PV penetration of 73% (1658 m² of PV modules with 15% efficiency) and the ability of covering half of electric and heat demands during 46.26% of the time, with a total battery installation of 1,188 MWh. The total cost is around 83’000 CHF per year for the horizon of 5 years (an assumed battery lifetime).

5.2. PV penetration vs. Battery installation vs. Self-consumption aspect:

6. Conclusion:
Optimally allocated ESSs represent a valid solution for DSOs that want to increase a safe penetration of PVs used to cover additional demand of HPs and in the same time increase the self-sufficiency of their customers. It increases the lifetime of grid infrastructure and postpone large control infrastructure deployment as well as grid infrastructure reinforcement.

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References: