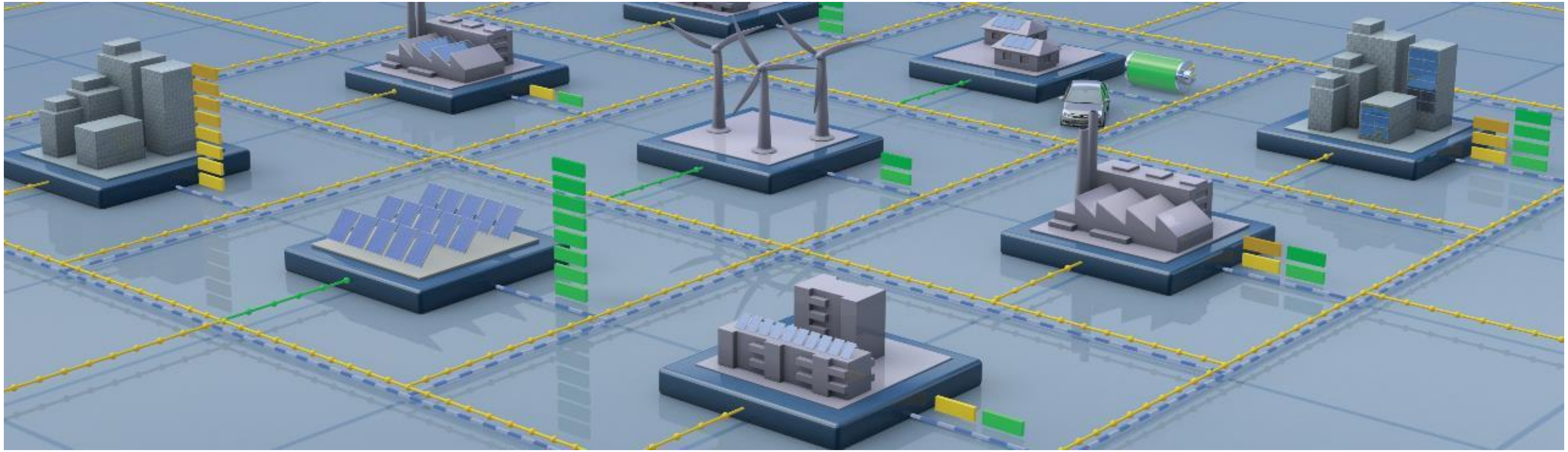
Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

Förderung: https://projekte.ffg.at/projekt/4148327



METHODS AND SCENARIOS FOR STRATEGIC GRID PLANNING IN DISTRIBUTION NETWORKS (PROJECT 567)

IRED2022, Adelaide, Australia, 26th of October 2022

Helfried Brunner (AIT)

AGENDA

- Context
- Motivation
- Approach
- Summary

AUSTRIA – FACTS AND FIGURES

26th of October is Austria's national day

AUSTRIA – FACTS AND FIGURES

- Area: 83,850 km2 (0,01xAUS)
- Population: 8.9 Mio (0,34x AUS)
- Number of TSOs: 1
- Number of DSOs: 122
- Peak load: 10.27 GW
- Hydro: 15GW (5.5 GW pumped hydro)
- PV: 3 GW
- Wind: 3.5 GW
- Thermal: 6.2 GW (mainly gas)

Voltage level	System length in km
380 kV	3.055
220 kV	3.744
110 kV	11.527
1 kV to 110 kV	71.186
1 kV and below	175.546

Source: e-control: statistics, installed capacities as of July 2020
https://www.e-control.at/en/statistik/strom/bestandsstatistik

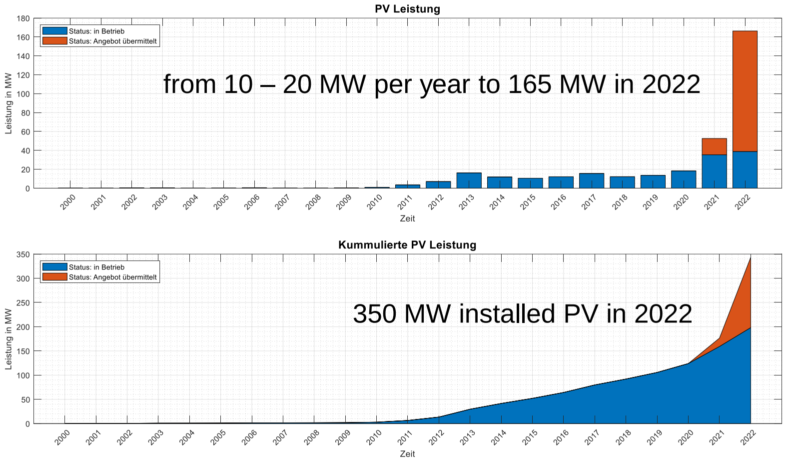
Govermental objectives:

- 100% renewable based electricity system until 2030 (status 2021 is 78%)
- 100% renewable based energy system until 2040

MOTIVATION

- Energy transition occurs at distribution system level (PV, heat pumps, e-mobility)

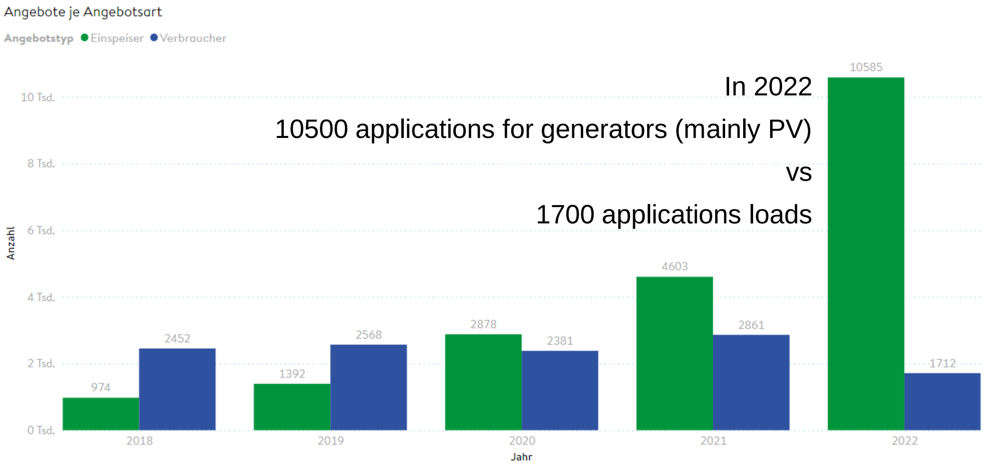
PV capacity



Blue – in operation

Red – approved grid access

Grid access applications



Figures from KNG-Kärnten Netz, KNG is serving around 250000 costumers

MOTIVATION

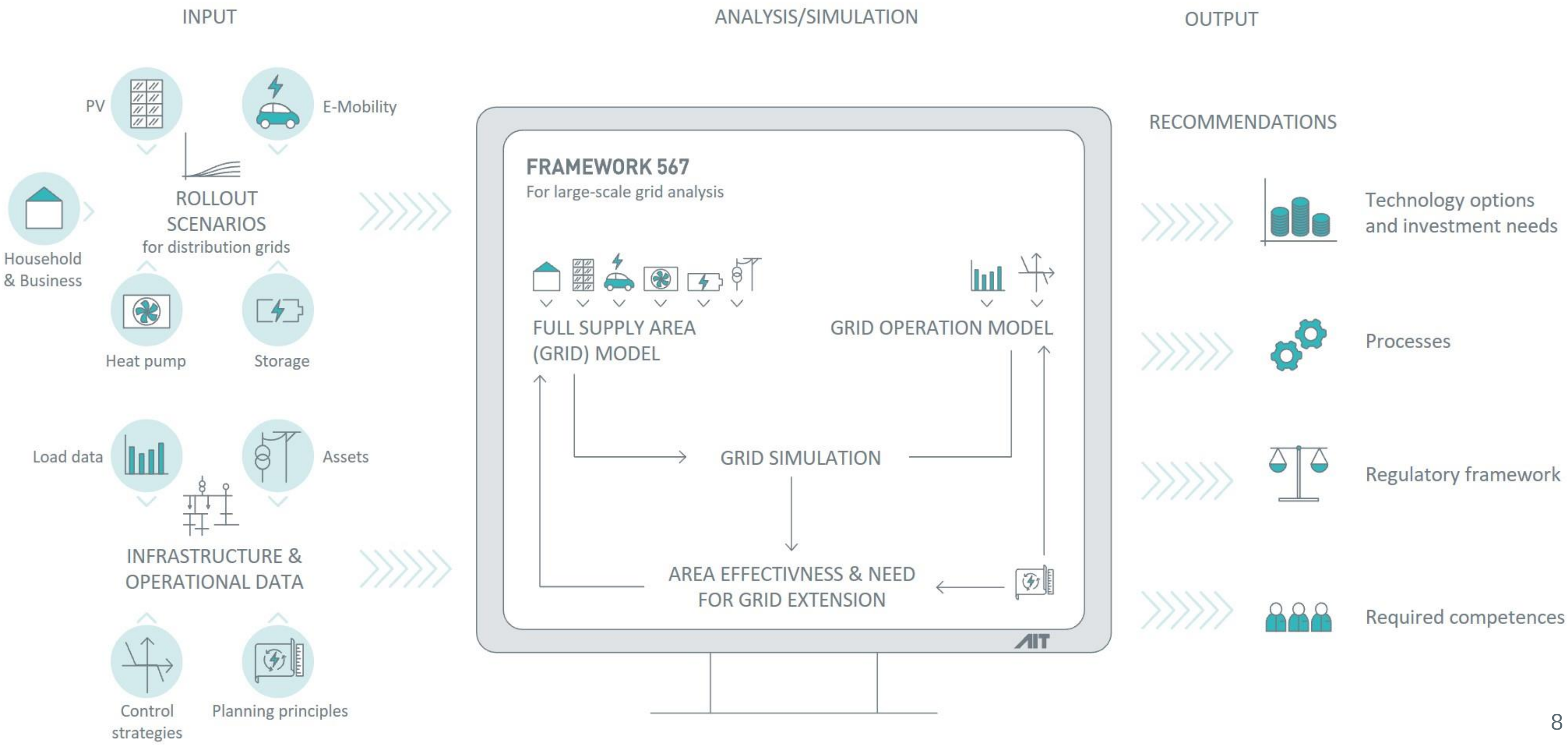
- Definition of national scenarios for generations and consumption
- Regionalisation – spatial distribution of different technologies – ramp-up scenarios
- Full DSO supply area grid models (geo-referenced)
- Quantitative area effectiveness of future measures in the entire MV/LV infrastructure of a DSO
- Quantification of related costs

NETWORK LEVELS IN AUSTRIA

Network level	Nr.
Extra high voltage - EHV (380/230kV)	1
EHV/HV transformer	2
High voltage - HV (110kV)	3
HV/MV transformer	4
Medium voltage MV (10/20/30kV)	**5**
MV/LV transformer	**6**
Low voltage grid - LV (0.4kV)	**7**

Project 567

SIMULATION FRAMEWORK

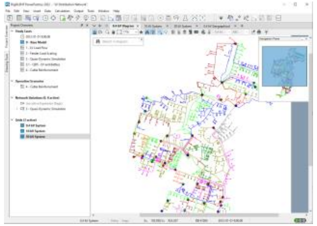


TOOLING

PowerFactory

Grid simulations

Python-Interface



PFLib

Simplified and efficient automation of processes in PowerFactory

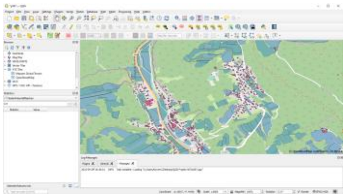
Python Library

AIT development

QGIS

Processing geo-referenced data

Python-interface



Python

Automated data processing and result analysis, …

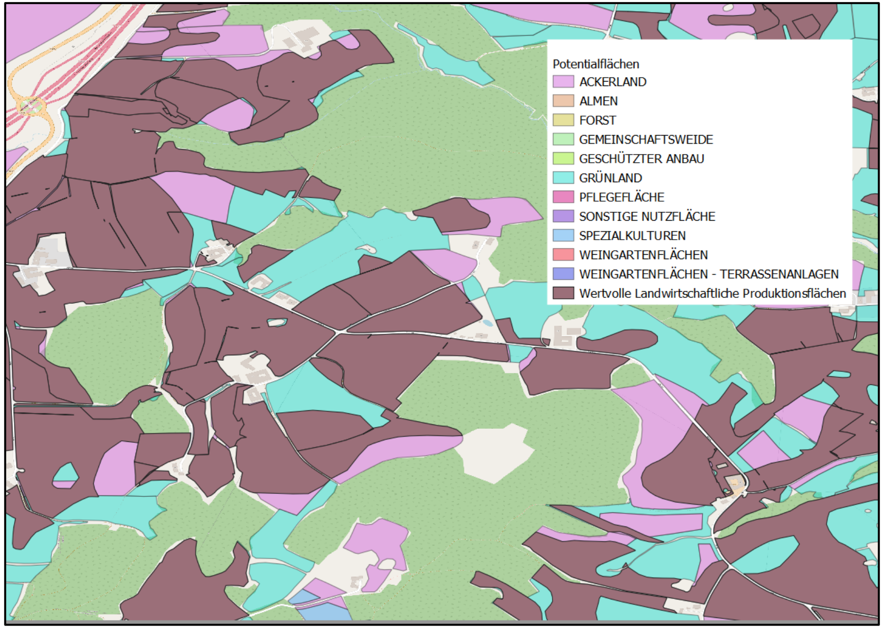
APPROACH

Regionalisation – Photovoltaic

PHOTOVOLTAIC OVERVIEW

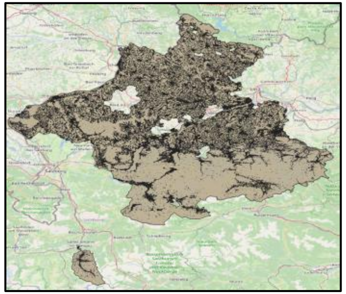
Rooftop PV

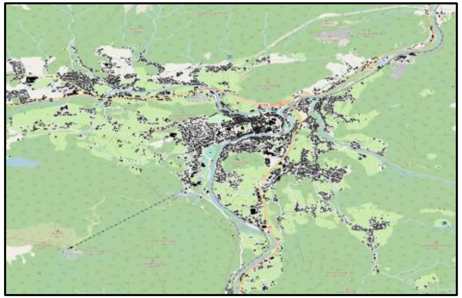
Ground mounted PV



DATA FOR ROOFTOP PV

Buildings ground area in the entire supply area

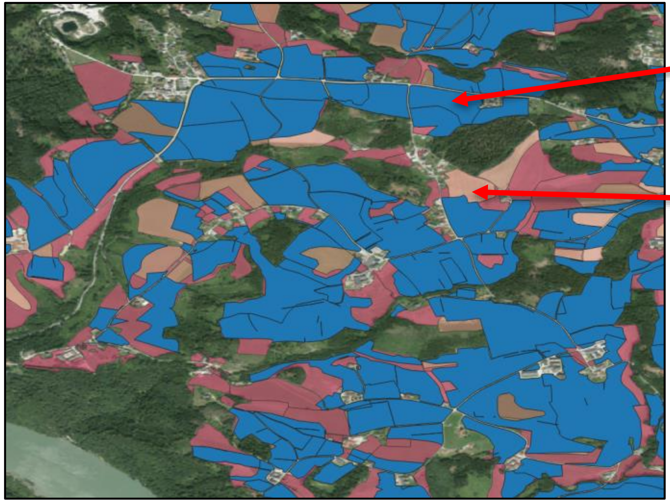




Mapping with solar irradiance cadastre

DATA FOR GROUND MOUNTED PV

- Data basis – reference areas



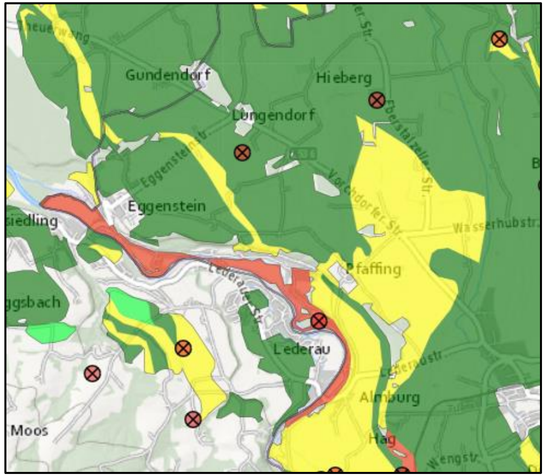
agriculturally valuable areas (AGES/BML[1])

- farmland
- grassland

reference areas (AMA[2])

- ACKERLAND
- ALMEN
- FORST
- GEMEINSCHAFTSWEIDE
- GESCHÜTZTER ANBAU
- GRÜNLAND
- PFLEGEFLÄCHE
- SONSTIGE NUTZFLÄCHE
- SPEZIALKULTUREN
- WEINGARTENFLÄCHEN IM ERTRAG INKL.
- WEINGARTENFLÄCHEN IM ERTRAG INKL.

Soil fertility (eBOD2[3])



Wertigkeit Ackerland:

- geringwertig
- geringwertig bis mittelwertig
- mittelwertig
- mittelwertig bis hochwertig
- hochwertig

Wertigkeit Grünland:

- geringwertig
- geringwertig bis mittelwertig
- mittelwertig
- mittelwertig bis hochwertig
- hochwertig

[1] https://geometadatensuche.inspire.gv.at/metadatensuche/srv/ger/catalog.search#/metadata/2022c513-fc01-40b6-8841-0d176dd88ea4
[2] https://geometadatensuche.inspire.gv.at/metadatensuche/srv/ger/catalog.search#/metadata/9db8a0c3-e92a-4df4-9d55-8210e326a7ed
[3] https://bodenkarte.at

PV OBJECTIVES AND PARAMETERS

Assumptions and procedure:

- Objective Austria 2030: 11 TWh/a[1]
- Objective Austria 2050: 30 TWh/a[2]
- Distinction roof-top PV and ground mounted PV broken down to supply areas

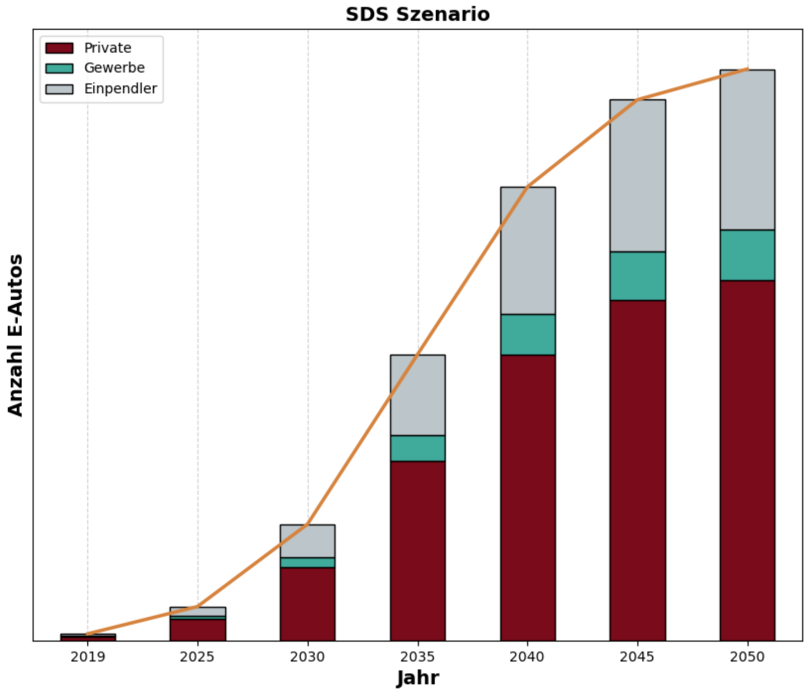
Parameter
Min. size roof-top PV
Min. size ground mounted PV
Max. size roof-top PV
Max. size ground mounted PV
Calculation factor irradiation/PV (polycrystalline)
annual yield per kWp
Building surface per kWp roof-top PV
Reduction factor for considered buildings
PV efficiency for ground mounted PV with BoFo 1-2
PV efficiency for ground mounted PV with BoFo 3-4

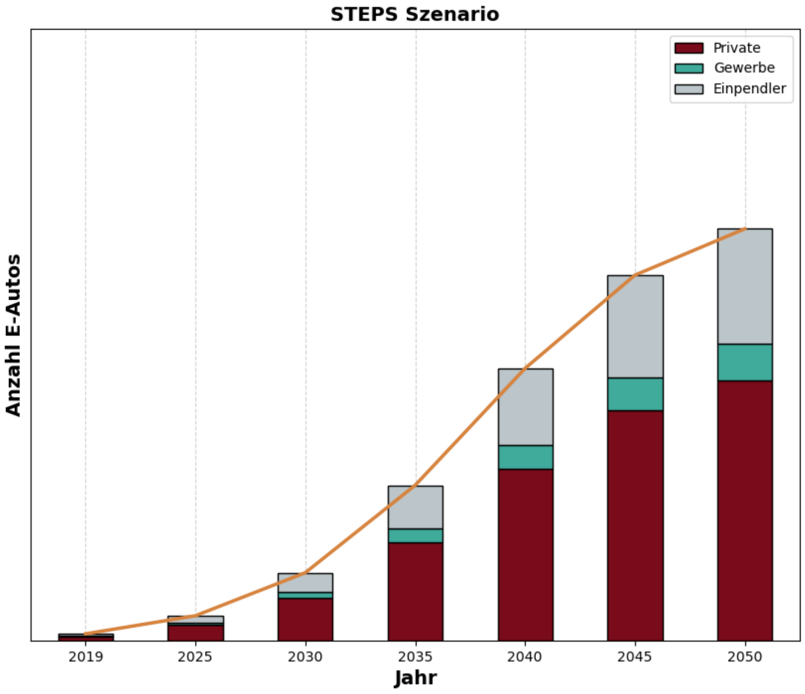
[1] Innovative Energietechnologien in Österreich Marktentwicklung 2019, nachhaltigwirtschaften
[2] Basierend auf dem Durchschnittswert aus mehreren Sudien

APPROACH

Regionalisation – e-mobility

TOTAL NUMBER OF E-CARS (PRIVATE)



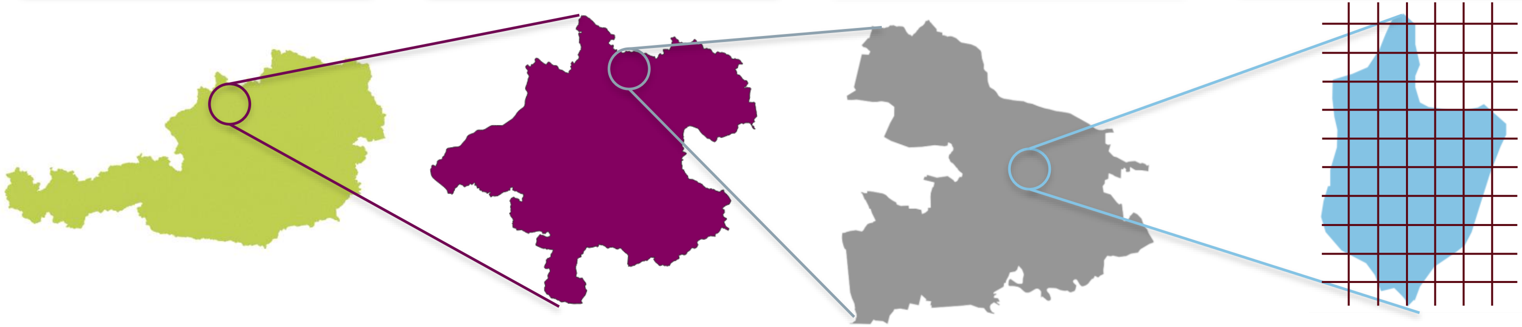


E-MOBILITY REGIONALISATION

- Top-Down-Approach

EPKW* in Stk.	2025	2030	2035	2040	2045	2050
SDS**	315.091	1.079.621	2.659.068	4.124.746	4.798.135	4.991.445
STEPS**	229.475	629.214	1.443.272	2.483.742	3.240.054	3.594.455

National | Province | Community | Raster (250x250m)



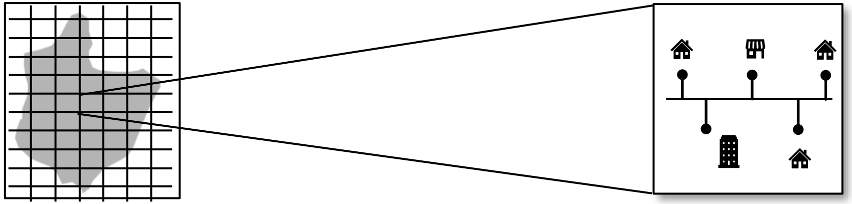
* EPKW = Elektrofahrzeuge, ** International Energy Agency, „Global EV Data Explorer", https://www.iea.org/articles/global-ev-data-explorer

OVERVIEW APPROACH

Repeated for each year and each scenario

Number of cars per raster

Mapping to metering points



- Private
- Business
- Commuter

- Calculation number of private and public charging points
- List of metering point per supply area[1]
- Random allocations

$pLP = ePkw_{private} + ePkW_{Gewerbe}$

$öLP = (ePkw_{private} + ePkW_{Gewerbe} + ePkW_{Einpendler}) \times 0.1$

1 Netzbereiber
2 Faktor, um die Anzahl der Einpendler in einem bestimmten Raster zu variieren
3 ÖAMTC Expertenbericht mobilität & klimaschutz 2030
4 Car icons created by monkik - Flaticon
5 BUW

ALLOCATION TO SPECIFIC LOCATIONS

Shopping centres

Petrol stations

Tourism (ski resorts)

Next node

APPROACH

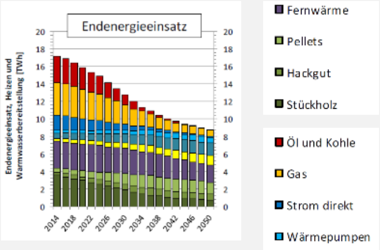
Regionalisation – heat pumps

OVERVIEW APPROACH

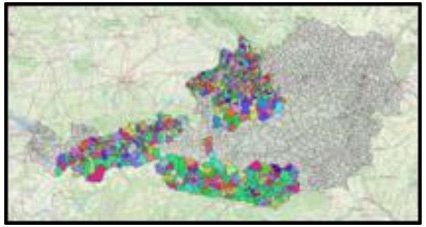
Repeated for each year and scenario

Number of HPs per province

- Final energy use per HP[1]
- Average energy consumption per HP[2]

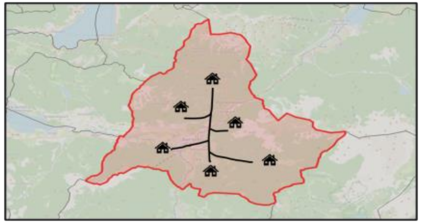


Number of HPs per community

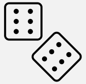


- Final energy use for heating and warm water per province and community
- Consideration of district heating
  - low / medium / high heat density[3]
- +70% scenario

Allocation to metering points



- List of metering points of the supply area
- Randomised allocation



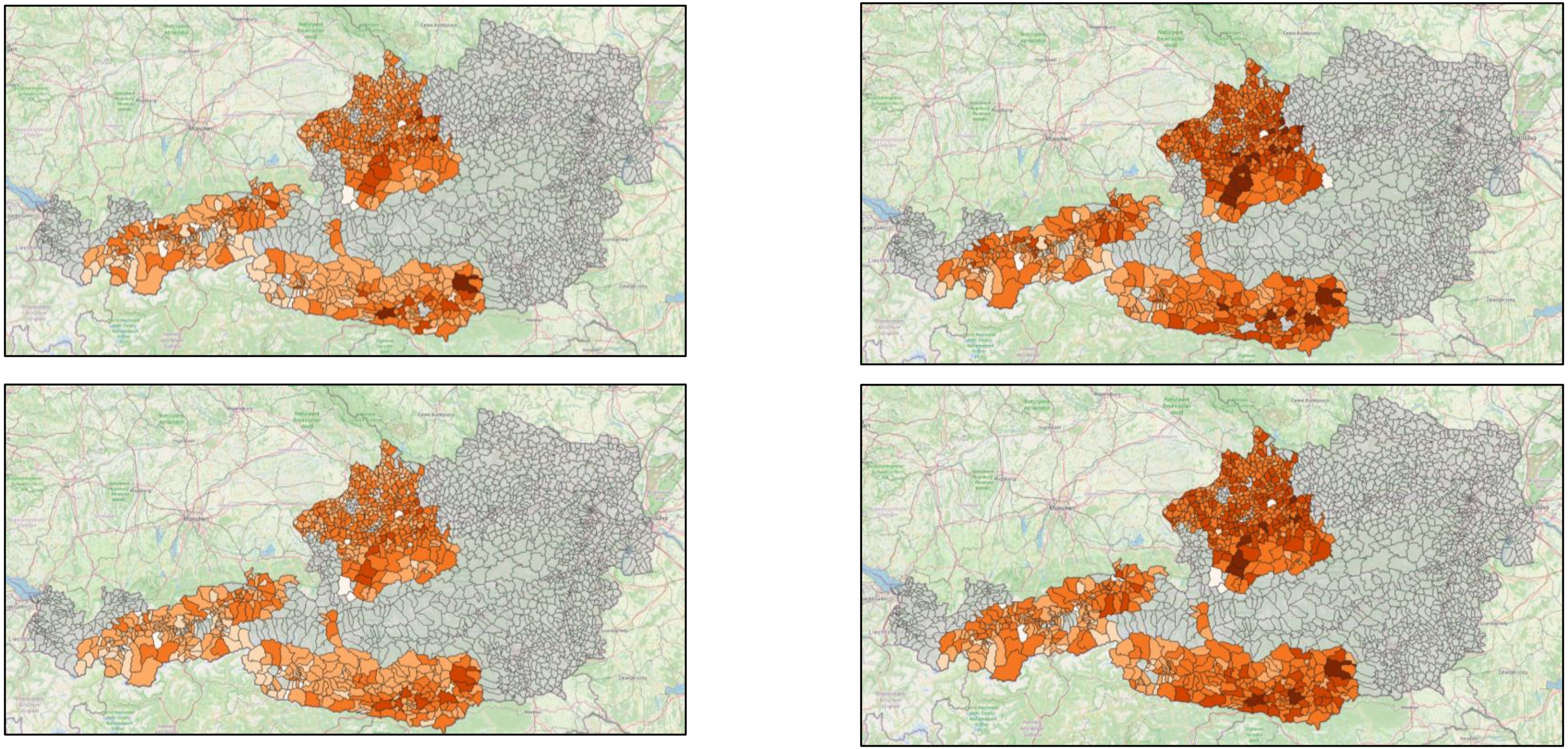
[1] Wärmezukunft 2050, Erfordernisse und Konsequenzen der Dekarbonisierung von Raumwärme und Warmwasserbereitstellung in Österreich
[2] Wärmepumpen Profile
[3] https://maps.invert.at/waermezukunft_2050#map=7/1611553.53/6086383.74/0/0
[4] Netzbetreiber

NUMBER OF HEAT PUMPS

2030 | 2050

Without district heating

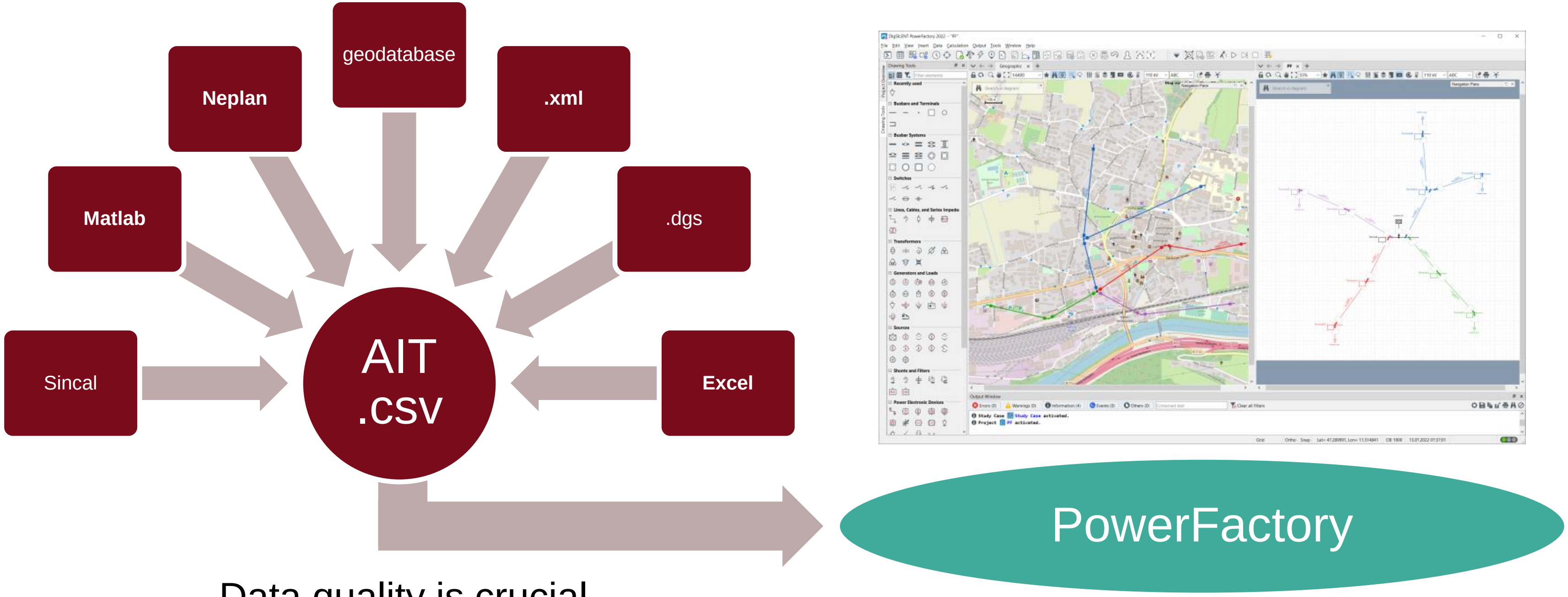
With district heating



APPROACH

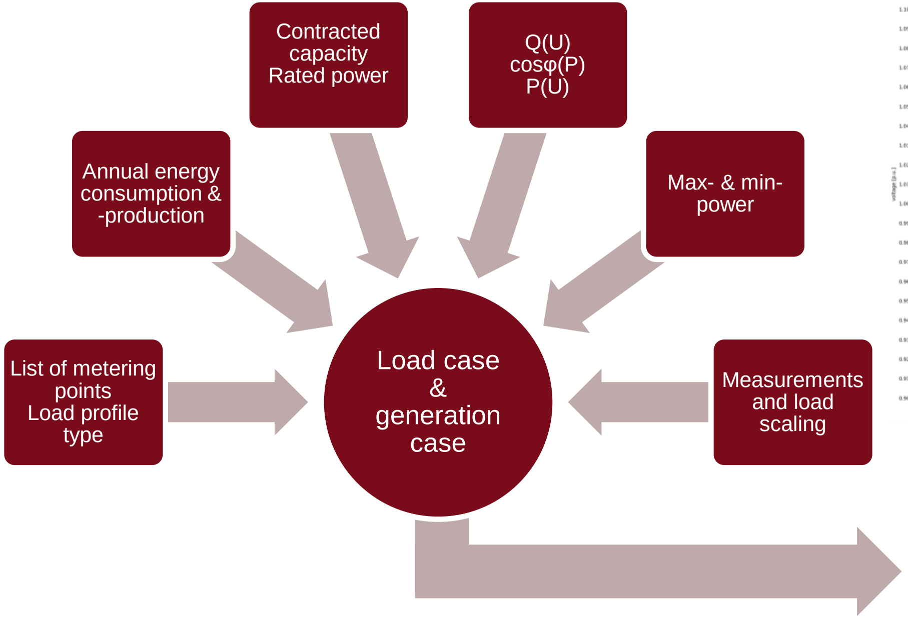
Grid simulations

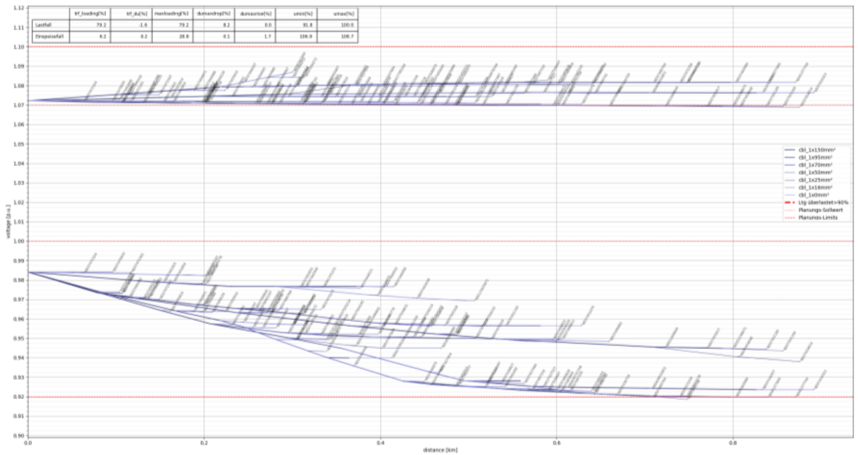
GRID DATA IMPORT



Data quality is crucial

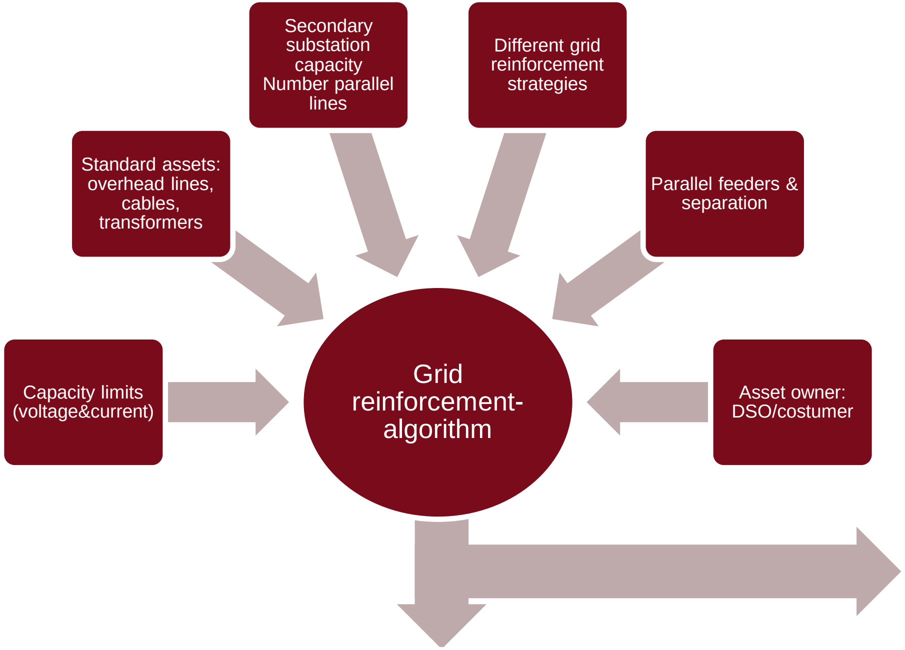
REFERENCE LOAD FLOW

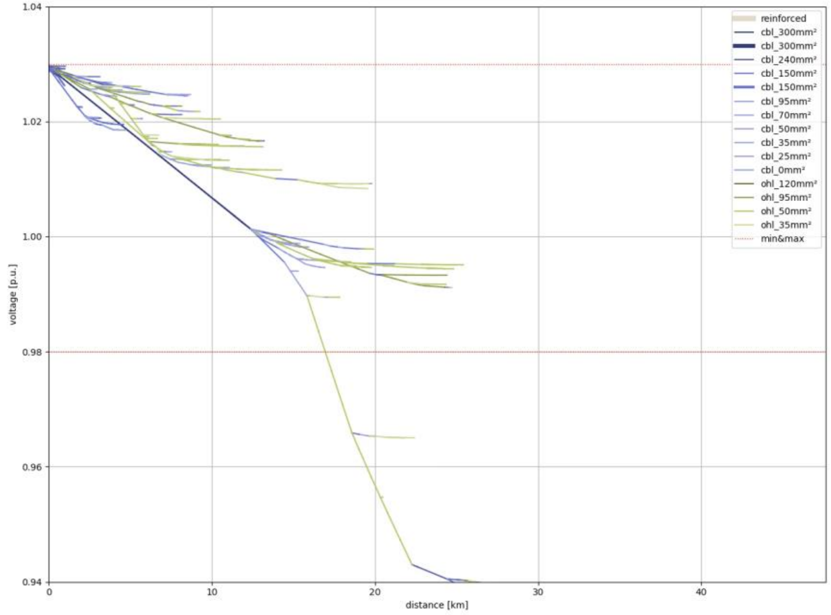


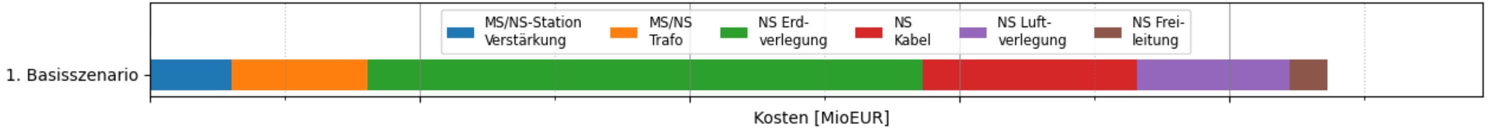


Voltage drop diagram

STANDARD GRID REINFORCEMENT







DIFFERENT MEASURES

Grid → controls
static → dynamic
Passive → Active

VOLTAGE

MV	LV
Increasing system voltage	Building new secondary substations
Reduction of intemediate voltage levels	Manual transformer stepping
Reactive power compensation	950V-solutions
Primary substation – current compounding	OLTC (+voltage control strategies)
Voltage drop compensator	
Reactive power control	
Active power control (P(U), PV 0.7*Pnom, EV 0.5*Pnom)	
Storage systems	

CURRENT

MV	LV
Increasing system voltage	Building new secondary substations
Reduction of intemediate voltage levels	Manual transformer stepping
Reactive power compensation	950V-solutions
Primary substation – current compounding	OLTC (+voltage control strategies)
Voltage drop compensator	
Reactive power control	
Active power control (P(U), PV 0.7*Pnom, EV 0.5*Pnom)	
Storage systems	

Not owned by DSO

CALCULATION VARIANTS

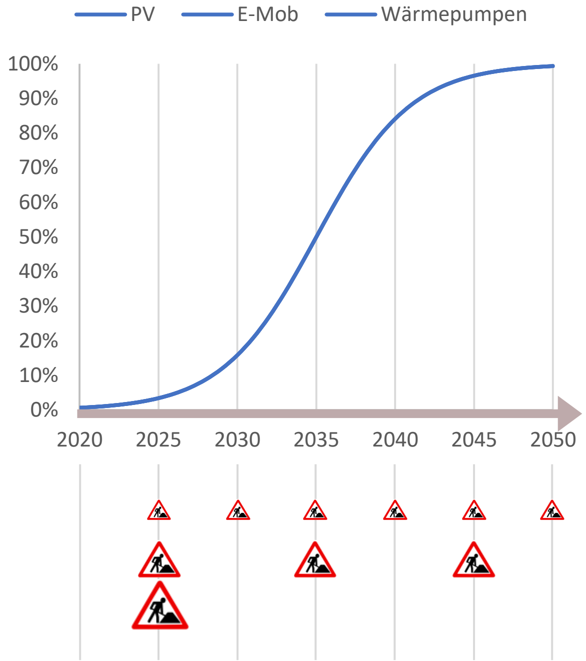
Calculation variants

Time horizon
- 2020-2050

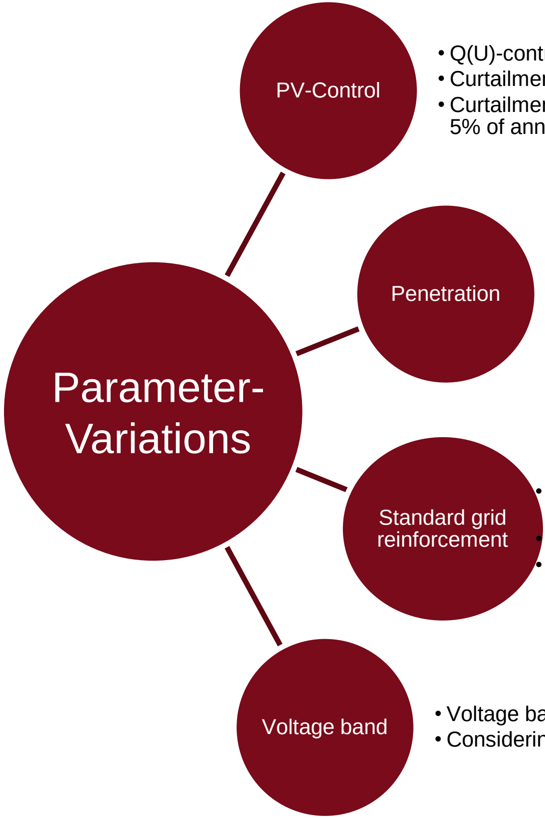
Interval
- every 5 years

Planning horizon
- Short term
- 10 years
- until 2050

Limits vs. target value dimensioning
- Transf. loading.100% vs.50%
- Line loading 90% vs. 50%
- Voltage rise: 3% vs. 2%
- Voltage drop   6% vs. 5%



PARAMETER VARIATIONS



PV-Control

- Q(U)-control
- Curtailment power (70%)
- Curtailment energy (e.g. 5% of annual production)

Penetration

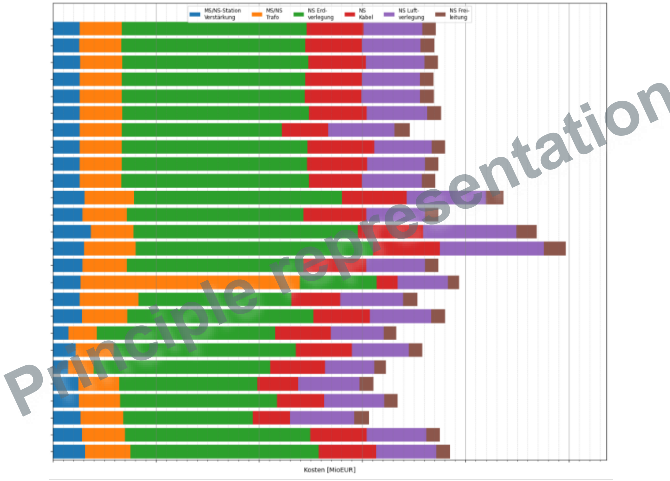
- PV share in LV & MV
- STEPS or SDS Scenario for e-mobility
- Heat pumps

Standard grid reinforcement

- Default cross section (e.g. 240mm² instead 150mm²)
- Number parallel lines
- …

Voltage band

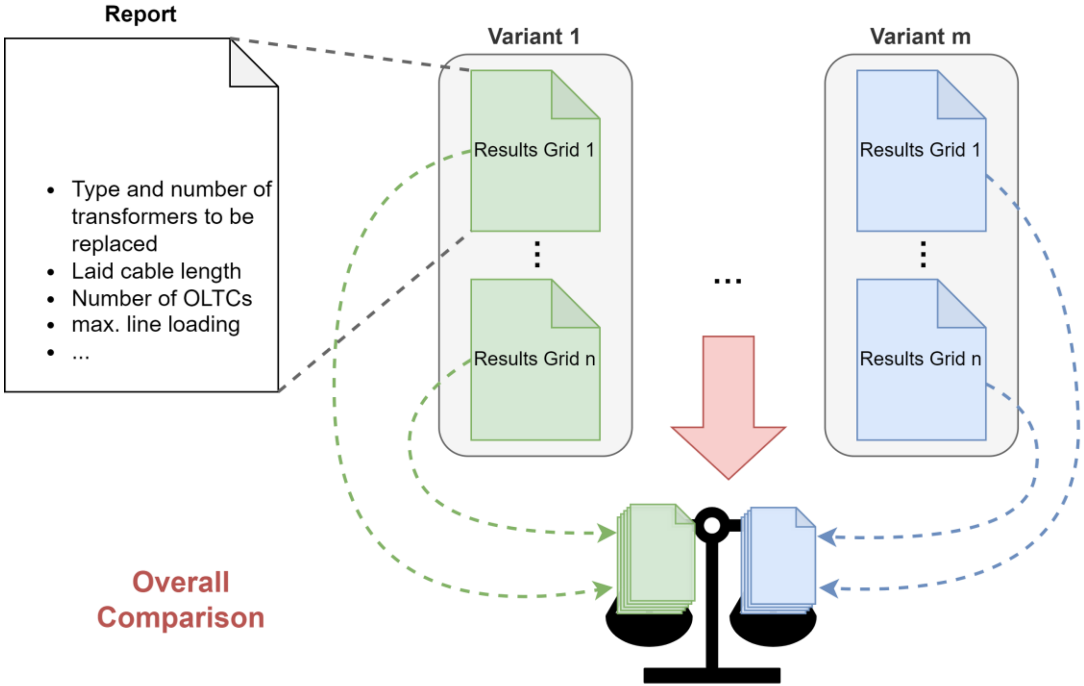
- Voltage band allocations
- Considering (n-1) principle



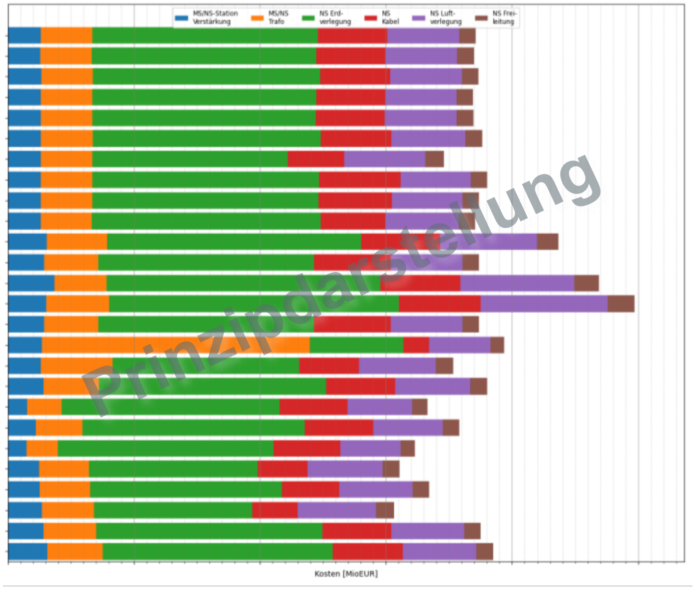
APPROACH

Result preparation

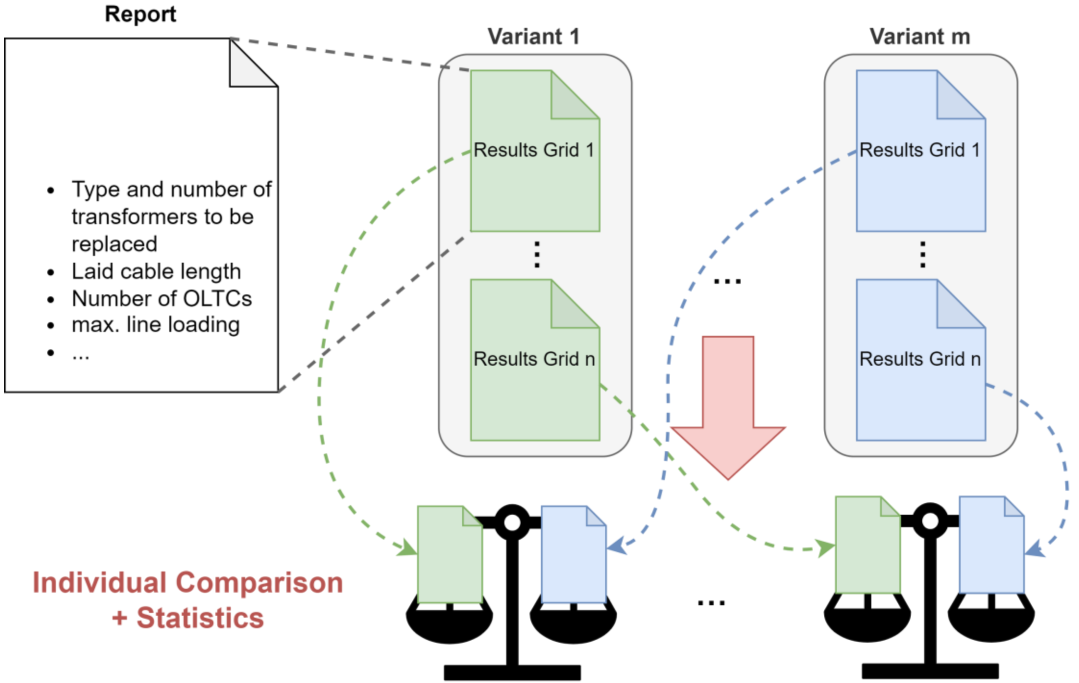
OVERALL COMPARISON



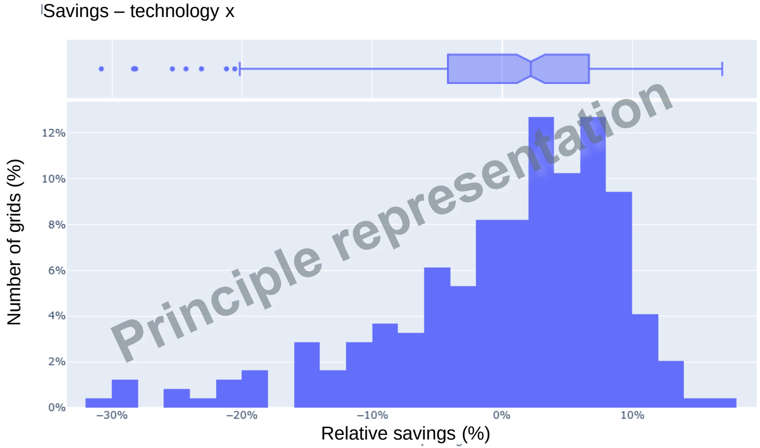
Analysing a measure/variant for **the entire supply area**



INDIVIDUAL COMPARISON OF MEASURES



Analysing how often and how much a specific measure/variation is **better/worse** compared to a reference scenario



SUMMARY

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

SUMMARY

- Analysing the impact of different measures/variants on the entire supply area (LV/MV grids)
- Investigating area effectiveness of different grid reinforcement measures
- Utilisation of geo-referenced data
- Regionalisation of PV, heat pumps and e-mobility
- Results preparation for different target groups: Electricity sector, CEO´s perspective, grid planners

THANK YOU VERY MUCH!

Förderung: https://projekte.ffg.at/projekt/4148327

Helfried Brunner Helfried.Brunner@ait.ac.at