User-Centred Energy Systems

A Technology Collaboration Programme by IEA

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

EVALUATING REAL WORLD EV AND HEAT PUMP FLEXIBILITY POTENTIAL

Users TCP Academy

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With contributions from: Ivan Mariuzzo, Daniel Schwabeneder, Tara Esterl

AGENDA

Introduction to the project

What is flexibility and where can it be used?

High-Level model, application and results

Heat pump flexibility

EV flexibility

Policy recommendations and Research Gaps

About UsersTCP

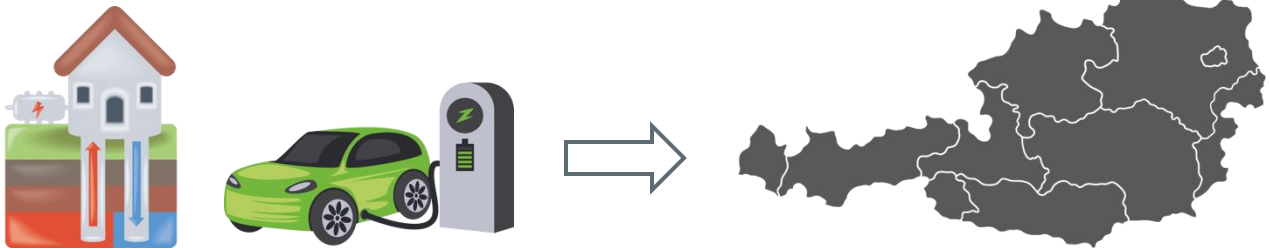
Q&A

INTRODUCTION TO THE PROJECT

Support of **Users TCP** and **4E** in the cross-TCP Coordination Group on Flexibility by

Interpretation, application, and evaluation of a proposed generic model for calculating flexibility potentials of behind-the-meter electric appliances

Testing of the model on

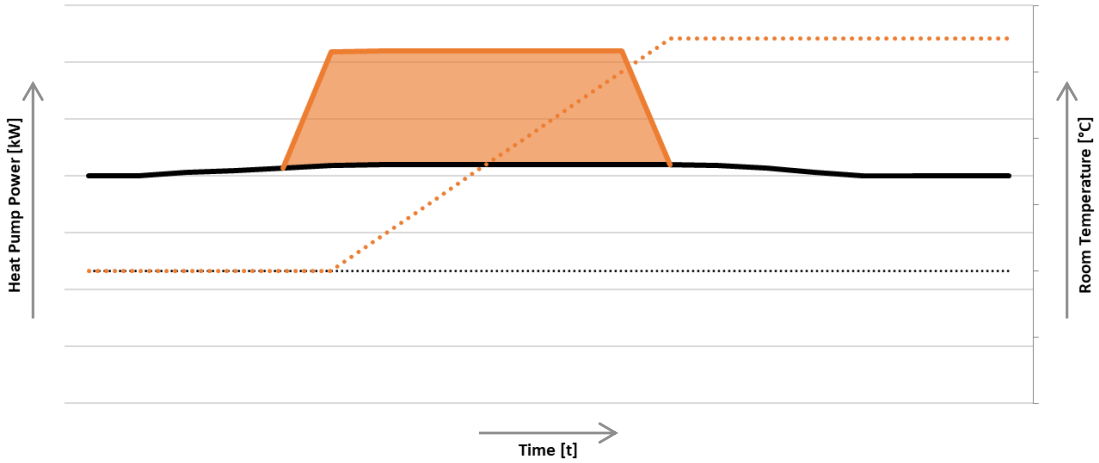


Heat Pumps EVs Austria

Austria Map PNGs von Vecteezy
Elektroauto PNGs von Vecteezy
Zuhause PNGs von Vecteezy

INTRODUCTION TO FLEXIBILITY IN DIFFERENT COMPONENTS

Assumption: There's an operational profile of a component or component pool, with the possibility of deviation; the operational profile is the baseline, the deviation reflects the flexibility potential of the component or pool.



Preliminary or catch-up effects that are necessary to return to the baseline temperature are not shown here!

WHERE TO USE THE FLEXIBILITY

MARKET-BASED

Spot markets		Balancing and system services				
day-ahead market	**intraday market**	**primary (FCR)**	**secondary (aFRR)**	**tertiary (mFRR)**	**Redispatch/ congestion management**	**Imbalance settlement**
Price differences		Capacity payments				
		Energy payments for activated amount				Cost reduction

Where do revenues come from?

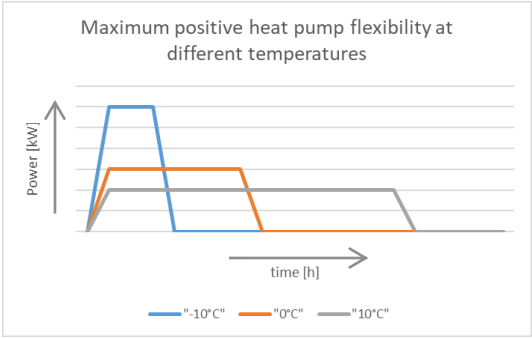
NON MARKET-BASED

Peak shaving & Load shifting		
Reduce renewable curtailment due to limited grid access	**Increase self-consumption**	**Reduce power peaks**
Increase revenues from generation	Avoidance or reduction of variable network charges, taxes, and consumption-based tariffs	

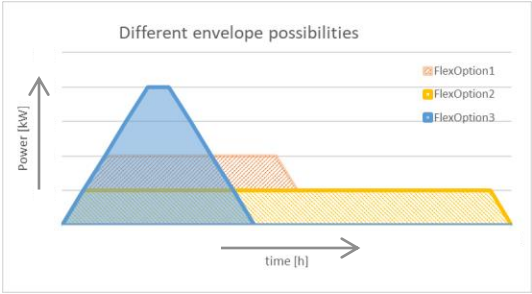
Where do revenues come from?

FLEXIBILITY CALCULATION

- Height of technical flexibility changes with duration of activation and environmental parameters



- Since we **focus** on the **social, regulatory and behavioral** parameters in this project, the assumption for the ***technical potential is the maximum activation possible for 4 hours assuming an average load factor***



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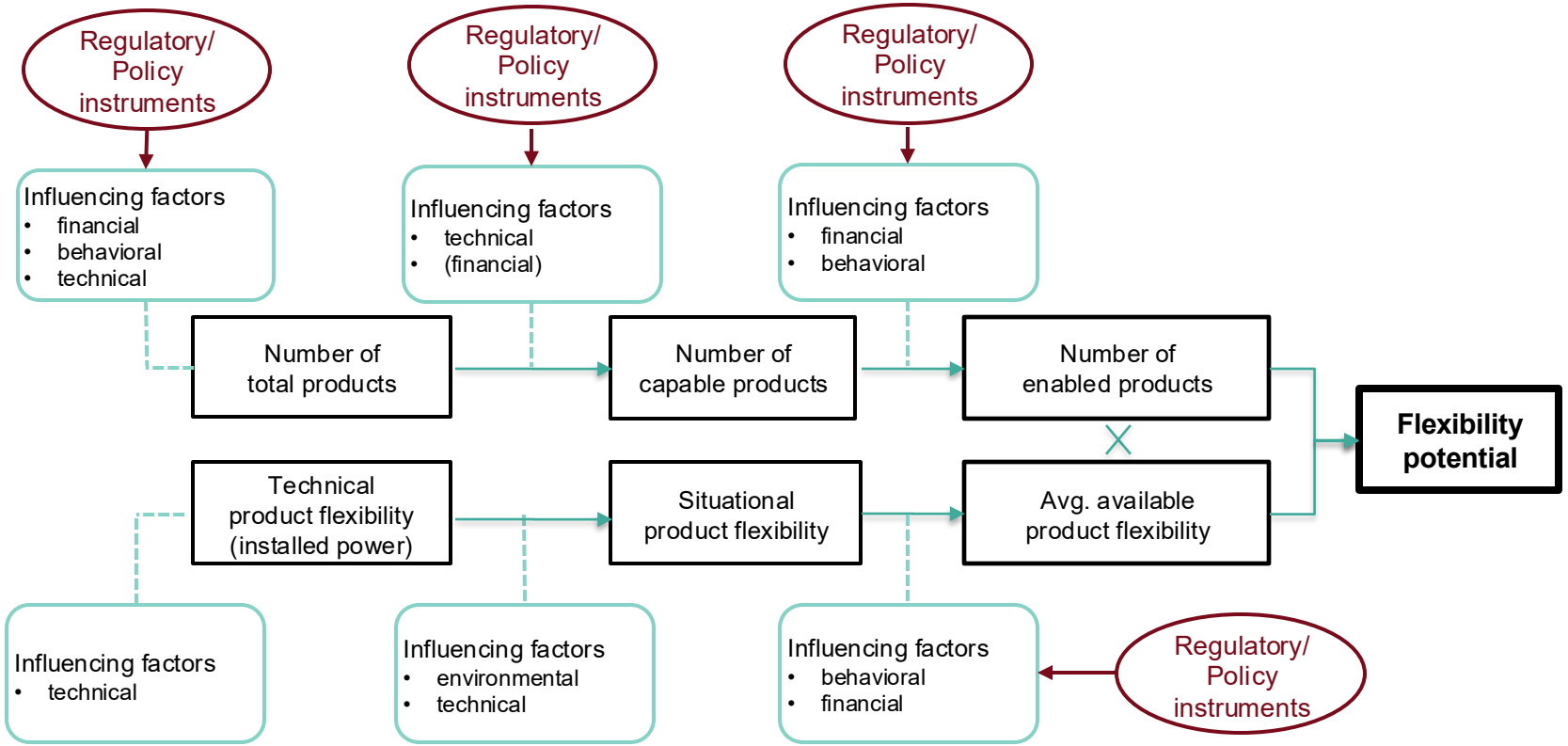
USERS APPLIANCE CAPABILITY

High Level Model

GENERAL HIGH-LEVEL MODEL



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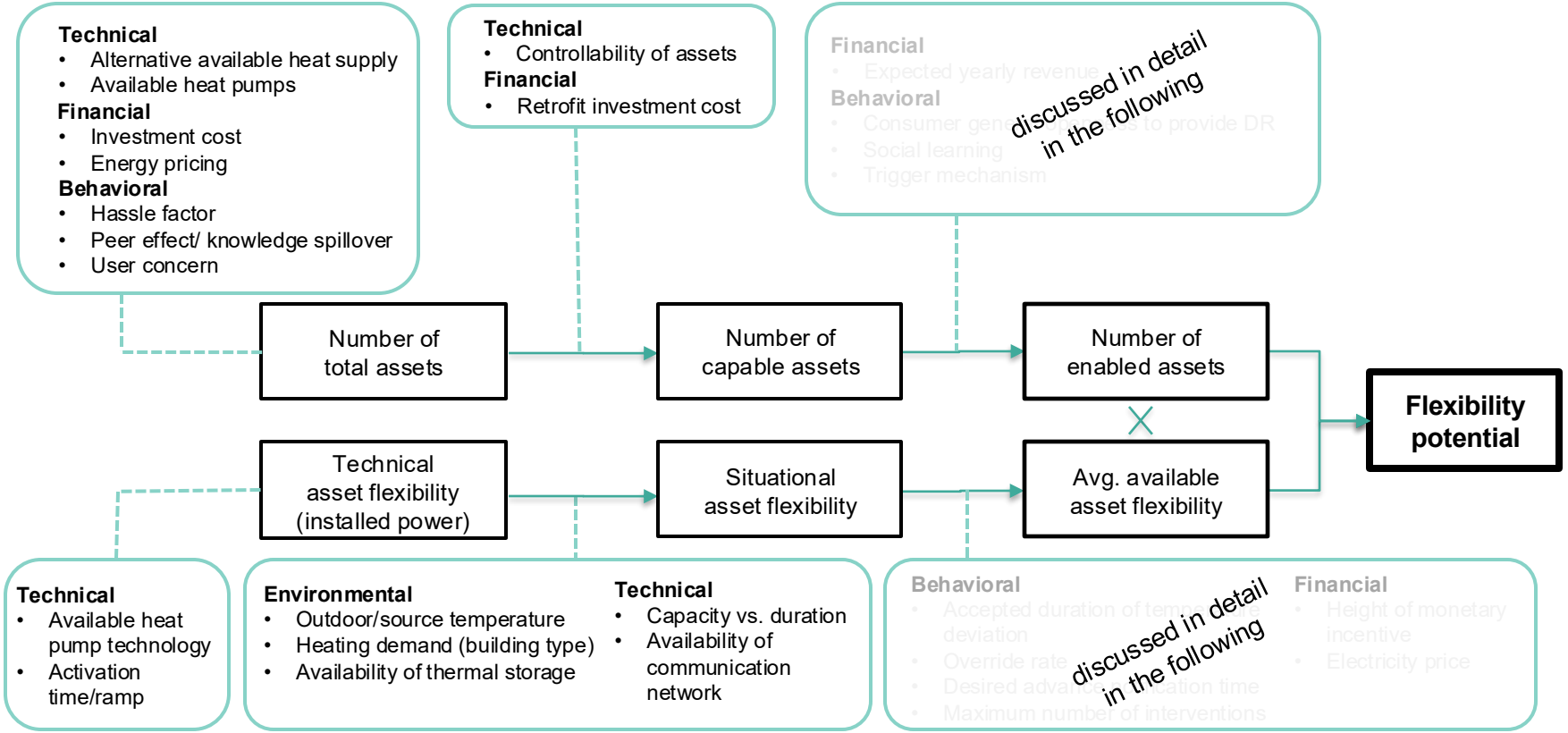
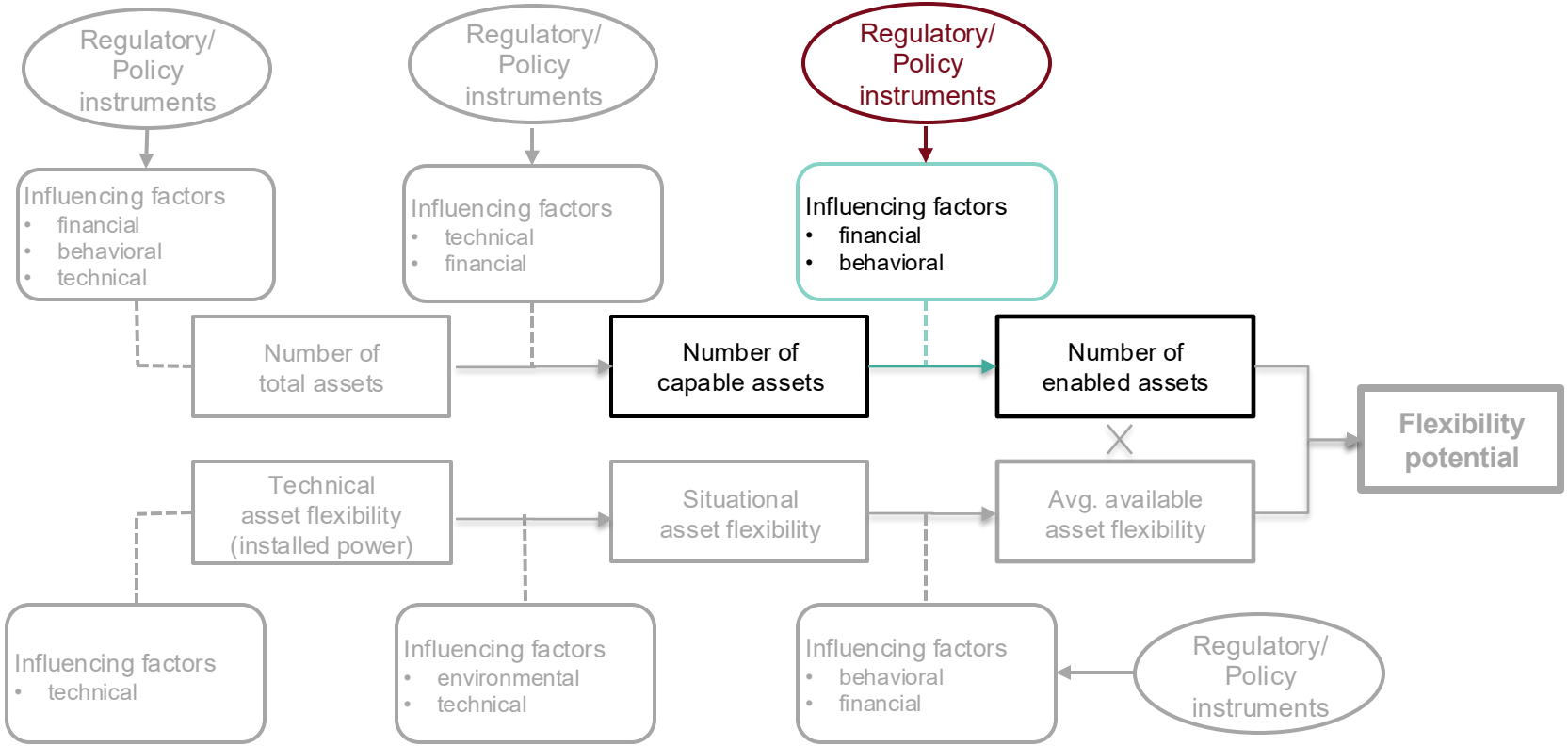
HEAT PUMP FLEXIBILITY

Model application and results

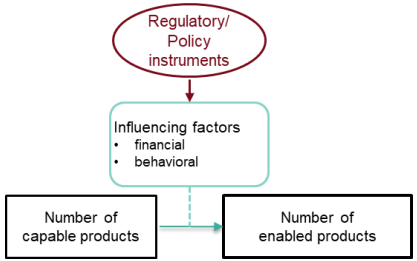
INFLUENCING FACTOR FOR HEAT PUMPS



IN DEPTH-LOOK: WILLINGNESS OF USERS



WILLINGNESS OF USERS



Behavioral influencing factors

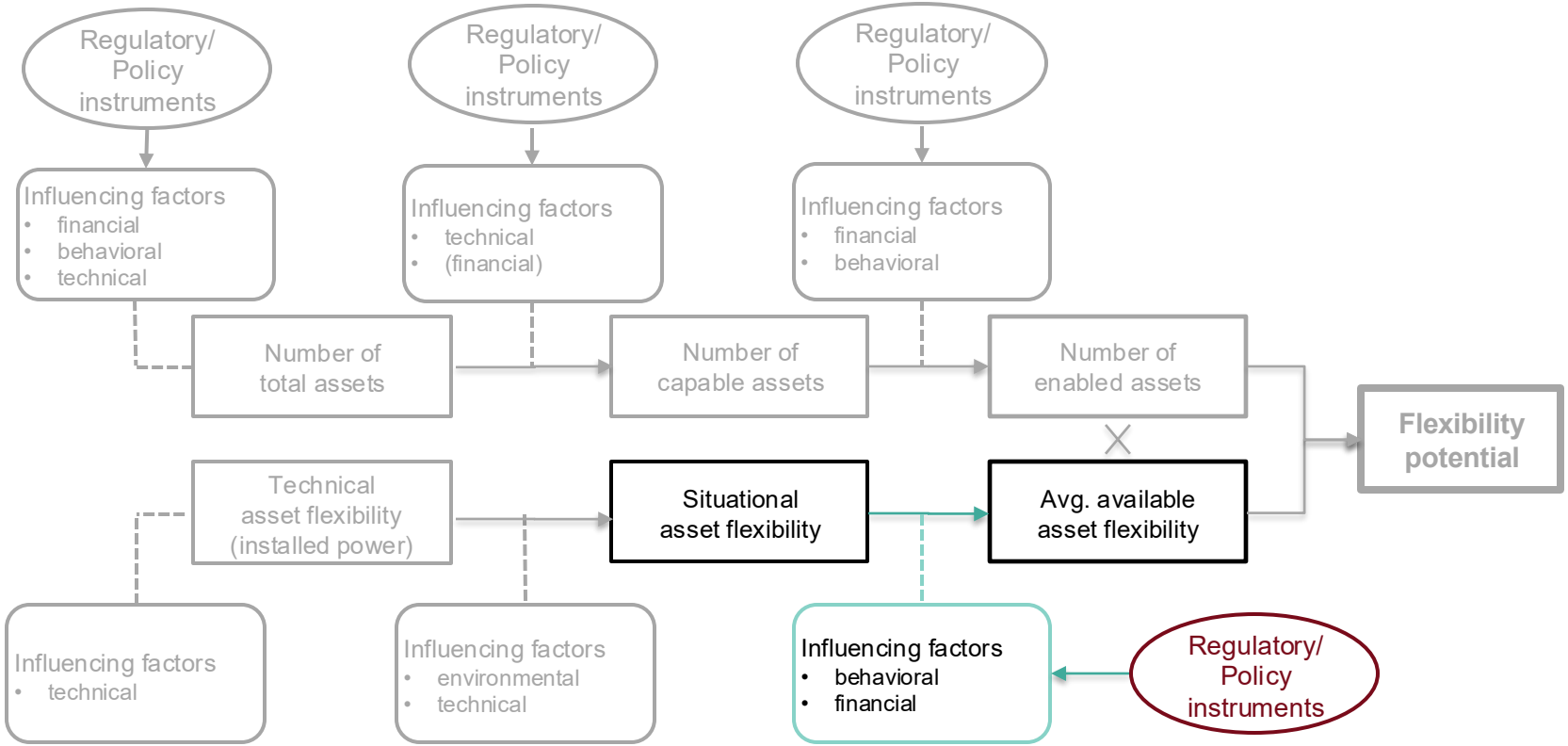
- Consumer general openness to provide DR
  - Allowance for external control:
    - **DE:** External control off-limits for a quarter. [10]
    - **PL:** 84% have general openness to participate for obtaining tangible benefits or savings. [12]
    - **US Midwest**: 20% of residents are willing to let utilities control their home equipment and appliances anytime of the day and an additional 3%–15% of respondents are fine with utilities controlling their appliances at different times of the day. [13]

- Social learning
  - **PT:** Social learning significantly influences DR acceptance. [15]

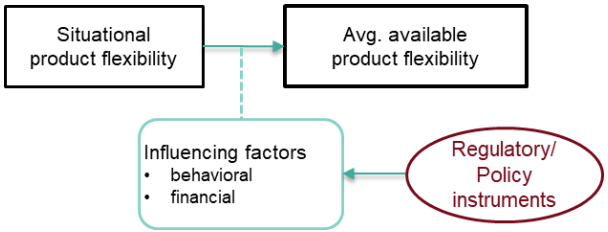
Financial influencing factors

- Expected yearly revenue
  - **US Midwest:** $10 to $50, 47% are willing to enroll in the program. Specifically, respondent participation intention is 38%, 47%, 48%, 43%, and 56% for programs offering a $10, $20, $30, $40, and $50 annual incentive. [13]
  - **FI:** The expected compensations for consumers were 200 €/annum for heating. [14]

IN DEPTH-LOOK: AVERAGE AVAILABLE ASSET FLEXIBILITY



AVERAGE AVAILABLE ASSET FLEXIBILITY



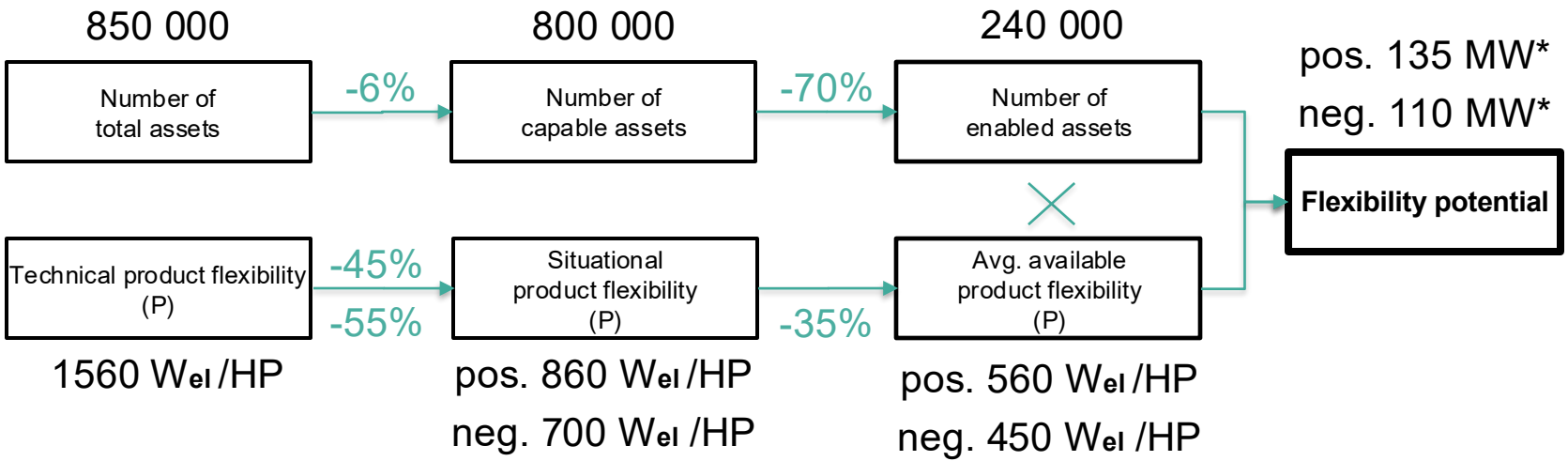
Behavioral influencing factors

- Height of allowed temperature deviation influences the duration of the flexibility activation.
- Accepted duration of temperature deviation vs. maximum number of interventions
  - **CH**: 1/day - 30 min; 3/week - 1 h; 20/year - 3 h [18]
- Notification in advance
  - **PL**: 25% want to know 24 hours, 25% 6 hours in advance (only 15% one hour). 15% more than one week. [12]
- Override rate
  - **US, CAN**: Average override rate of 12,9% (in air-conditioning) [21]

Financial influencing factors

- The more lucrative or visible the program, the more likely the user will stay enrolled and not override.

THEORETICAL NUMBERS FOR AUSTRIA, 2030



*Represents only the share of total flexibility that users allow as short-term flexibility

At 0° C, for max. 4h.

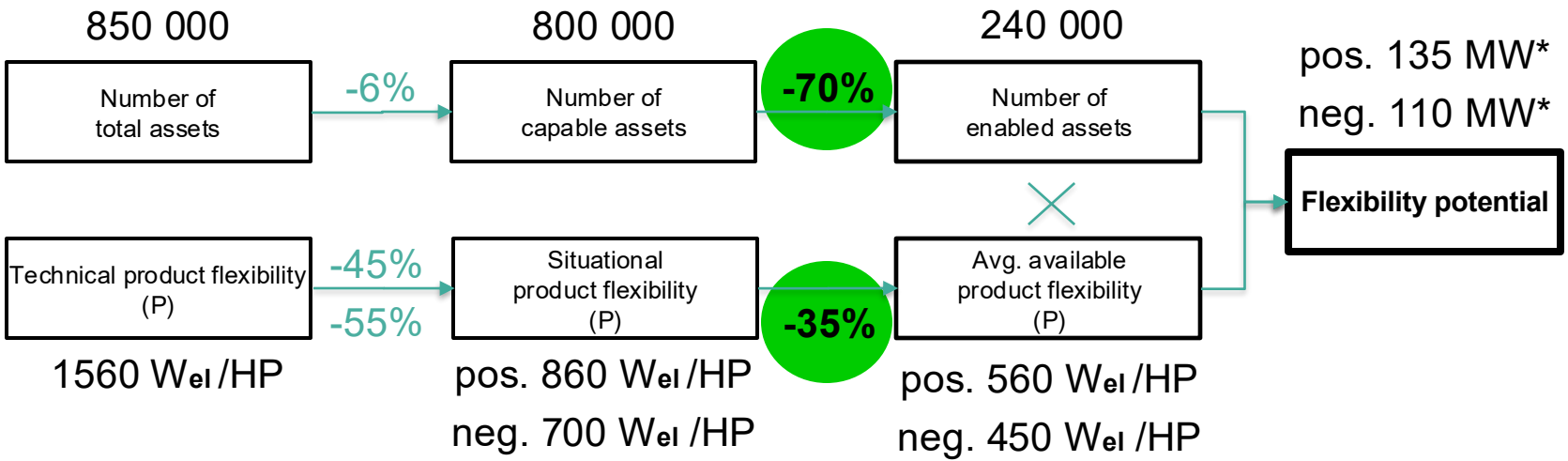
Conservative case

(rounded numbers)

positive flexibility – reducing el. demand – shutting HP off/ decreasing HP capacity

negative flexibility – increasing el. demand – turning HP on/ increasing HP capacity

THEORETICAL NUMBERS FOR AUSTRIA, 2030



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At 0° C, for max. 4h.

Conservative case

(rounded numbers)

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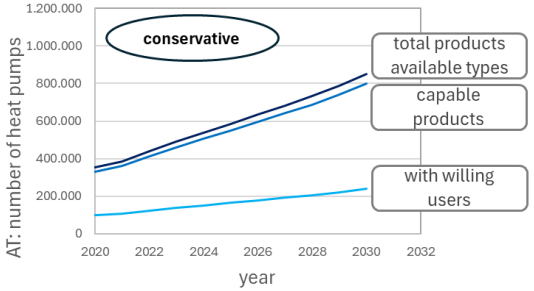
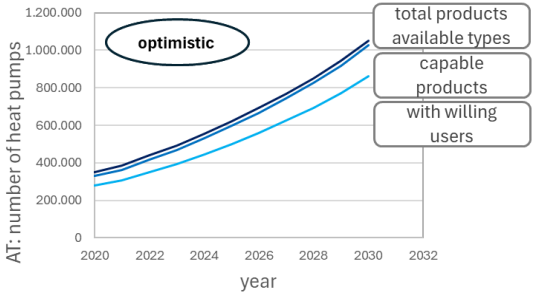
EXAMPLE: CALCULATION OF POSITIVE FLEXIBILITY FORECAST FOR AT

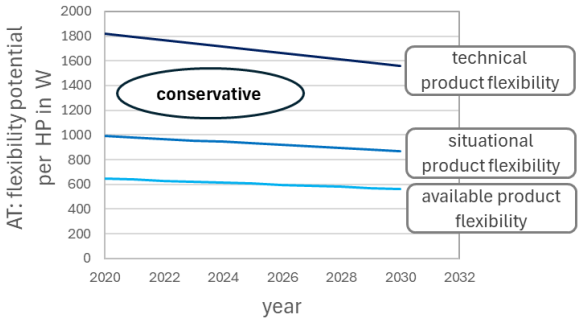
Conservative scenario

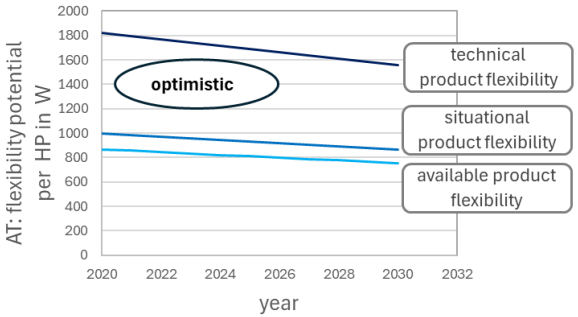


assets

Optimistic scenario

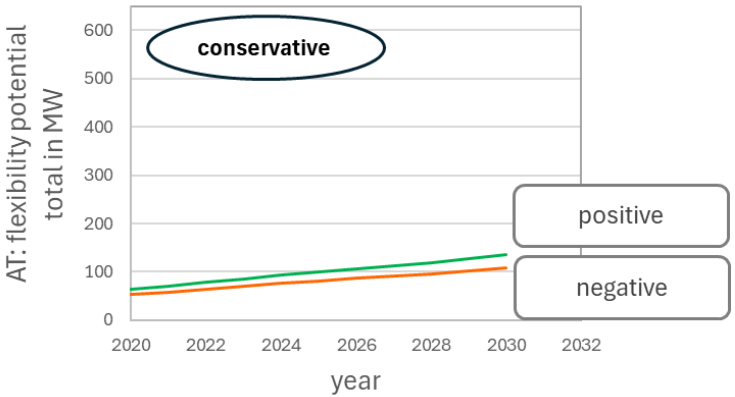






ESTIMATION: FORECAST POSITIVE AND NEGATIVE FLEXIBILITY POTENTIAL FOR AT

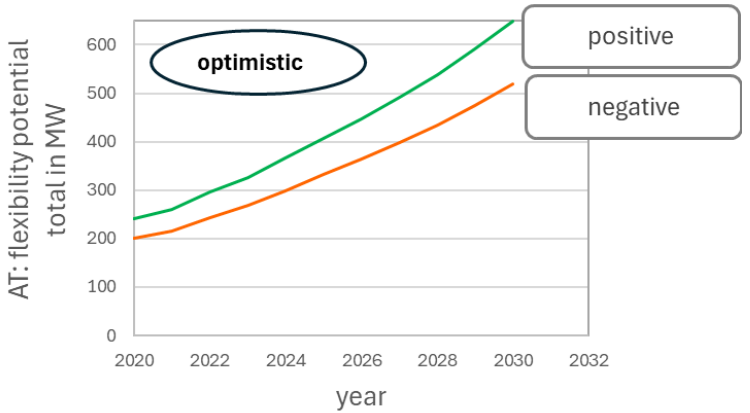
Conservative scenario



2030 pos: 135 MW

2030 neg: 108 MW

Optimistic scenario



2030 pos: 650 MW

2030 neg: 520 MW

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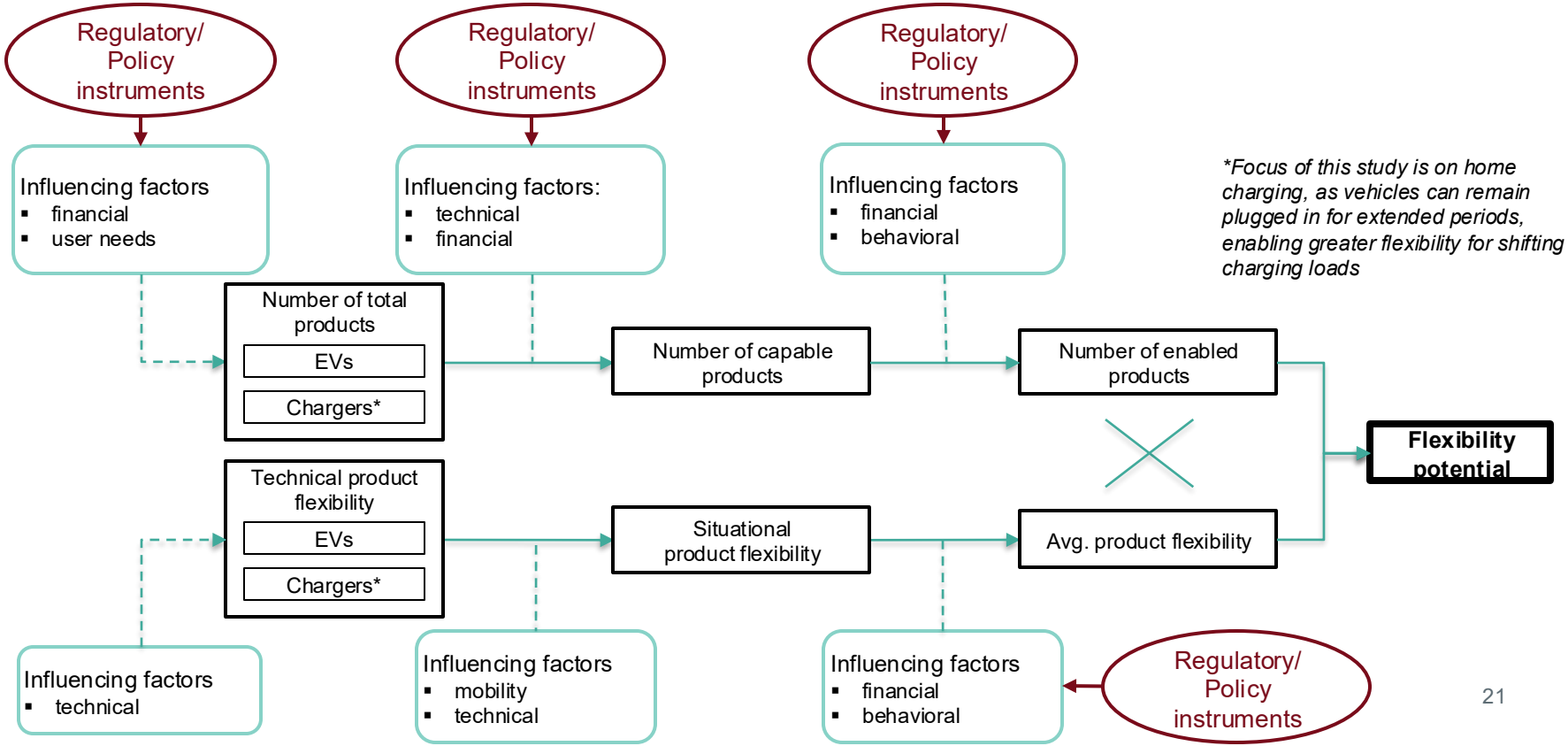
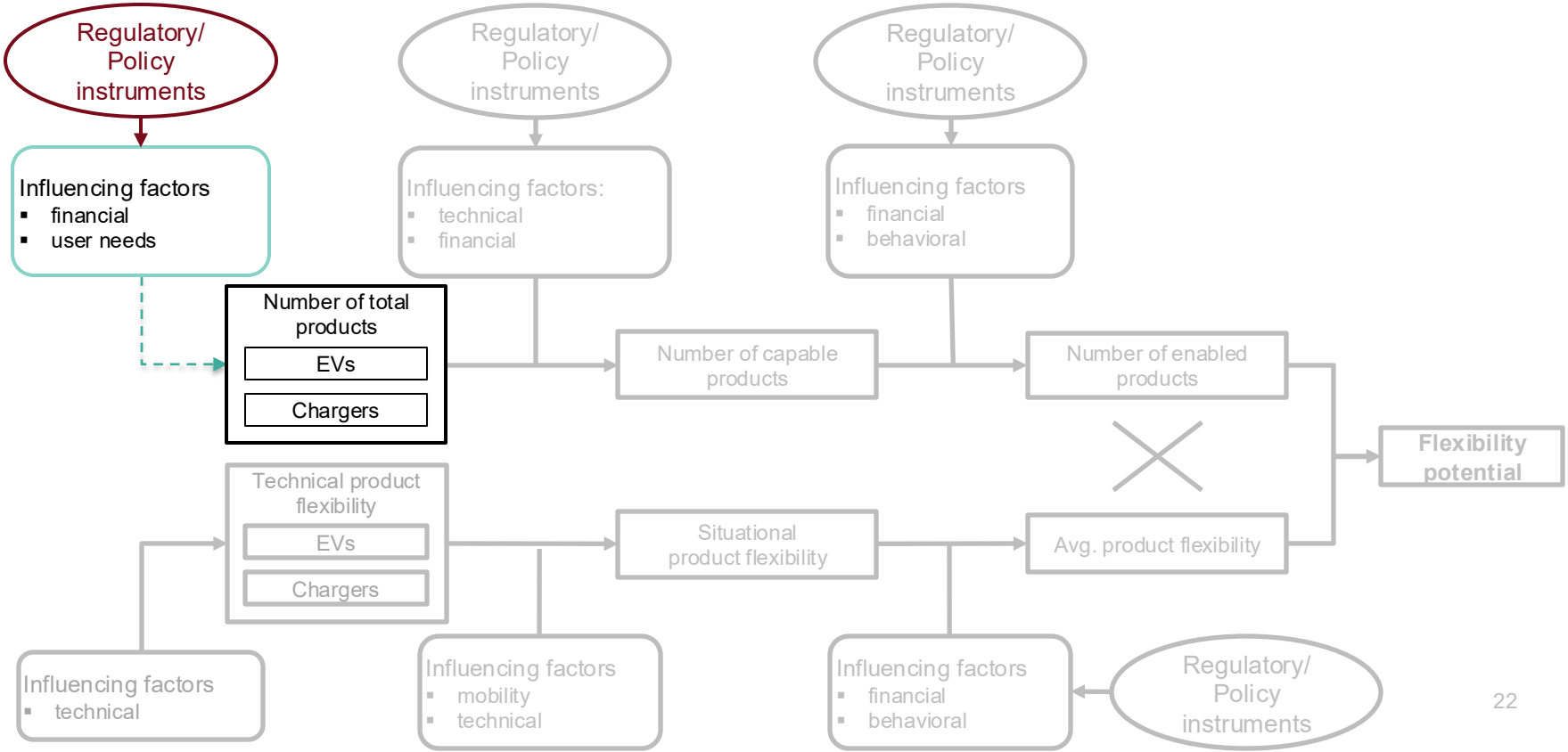
ELECTRIC VEHICLE FLEXIBILITY

Model application and results

HIGH LEVEL MODEL FOR EVS



IN DEPTH-LOOK: NUMBER OF TOTAL PRODUCTS



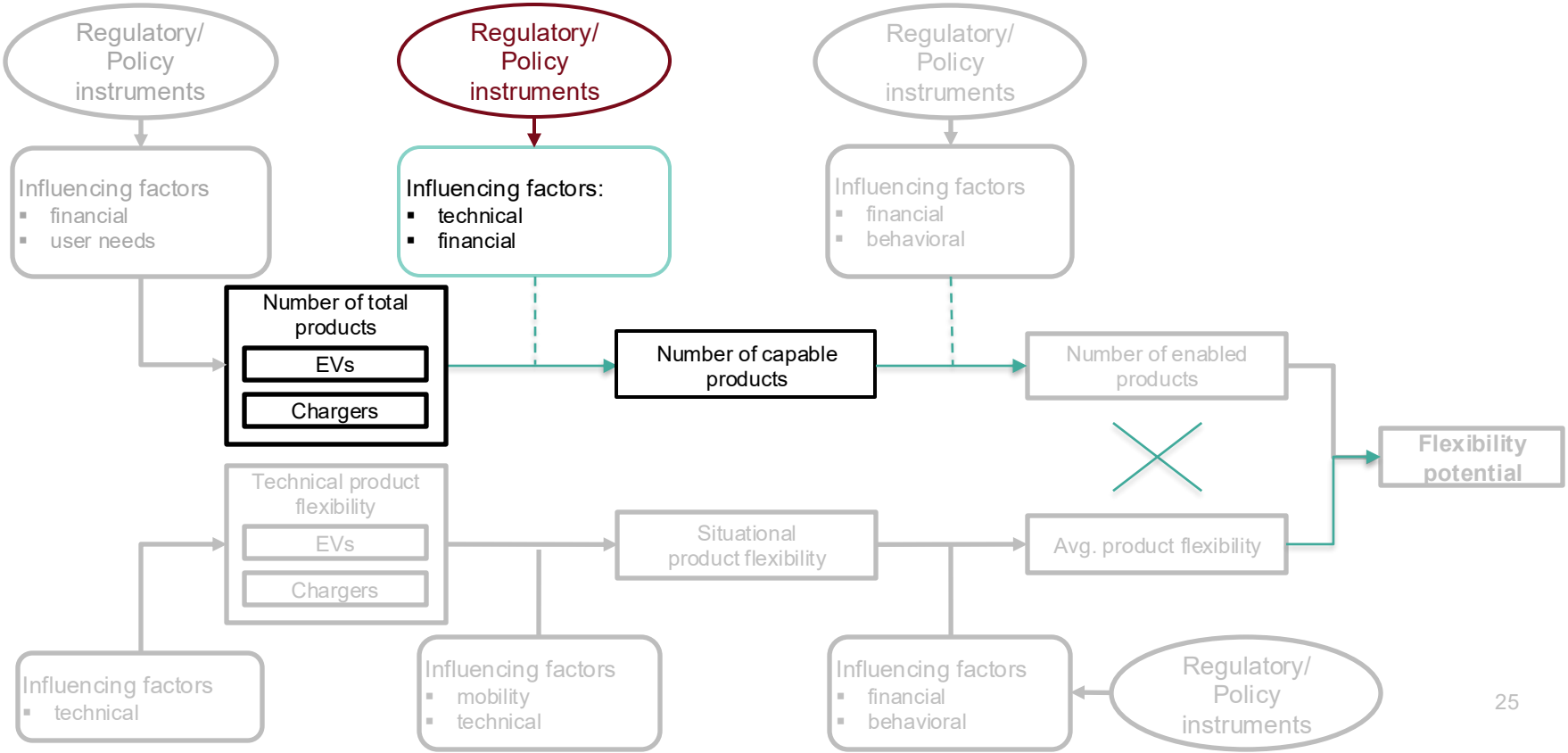
NUMBER OF TOTAL PRODUCTS

✓ Data available
~ Some data available
✗ No data available

✓ Financial influencing factors for EVs

- **EV investment costs:**
  - Investment-driven manufacturing scale and learning-by-doing in EV battery production have driven substantial battery cost reductions [51]
  - EVs might by 2027 become cheaper than conventional cars (same category + performance) [39]
- **Charging infrastructure availability:** Adding one additional charging port per 1,000 residents is associated with a ~0.4% increase in EV adoption, while one additional charging station per 1,000 residents correlates with a ~2% rise in EV uptake. Moreover, private charging infrastructure—e.g. workplace or home charging—has a stronger effect than public stations, delivering an estimated 15.7% increase in EV adoption compared to 2.8% for public chargers [52]
- **Alternative fuel costs:** A given change in gasoline prices has roughly four to six times the effect on EV demand as a similar percentage change in electricity prices [50]
- Cost ratios to alternatives (both for investment costs as well as fuel costs) matter more than absolute costs

IN DEPTH-LOOK: NUMBER OF CAPABLE PRODUCTS



NUMBER OF CAPABLE PRODUCTS

✓ Data available
~ Some data available
✗ No data available

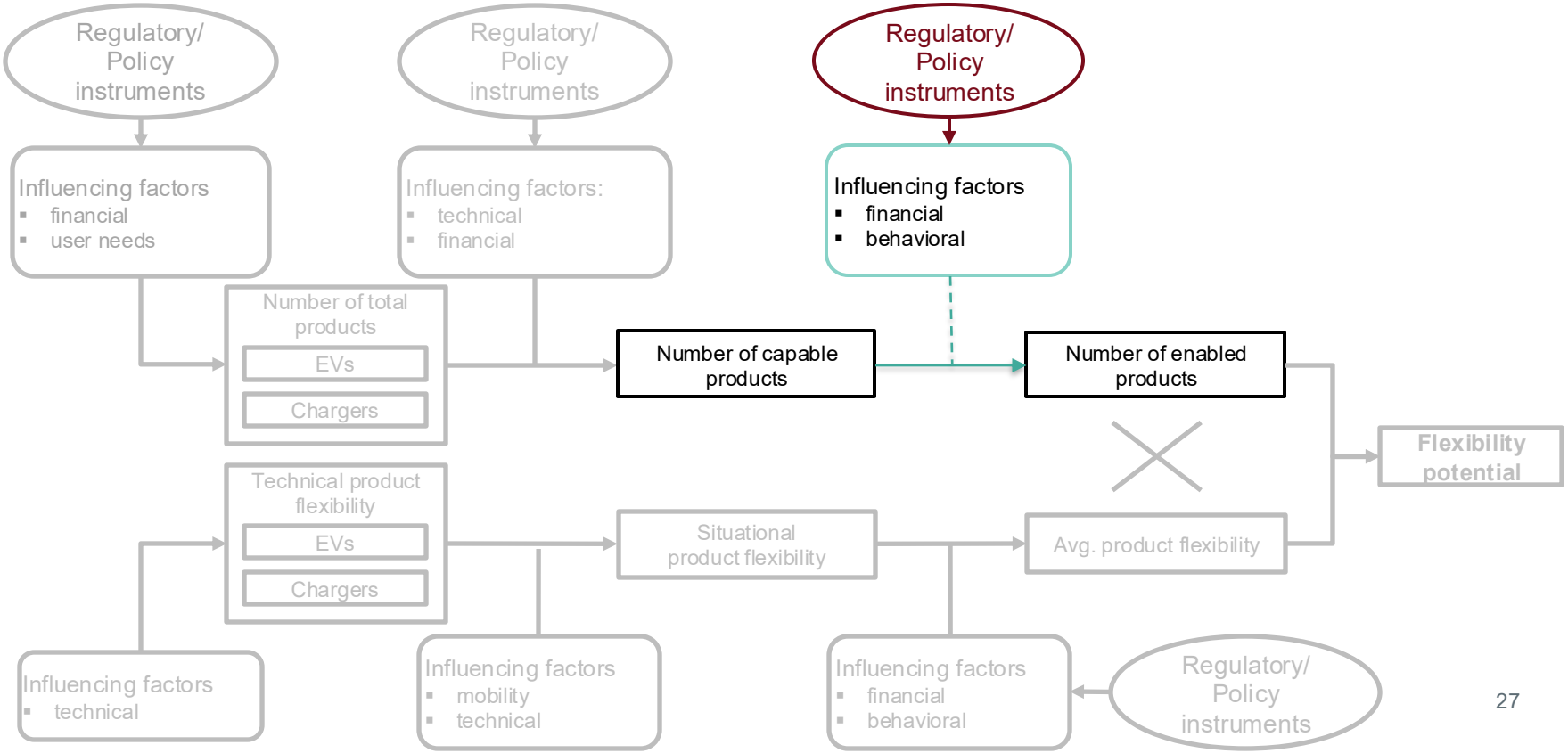
Regulatory measures

- Financial incentives for home chargers

~ Financial influencing factors for home chargers

- Home chargers require a private parking lot. In Austria 86% of households have home parking [11]
- CA: With a subsidy of CAD 1000, 1 in 5 EV owners will install a home charger [32]
- US: Subsidy of 30%, max. USD 1000 tax credit added approx. 100–150 home chargers annually in California from 2020 - 2023 [33]
- US: USD 2000 per charger results in ~1 additional charger installed per 2–3 eligible households, compared to <10% adoption without subsidies [34]
- US: subsidies covering 50–75% of home charger costs increases installation rates by 30–40% in regions with moderate EV adoption [35]

IN DEPTH-LOOK: WILLINGNESS OF USERS



NUMBER OF CAPABLE PRODUCTS WITH WILLING USERS

✓ Data available
~ Some data available
✗ No data available

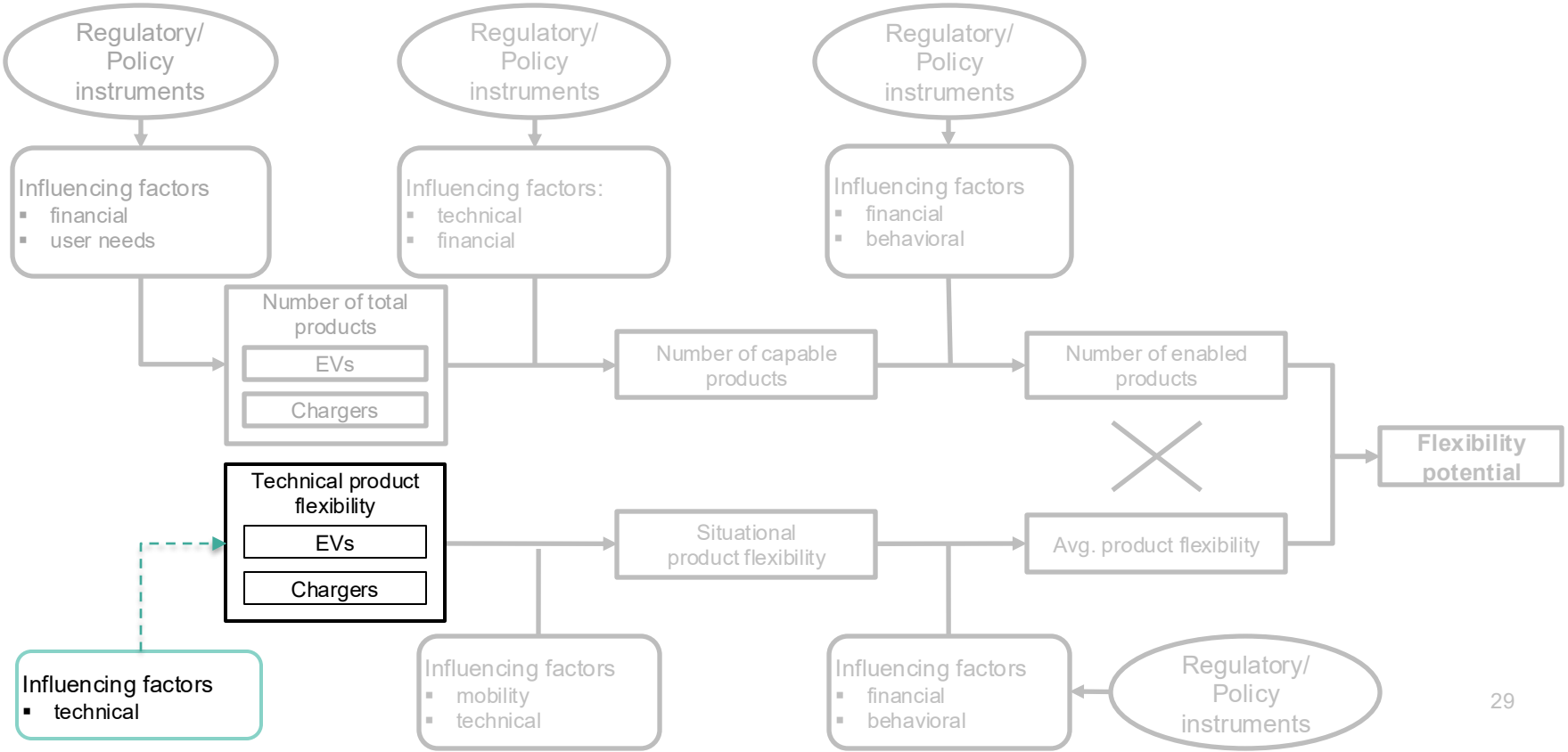
Regulatory measures

- Financial incentives for flexibility provision

~ Financial influencing factors

- US: offering USD 0.10–$0.20 per kWh for shifting charging to off-peak times or participating in V2G increased user participation by 40–60% [36]
- US: USD 100 annual payment for participating in smart charging programs increasing willingness by 30–50%. For V2G, payments of USD 200–500 per year per vehicle led to 50–70% participation rates among EV owners, compared to <20% without incentives [37]

IN DEPTH-LOOK: TECHNICAL PROD. FLEXIBILITY



TECHNICAL PRODUCT FLEXIBILITY

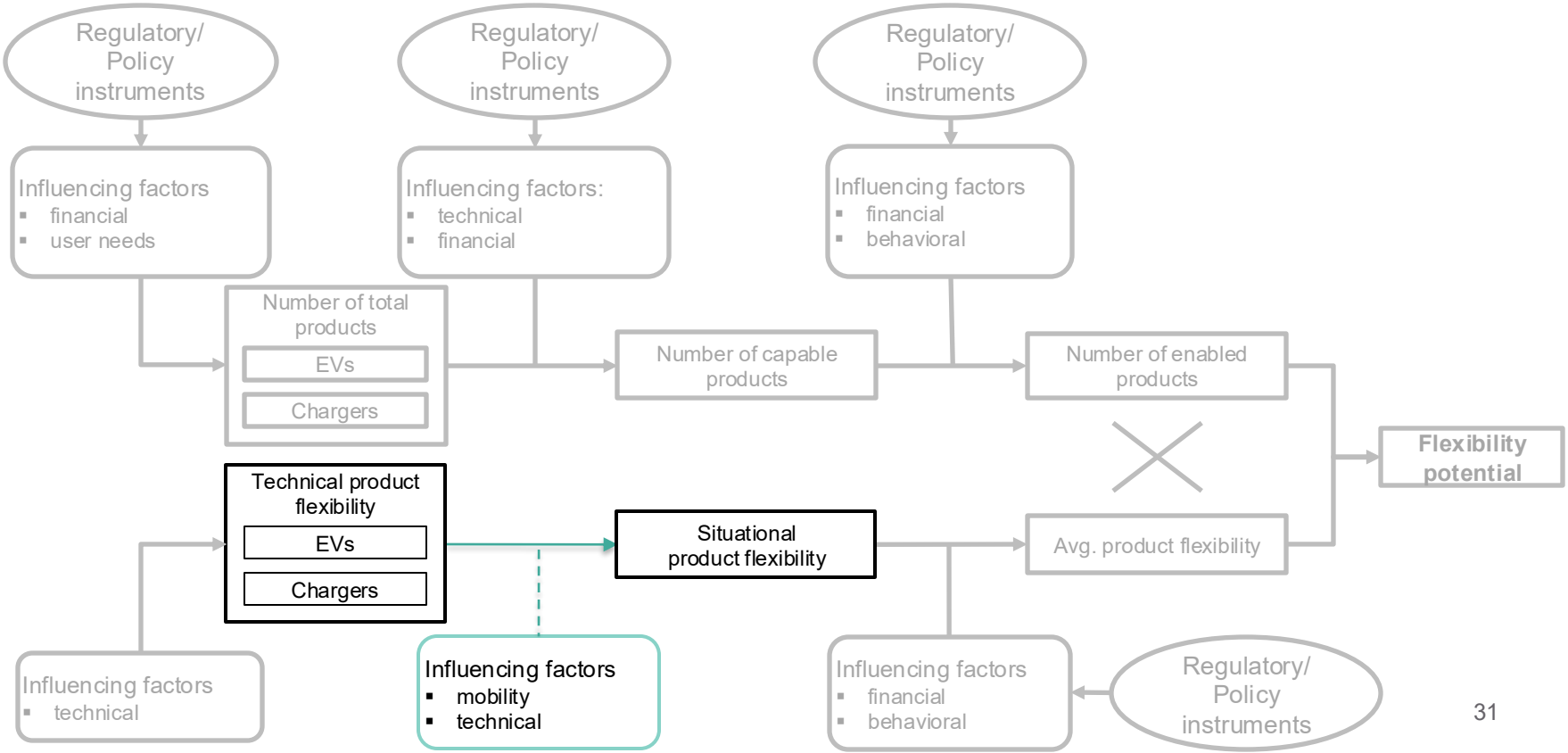
Technical influencing factors:

- Power flexibility is limited by the home charger (7kW)
- Energy flexibility is limited by the battery capacity (54kWh)

Regulatory measures

- Regulatory / policy instruments have **no direct influence** on the products but could influence them if they target changes in typical charging power ranges or battery capacities.
- Mainly they are **technology-driven** and **market-driven**

IN DEPTH-LOOK: SITUATIONAL PROD. FLEXIBILITY



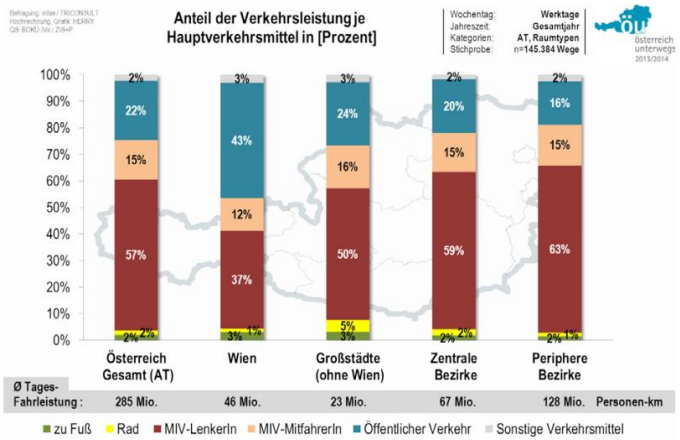
SITUATIONAL PRODUCT FLEXIBILITY

Regulatory and policy instruments

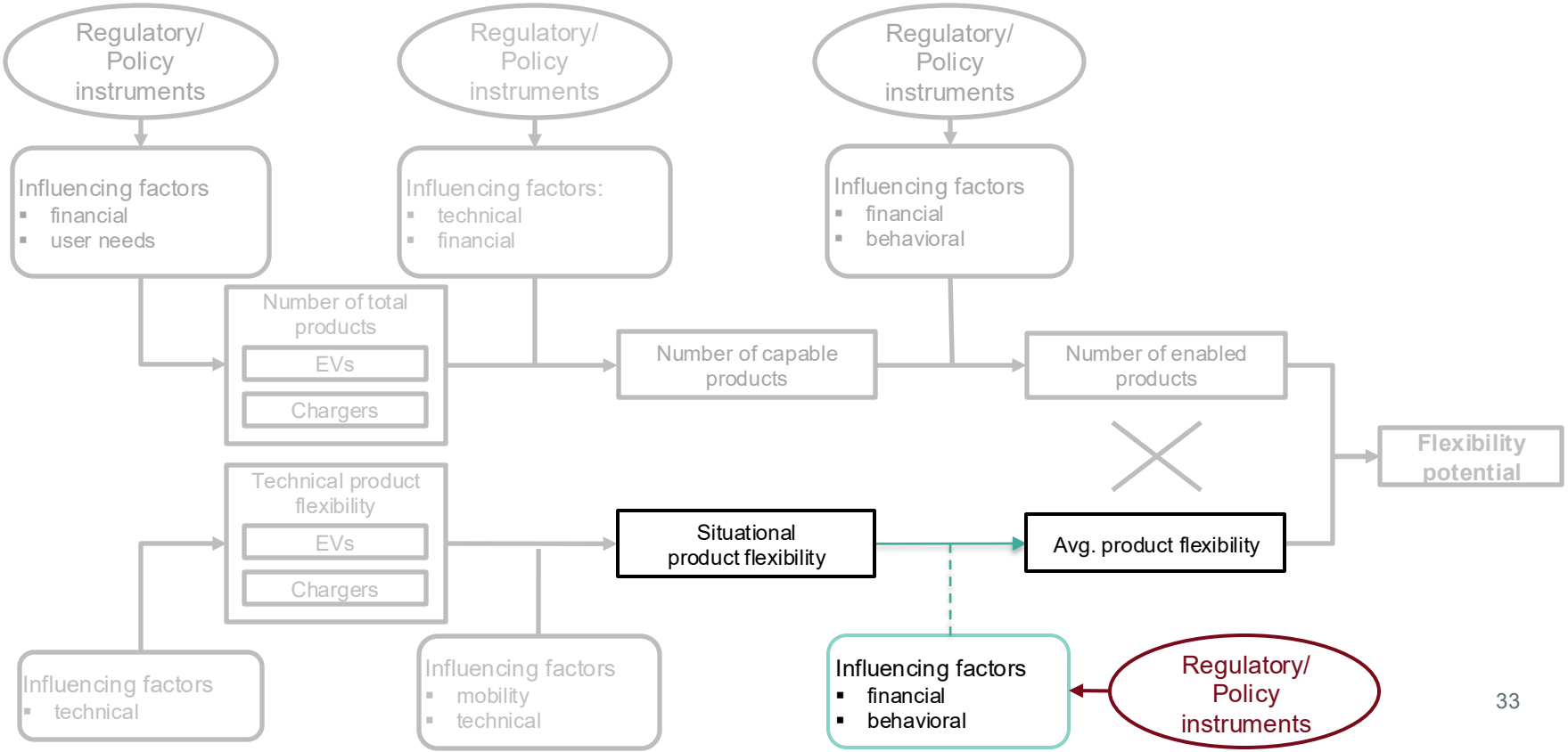
- Mostly based on **technology** and **mobility behavior**

Influencing factors

- Each Austrian person moves 34.3 km per day on average, 19.5 km (57%) using the car [11]
- Average daily consumption is 2.8 kWh
- Power flexibility is due to this charging demand: slightly asymmetric +7 kW / -6.7 kW
- Energy flexibility potential is approx. between 50% - 80% of the battery capacity (V2G).



IN DEPTH-LOOK: AVG. PRODUCT FLEXIBILITY



AVERAGE PRODUCT FLEXIBILITY

✓ Data available
~ Some data available
✗ No data available

Regulatory and policy instruments

- Public awareness campaigns to motivate people to plug in their EVs for flexibility provision

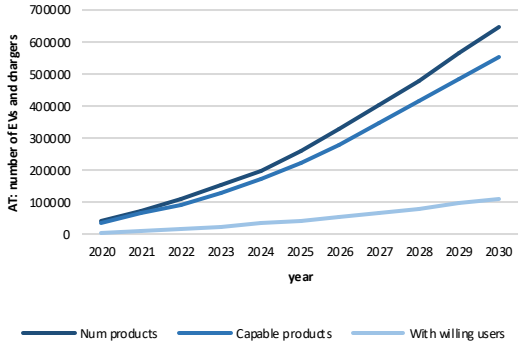
✗ Behavioral influencing factors

- Users may plug in their EVs every day (high flexibility potential), or only if recharging is needed (low flexibility potential), influenced by
  - Hassle factor: plugging the EV by wire versus integrated charging pad
  - Range anxiety and fear of battery degradation through V2G [38]
- If the EV is plugged in 50% of the time, the flexibility is reduced by 50%
  (no real data available since the technology is not available yet)

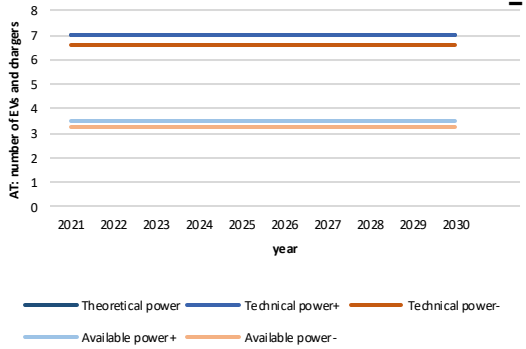
ESTIMATION FOR POWER: FORECAST FOR AT

Conservative scenario

Num products



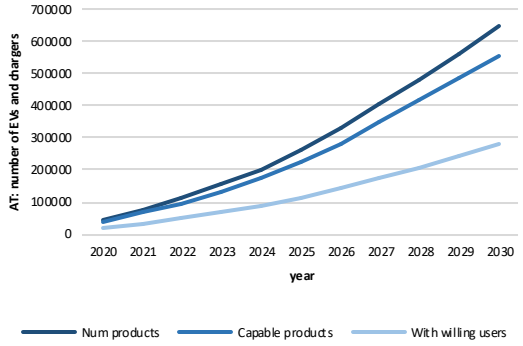
Avg. product flex



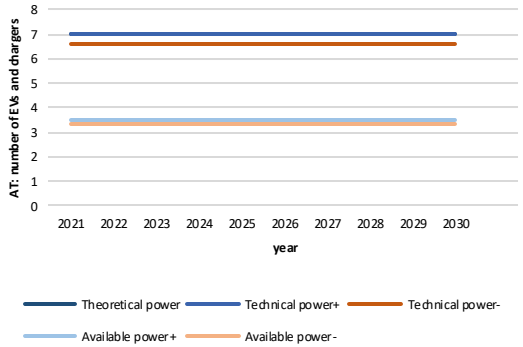
= +391 / -368 MW*

Optimistic scenario

Num products



Avg. product flex



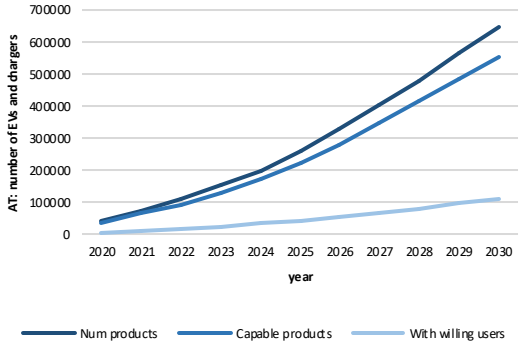
= + 977 / -921 MW*

*** in 2030**

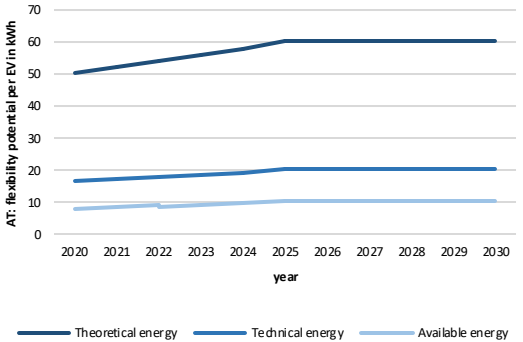
ESTIMATION FOR ENERGY: FORECAST FOR AT

Conservative scenario

Num products



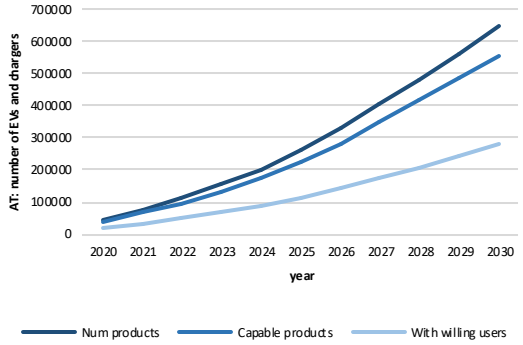
Avg. product flex



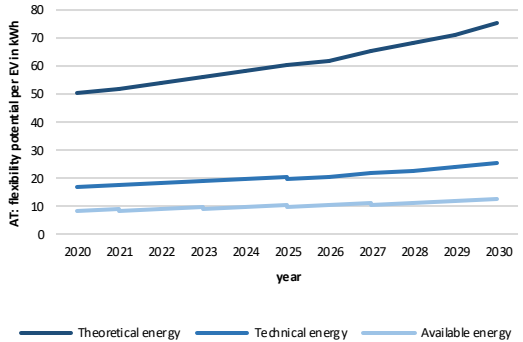
= 1004 MWh*

Optimistic scenario

Num products



Avg. product flex



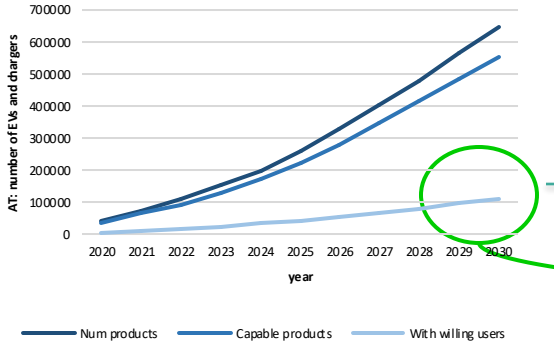
= 3488 MWh*

*** in 2030**

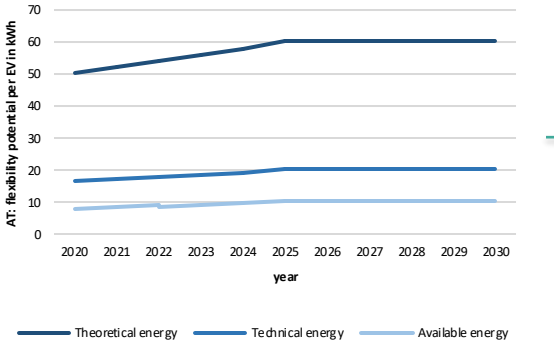
ESTIMATION FOR ENERGY: FORECAST FOR AT

Conservative scenario

Num products



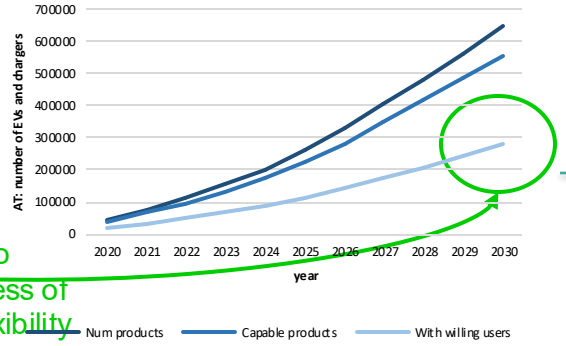
Avg. product flex



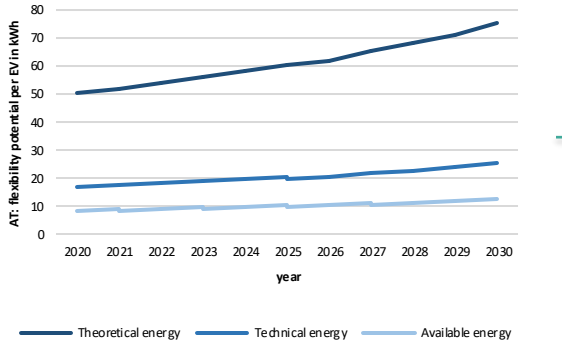
= 1004 MWh*

Optimistic scenario

Num products



Avg. product flex



= 3488 MWh*

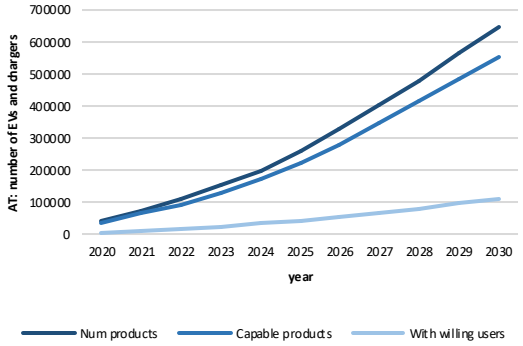
Difference in the two scenarios: Willingness of users to provide flexibility

* in 2030

ESTIMATION FOR ENERGY: FORECAST FOR AT

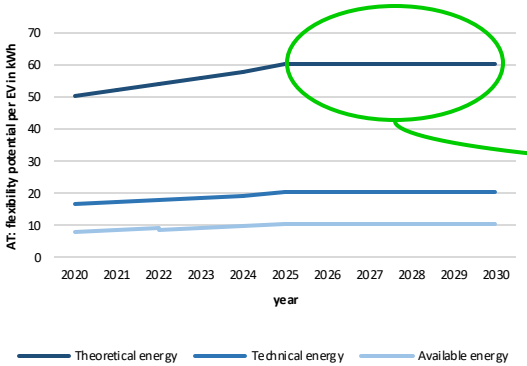
Conservative scenario

Num products



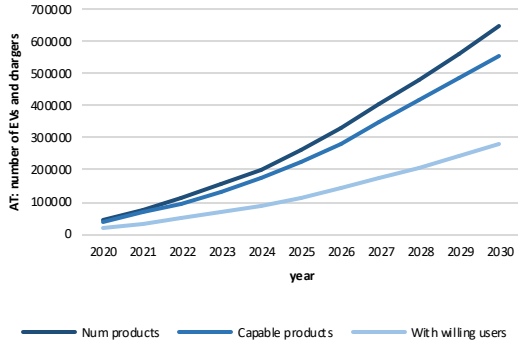
= 1004 MWh*

Avg. product flex



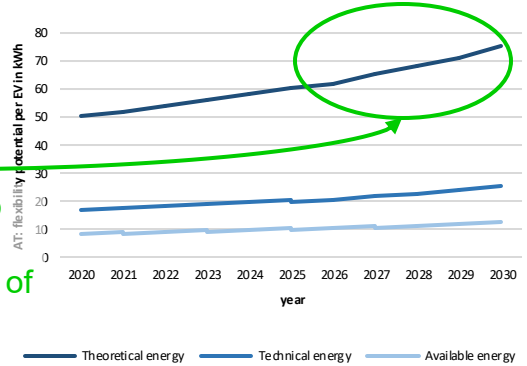
Optimistic scenario

Num products



= 3488 MWh*

Avg. product flex



Difference in the two scenarios: Will the average battery size of EVs increase?

*** in 2030**

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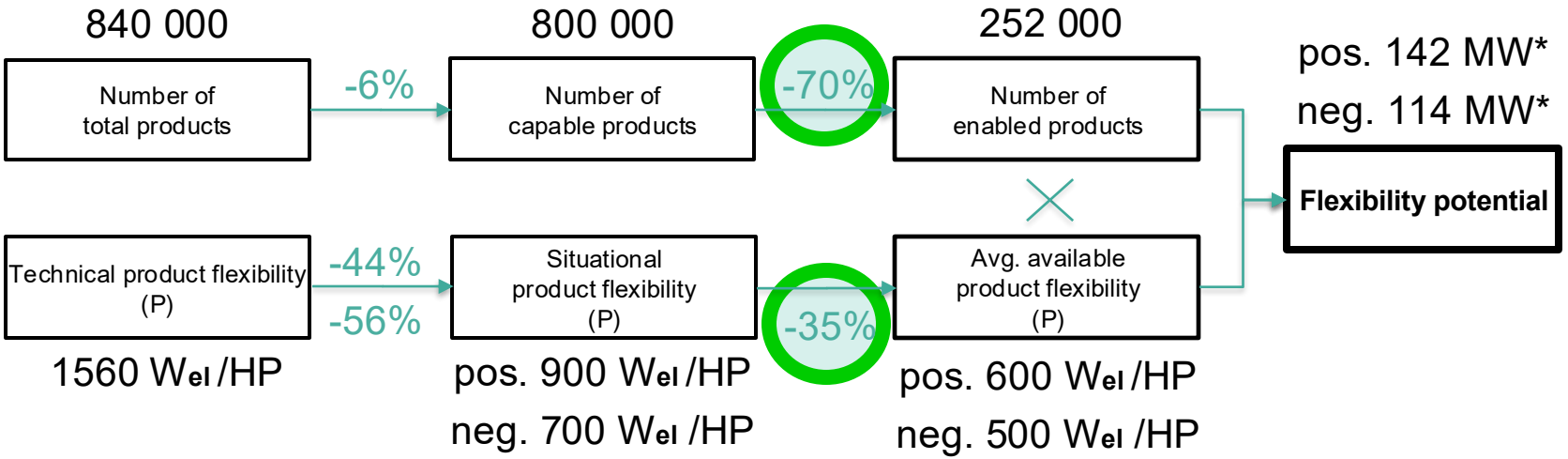
RESEARCH GAPS AND POLICY RECOMMENDATIONS

HP: THEORETICAL NUMBERS FOR AUSTRIA, 2030



*Represents only the share of total flexibility that users allow as short-term flexibility

At 0° C, for max. 4h.

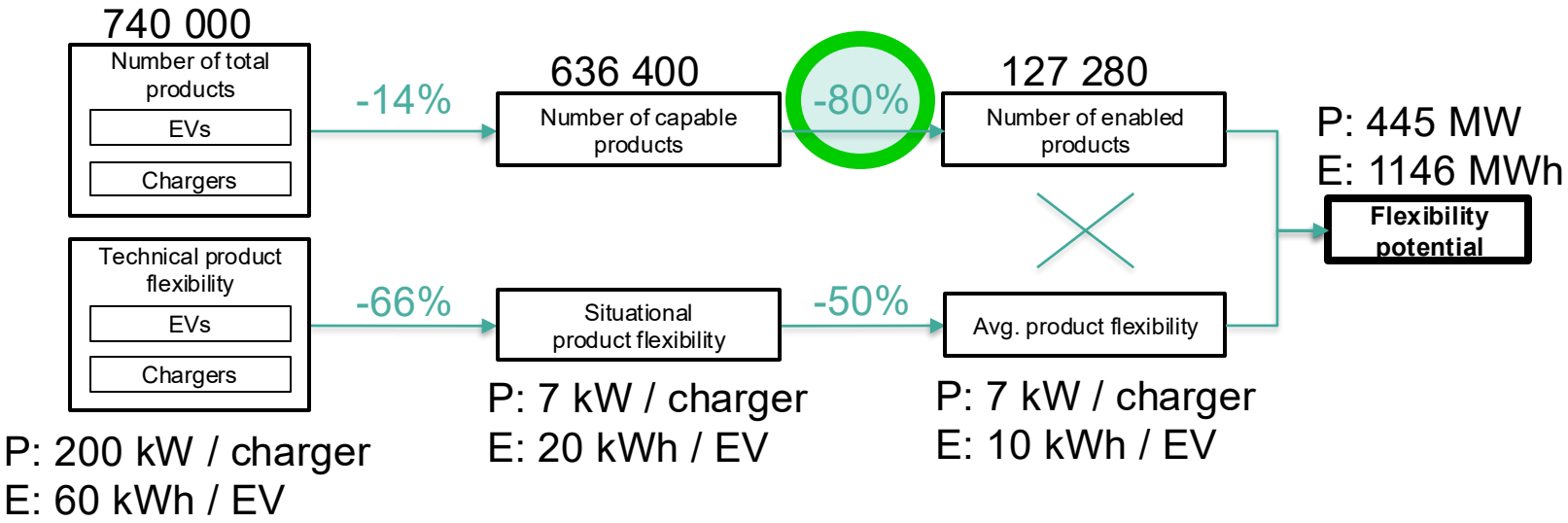
Conservative case

(rounded numbers)

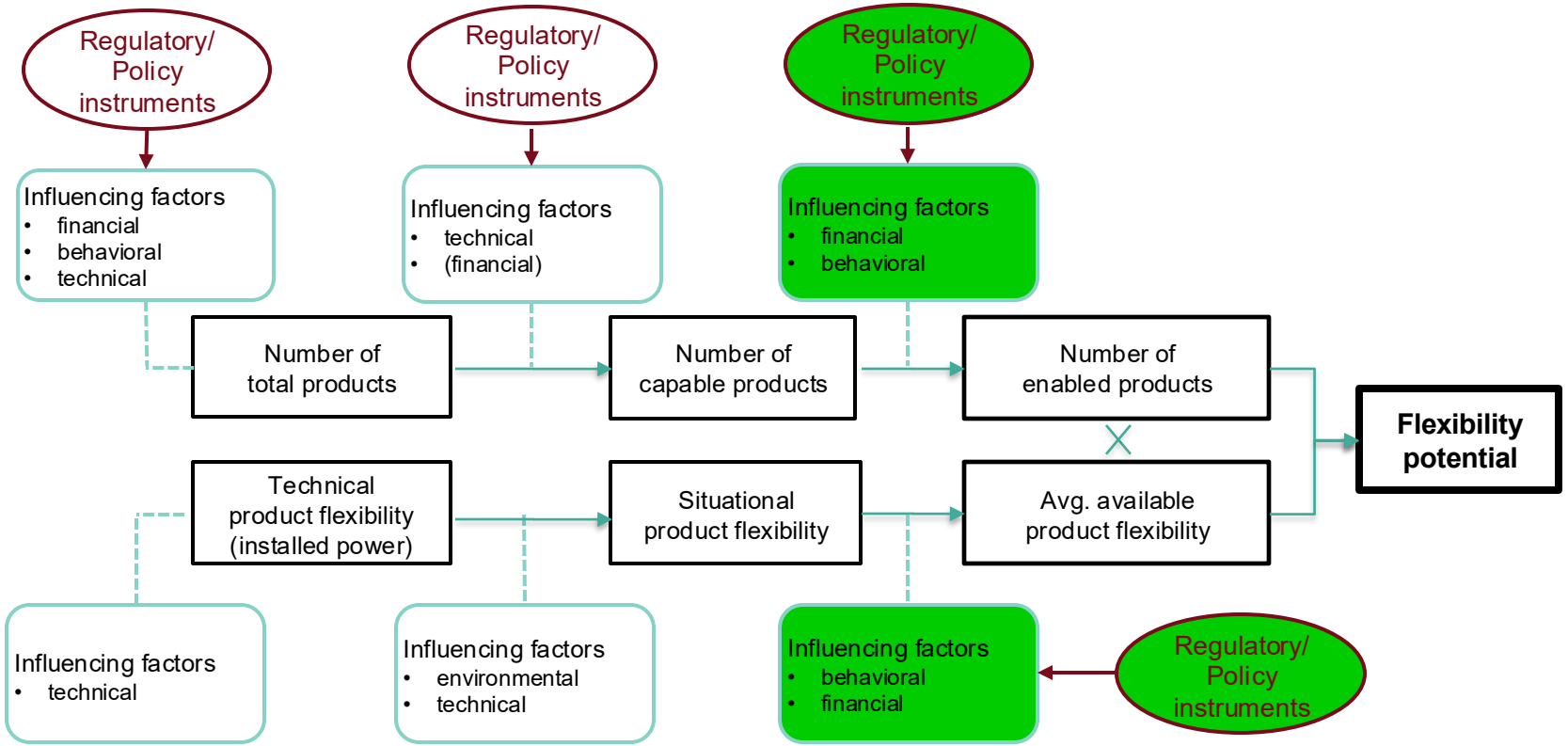
positive flexibility – reducing el. demand – shutting HP off/ decreasing HP capacity

negative flexibility – increasing el. demand – turning HP on/ increasing HP capacity

EV: THEORETICAL NUMBERS FOR AUSTRIA, 2030



RESEARCH GAPS



MANY POSSIBLE POLICY RECOMMENDATIONS

Policy measures	Influence type	Influenced parameter	Mechanism	Impact	
Ban on fossil fuels (energy, mobility)	Regulatory	Number of installed assets	Direct	Forces shift to electrified technologies	[32]
Binding standards for new buildings	Regulatory	Number of installed assets	Mixed	Incentivizes clean technology adoption	[33]
CO_2 fee	Financial	Number of installed assets	Indirect	Incentivizes clean technology adoption	[32], [34]
Subsidies for renovation of buildings (insulation etc.)	Financial	Number of installed assets	Indirect	Incentivizes clean technology adoption	[35]
Subsidies for HPS and EVs with performance/flexible standards	Financial	Number of installed and flexible assets	Direct	Lowers end-consumer cost of flexible assets	[29], [47]
Reduced taxes on flexible EVs & HPs	Financial	Number of installed & flexible assets	Direct	Lowers end-consumer cost of flexible assets	[30]
Legal requirement for device interoperability	Regulatory Technical	Number of flexible assets	Direct	Ensures devices can integrate with smart systems	[31], [48]
Public awareness campaigns, capacity building programs	Social	Number of enabled products. available user flexibility	Indirect	Encourages voluntary participation and informed choices	[23]
Enforce utility incentives / demand-side management (DSM) programs	Regulatory, Behavioral	Number of willing users	Mixed	Promotes flexibility through structured but optional programs	[26]
Training programs for HP/home charger installers or EV sellers/mechanics	Technical, Behavioral	Number enabled products, avg. product flexibility	Indirect	Enhances flexibility through better practices/planning and opens another channel to end consumers	[24]
Certification schemes for “flexible-ready” installers or products.	Technical, Behavioral	Number enabled products, avg. product flexibility	Direct	Improves availability of compliant technologies	[28]

CONCERNING NUMBER OF INSTALLED ASSETS

Policy measures	Influence type	Influenced parameter	Mechanism	Impact	
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CONCERNING NUMBER OF CAPABLE ASSETS

Policy measures	Influence type	Influenced parameter	Mechanism	Impact	
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CONCERNING FINAL USERS PARTICIPATION AND BEHAVIOR

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Policy measures	Influence type	Influenced parameter	Mechanism	Impact	
Ban on fossil fuels (energy, mobility)	Regulatory	Number of installed assets	Direct	Forces shift to electrified technologies	[32]
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That‘s where we lose most of the potential

CONCLUSION

- Extensive data on flexibility and related technologies exists, but different studies often seem inconclusive or lack quantitative depth.

- Policy measures are likely to influence both the number of flexible technologies deployed and the amount of flexibility they can provide. However, it remains unclear which measures are the most effective, as their specific impacts are not yet sufficiently researched.

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THANK YOU!

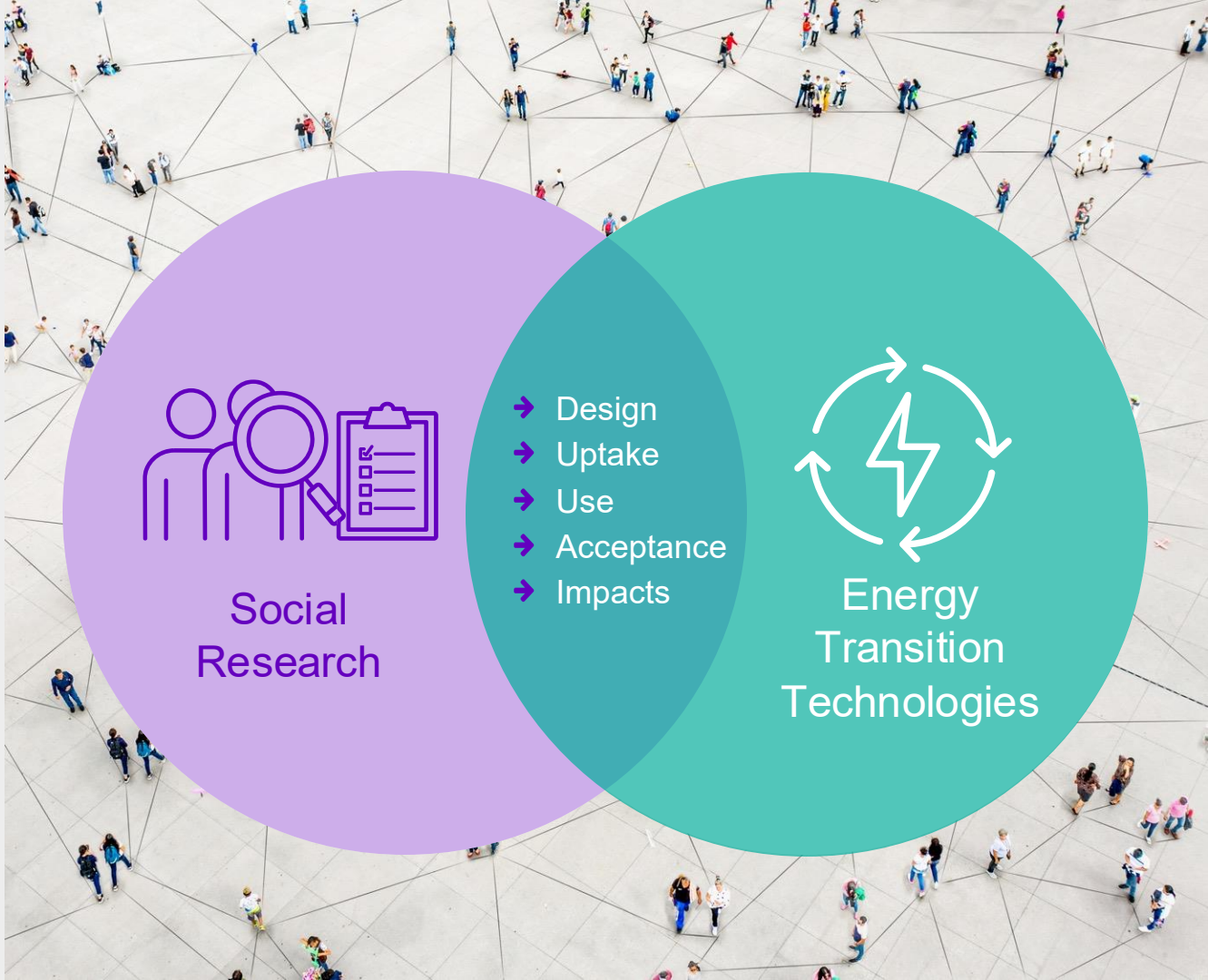
Presenters: Regina Hemm, Bin Hu, Viktoria Ilyés
Ivan Mariuzzo, Tara Esterl

Contact: regina.hemm@ait.ac.at

UsersTCP

What we do

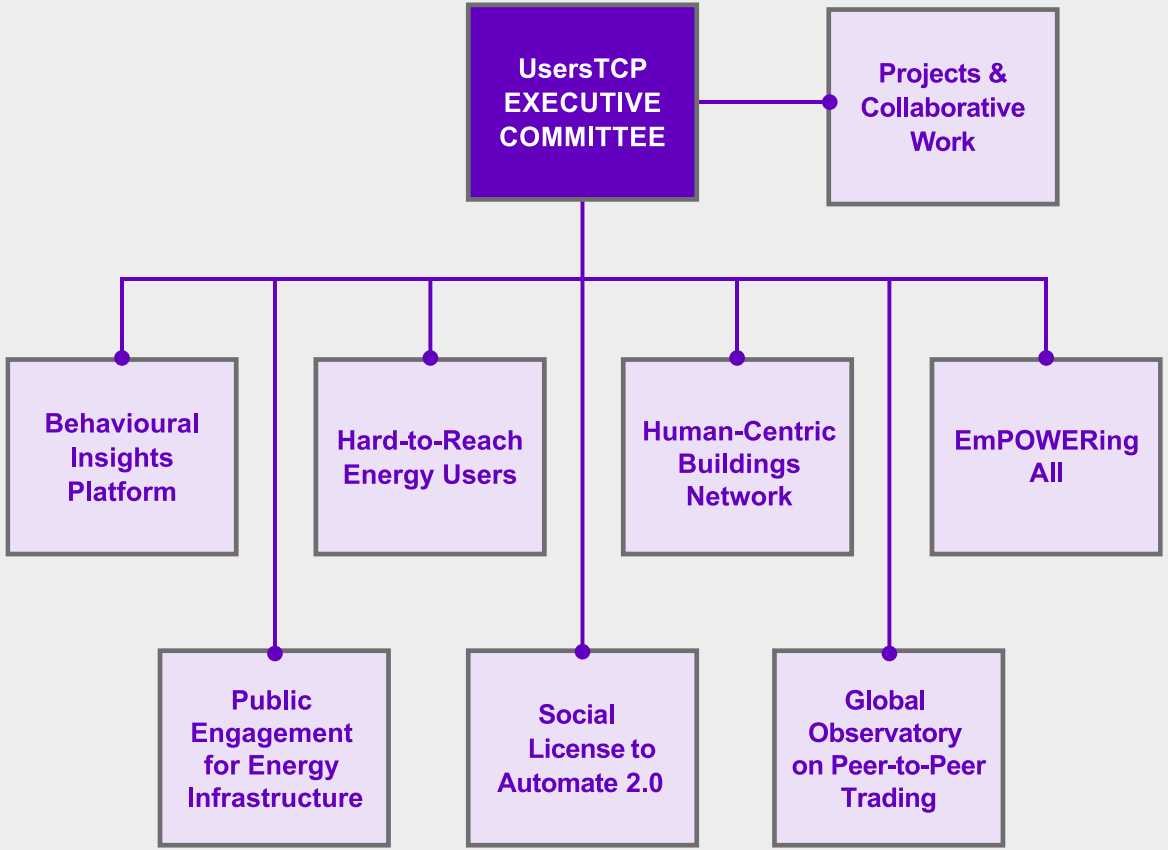
Social research to support energy transition policy goals



UsersTCP

Structure

The Users TCP's Tasks are the main international collaborative mechanisms through which we deliver on our strategy.



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Available soon

at www.userstcp.org

Email TCP Secretariat
to ensure you don't miss out
admin@userstcp.org

UsersTCP

Contact Us

For more information,
visit userstcp.org
or email TCP Secretariat
at admin@userstcp.org

Q&A