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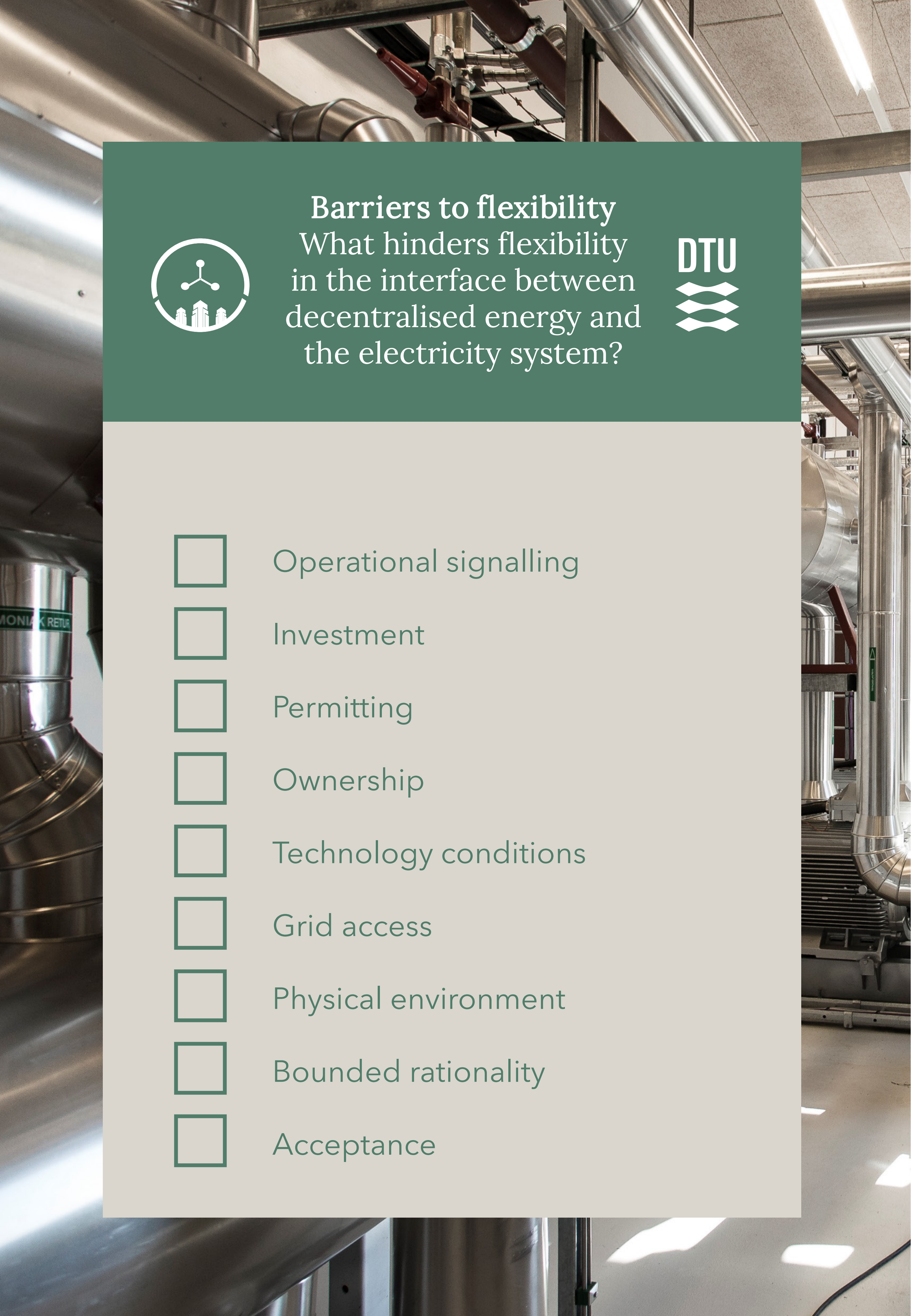

Barriers to flexibility
What hinders flexibility in the interface between decentralised energy and the electricity system?

DTU

- [ ] Operational signalling
- [ ] Investment
- [ ] Permitting
- [ ] Ownership
- [ ] Technology conditions
- [ ] Grid access
- [ ] Physical environment
- [ ] Bounded rationality
- [ ] Acceptance

Barriers to flexibility
What hinders flexibility in the interface between decentralised energy and the electricity system?

Policy brief
2021

By: Daniel Møller Sneum & Claire Bergaentzlé

Cover photo: Large-scale heat pump by Jesper Voldgaard

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Sector coupling, smart energy and integrated energy systems all assume one thing:

INTEGRATION BETWEEN ENERGY SECTORS MUST BE FLEXIBLE

But what if it isn't?

Through review of 109 pieces of literature, The FlexSUS Project brings you a comprehensive overview of barriers to flexibility in the interface between decentralised energy and the electricity system.

THIS BRIEF

- **defines flexible sector coupling** in the interface between district heating/cooling and the electricity system

- provides a taxonomy – a useful **checklist for policymakers driving increased flexibility** in integrated energy systems

- **indicates areas of priority** for technologies, decision-levels and project life cycles when addressing barriers.

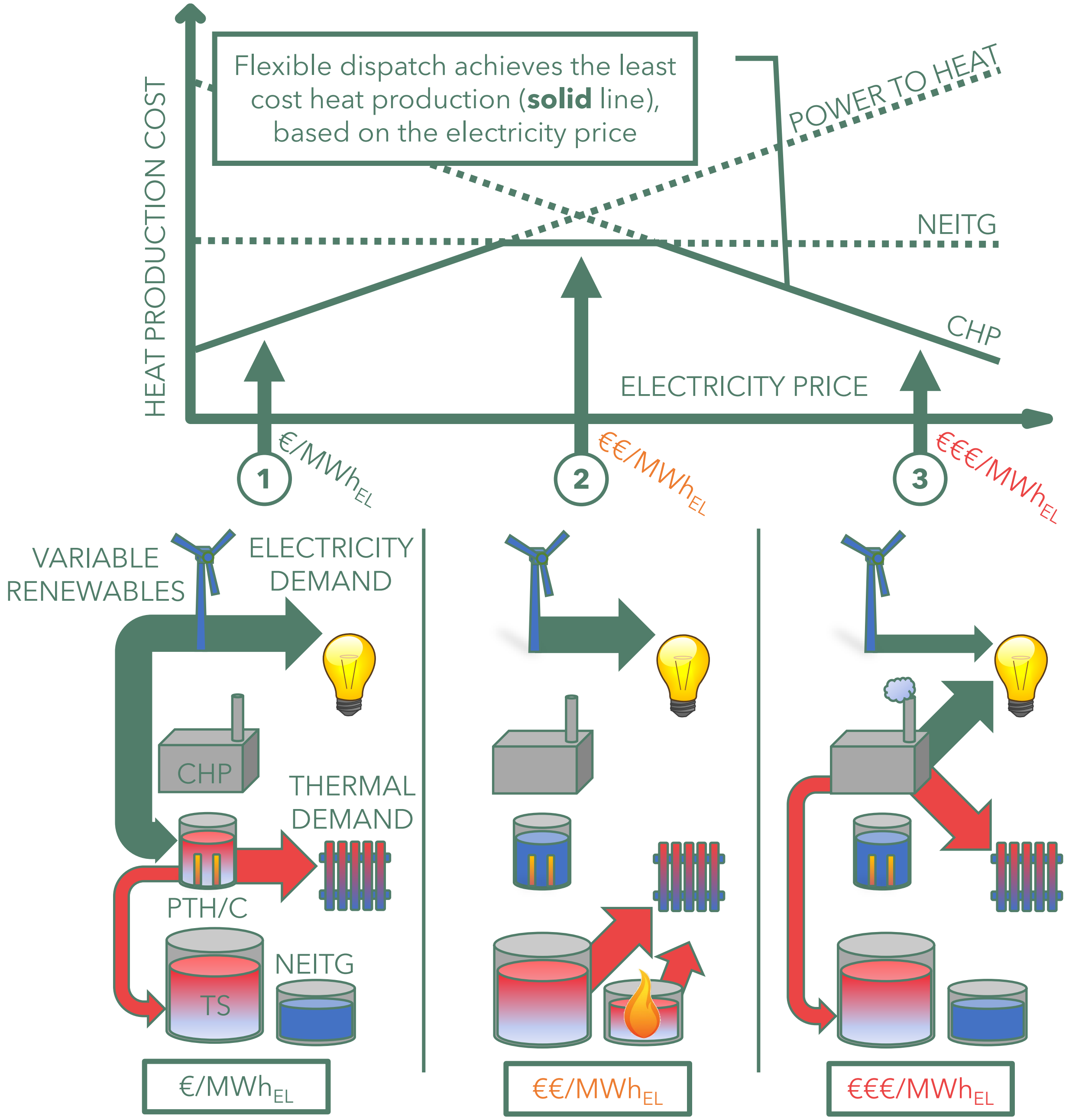
The findings are based on the scientific article *Barriers to flexibility in the district energy-electricity system interface – A taxonomy*.

While district energy (district heating and cooling) is the case in point, most of the findings apply for all decentralised energy systems/sector coupling/ integrated- and smart energy systems.

FLEXIBILITY = RESPONDING TO SIGNALS

e.g. electricity prices or emissions. The response can be to adjust production or consumption of energy vectors like electricity and heat.

EXAMPLE: FLEXIBLE DISTRICT ENERGY



1. Low electricity price/ high variable renewable energy share. PTH consumes electricity, supplies heat

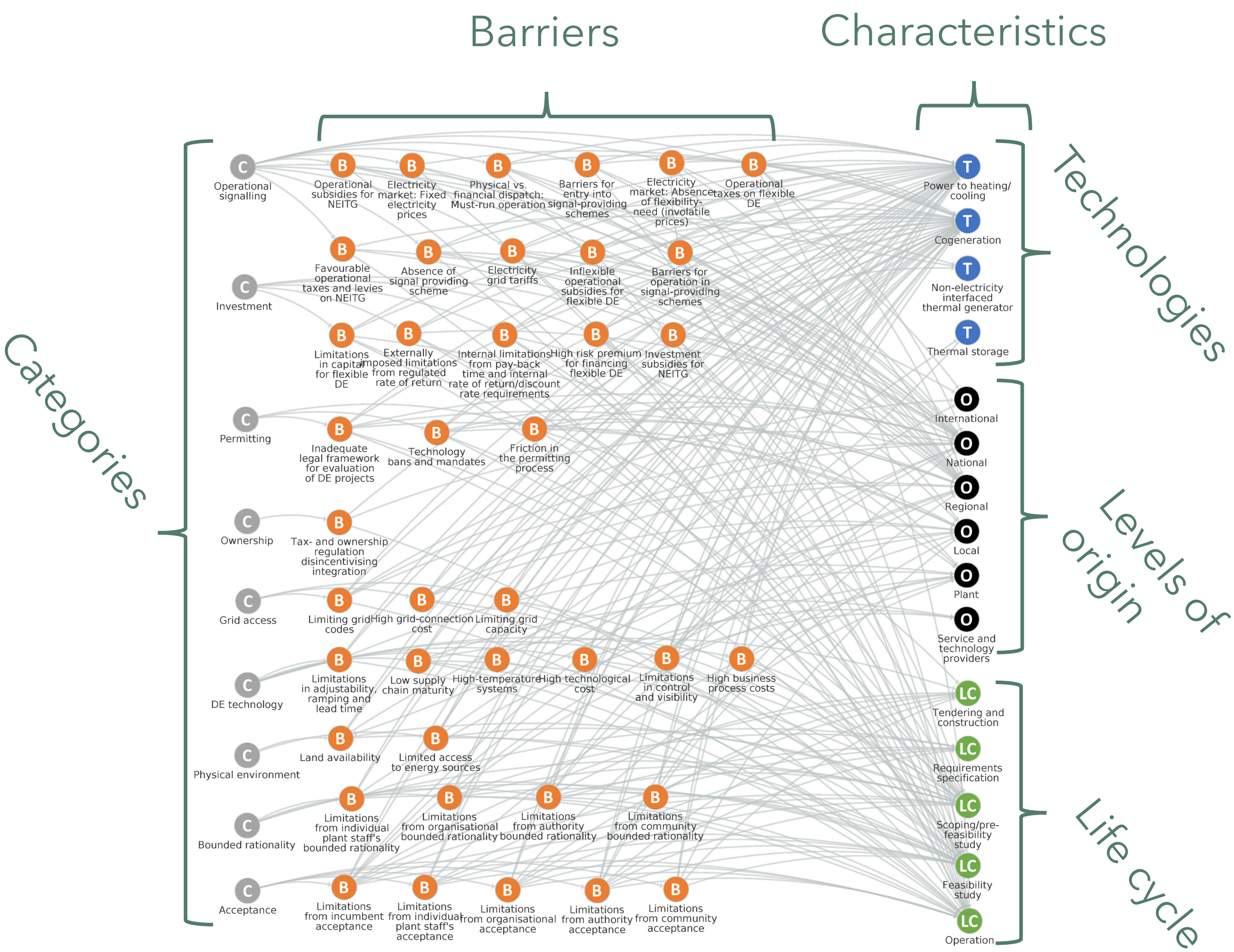
2. Medium electricity prices/medium variable renewable energy share. Thermal storage or NEITG supply heat

3. High electricity prices/low variable renewable energy share. Cogeneration supplies heat + electricity

CHP - Combined heat and power/cogeneration plant
NEITG - Non-electricity interfaced thermal generator (typically a boiler for heating or a chiller for cooling)
PTH/C - Power to heat/cold
TS - Thermal storage (typically a cold/hot water heat accumulator)

CATEGORIES AND CHARACTERISTICS OF BARRIERS

Barriers fit within categories and have characteristics. Example on next page.

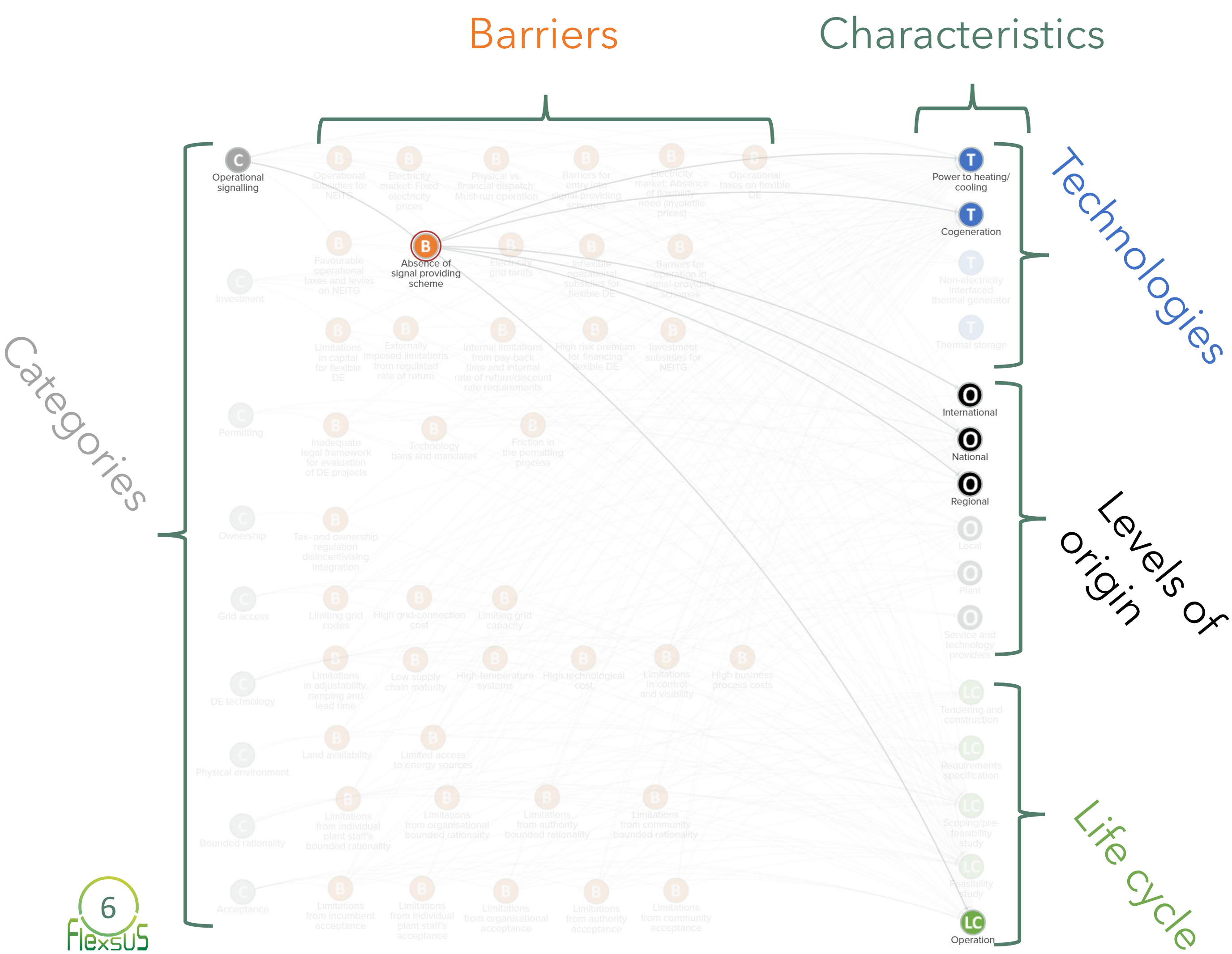


Interactive version

bit.ly/FlexibleDistrictEnergy

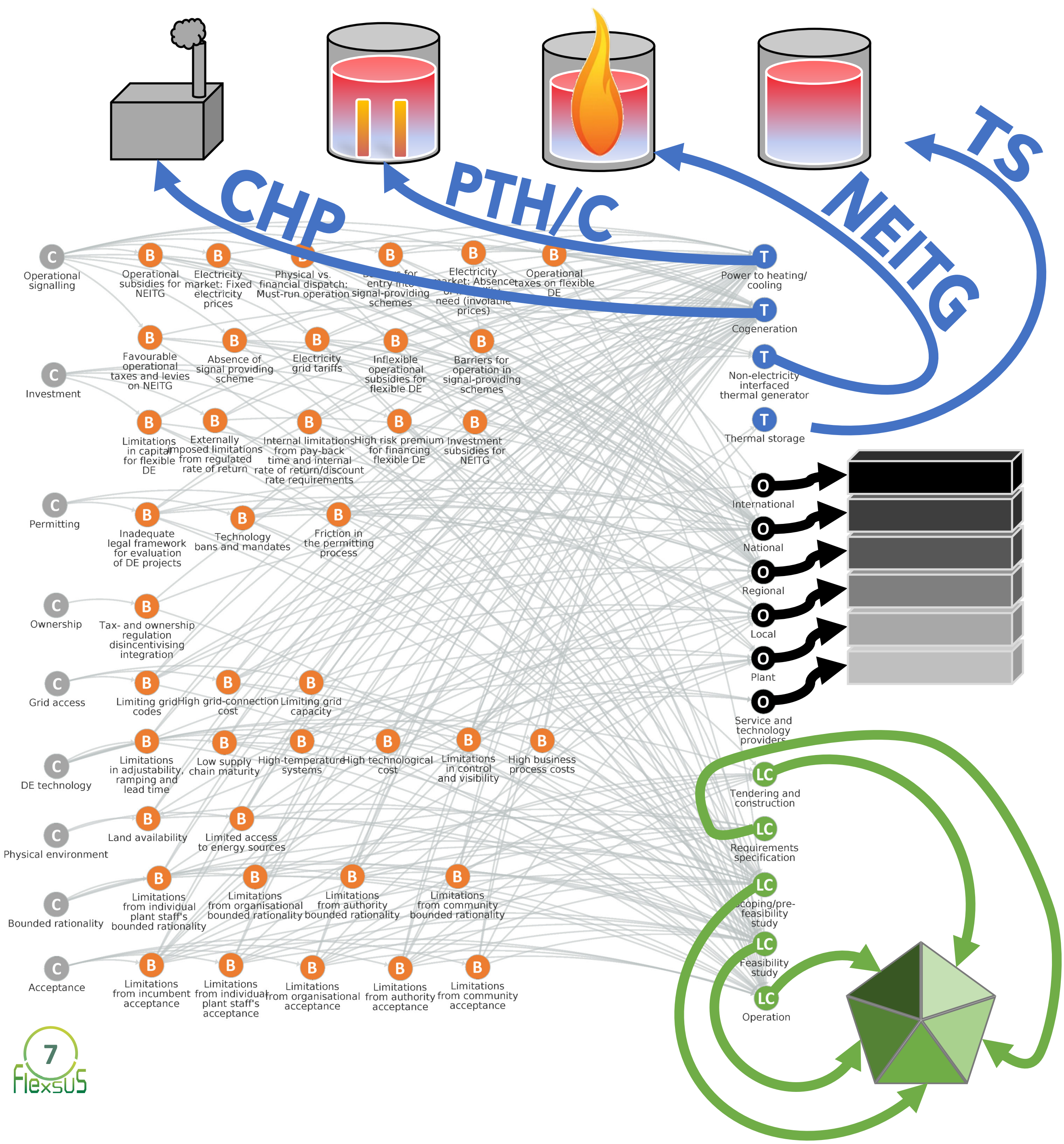
EXAMPLE

Absence of signal providing scheme is a Barrier that fits within the Category *Operational signalling*, has the Characteristics of affecting Technologies *Power to heating/cooling* and *Cogeneration*, Originating from *International*, *National* and *Regional* levels and impacting Life cycle phase *Operation*.



LEGEND

The checklist of barriers and solutions begins on the next page. These icons and abbreviations are used to describe barrier characteristics.

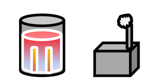


OPERATIONAL SIGNALLING #1	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Absence of signal-providing scheme	*Responding to signals requires the existence of a signal-providing scheme.*	*Establishment of a signal-providing scheme – e.g. electricity market or environmental footprint.*			
Electricity market: Absence of flexibility-need	*Price volatility in electricity markets is necessary to incentivise a shift in operation among technologies.*	*Price-reflective signals with higher granularity geographically or temporally (e.g. bids based on minutes instead of hours).*			
Electricity market: Fixed electricity prices	*Fixed electricity prices remove the ability to respond to real-time signals.*	*Introducing signals by shifting (part of) the fixed price to become variable*			
Physical vs. financial dispatch: Must-run operation	*Must-run operation reduces flexibility. Dispatch according to e.g. physical contracts or heat demand disregards flexibility needs.*	*Advanced control strategies that take into account both heat demand and other signals*			
Operational taxes on flexible district energy	*Taxes on the use of flexible district energy technologies reduce their competitiveness*	*Adjusting taxation to a point where the desired technologies are competitive*			

OPERATIONAL SIGNALLING #2	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Favourable operational taxes on NEITG	*If NEITG supplies cheaper heating, it will be dispatched. This is problematic if flexible technologies are uncompetitive.*	*Levelling taxes for electricity and biomass for heating*			
Inflexible operational subsidies for flexible district energy	*Operational subsidies can distort signals by dampening them or removing them entirely.*	*Signal-enabling subsidies such as feed-in-premiums or capacity payments.*			
Operational subsidies for NEITG	*Such subsidies decrease the relative competitiveness of flexible district energy technologies.*	*Adjust or remove subsidy, according to societal priority.*			
Electricity grid tariffs	*Like taxes, electricity grid tariffs can make PTH/C less competitive.*	*Time-of-use tariffs as a least-worst option. Ideally dynamic tariffs.*			
Barriers for entry into signal-providing schemes	*Discriminatory entry requirements can impact technologies otherwise capable of offering flexibility and services.*	*Reduce transaction costs of market access.*			
Barriers for operation in signal-providing schemes	*If potential for flexibility is under-utilised with an inadequate market design. E.g. if the market insufficiently values flexibility.*	*Fair remuneration for all assets that can provide flexibility.*			

INVESTMENT	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Investment subsidies for NEITG	*Such subsidies would decrease the relative competitiveness of flexible technologies.*	*Adjust or remove subsidy, according to societal priority.*			
Limitations in capital for flexible district energy	*Large upfront investment costs are common in district energy projects, making access to capital an essential issue.*	*Access to low interest, long term loans. Environmental benefits may justify subsidies.*			
High risk premium for financing flexible district energy	*Risk relates to the uncertainties of future conditions for flexible district energy technologies, especially the capability to deliver the desired return on investment.*	*Educate credit-assessors to understand projects. Support schemes. Subsidies for pilot projects.*			
Internal limitations from pay-back time and internal rate of return/discount rate requirements	*Required short pay-back times can challenge investments in flexible technologies.*	*Re-evaluation of need for strict hurdle rates. Public guarantees or subsidies to increase certainty.*			
Externally imposed limitations from regulated rate of return	*For regulated utilities, rate of return restrictions can disincentivise investment in flexible technologies.*	*Allow cost-recovery for investments in flexibility measures.*			

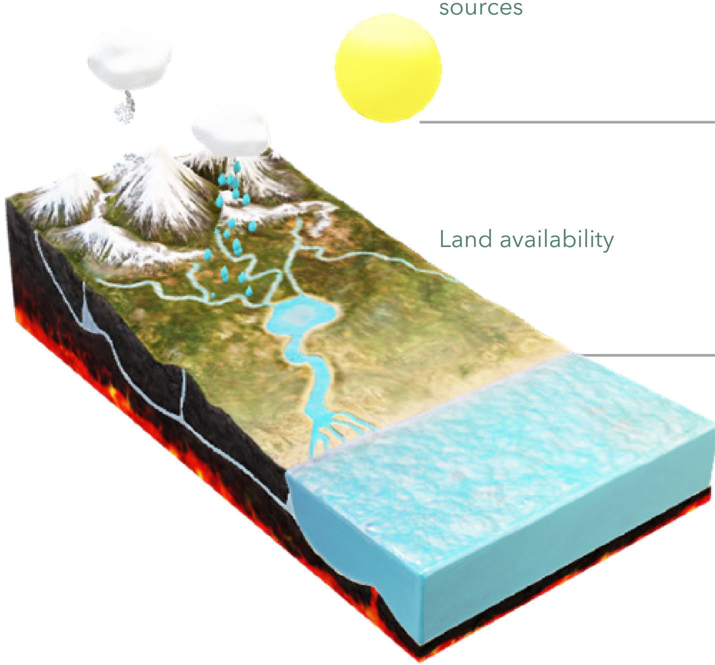
PERMITTING	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Technology bans and mandates	*Obligations to (not) use certain technologies can limit the array of options in district energy.*	*Evaluate whether requirements align with need. Adjust according to flexibility need.*			
Inadequate legal framework for evaluation of district energy projects	*The legal framework for technologies can be lacking or inadequate. E.g. falling between chairs of heat- and electricity regulations.*	*Ensure that flexibility benefits are reflected in feasibility study guidelines, e.g. by implementing the option of variability in electricity prices.*			
Friction in the permitting process	*Complexity and uncertainty in permitting can dampen the desire to undertake projects.*	*Streamline permitting process, e.g. through guidelines or by introducing thresholds under which projects are subject to less stringent permitting.*			

OWNERSHIP	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Tax- and ownership regulation disincentivising grid integration	*Ownership and integration in the district energy-electricity system interface can be impacted by tax regulation. E.g. when actions at a university's district energy plant make the university as a whole subject to utility regulation and taxation.*	*Adjust regulation to accommodate special types of generators, e.g. waivers for small actors.*			

Operational signalling | Investment | Permitting | Ownership | Technology | Grid access | Physical conditions | Bounded rationality | Acceptance

TECHNOLOGY CONDITIONS	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Limitations in adjustability, ramping and lead time	*Technical factors might limit district energy flexibility. E.g. for heat pumps, where ramping and cycling can be limited to avoid wear.*	*Retrofit cogeneration to enable turbine bypass operation, e.g. by letting minimum turbine load feed into a PTH unit.*			
High technological cost	*While district energy can be considered technologically mature, investment can still be substantial.*	*Support for increased innovation and subsidies or tax rebates.*			
High business process costs	*Business process costs are associated with the fixed costs of ownership of an asset. E.g. if flexible power plants have large amounts of personnel.*	*Provide clarity of context-specific business process costs. Digitalization as measure to improve asset management.*			
Low supply chain maturity	*The district energy supply chain can be subject to barriers regarding availability of trained installers, local contractor base and skills of actors.*	*Long-term policies to allow the supply chain to grow, e.g. by facilitating recruitment in relevant industries.*			
Limitations in control and visibility	*Flexibility in the district energy-electricity system interface depends on the ability to monitor, control and validate performance. E.g. lacking standards regarding communication.*	*Standardised and secure communication infrastructure between the signal provider and the district energy unit*			
High-temperature systems	*High temperature systems reduce ability to use PTH/C and TS.*	*Modernisation of networks, especially when old steam-based systems are due to retire*			

GRID ACCESS	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
High grid-connection cost	*High connection charges for coupling to the grid can be prohibitive for new entrants, e.g. if district energy is price-categorized on unequal terms with comparable grid connected technologies.*	*Non-discriminatory interconnection, e.g. by socialising the cost of cable length to accommodate for different geography.*			
Limiting grid codes	*Connection rules can be inconsistent and non-transparent and put limitations on bi-directional power flows.*	*Standardised interconnection agreements. Performance-based regulation for grid operators to incentivise expedient connection.*			
Limiting grid capacity	*Local grid can be a constraint if capacity is insufficient to serve the needs of district energy.*	*Before grid upgrades, smart use of grid with flexible district energy may mitigate the problem.*			



PHYSICAL CONDITIONS	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Limited access to energy sources	*Flexible technologies are dependent on energy sources to operate, e.g. heat pumps need heat sources and cogeneration needs fuel.*	*Mapping of resources together with existing or potential plants*			
Land availability	*Desired technologies can take up more space than alternatives, especially in urban environments.*	*Integrate technologies during renovation projects and during the planning of new infrastructure developments.*			

BOUNDED RATIONALITY	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Limitations from organisational bounded rationality	*Absence of awareness, e.g. among heating system operators on the possibility for flexibility.*	*Increased awareness through information provision, campaigns, financing of feasibility studies or capacity building schemes.*			
Limitations from community bounded rationality	*District energy can be dependent on a local community, as an off-taker of the thermal energy and stakeholder in the permitting process.*	*Well-managed process of information and dialogue, along with introduction of overall and local targets on environment, energy and economy.*			
Limitations from authority bounded rationality	*Absent authority recognition of system-wide benefits.*	*Targets on environment, energy and economy. This impacts authorities by e.g. requirements on renewable energy integration.*			
Limitations from individual plant staff's bounded rationality	*Individuals can e.g. be daily operators, lacking experience with new technologies like heat pumps.*	*Increased awareness through information provision, campaigns, financing of feasibility studies or capacity building schemes.*			

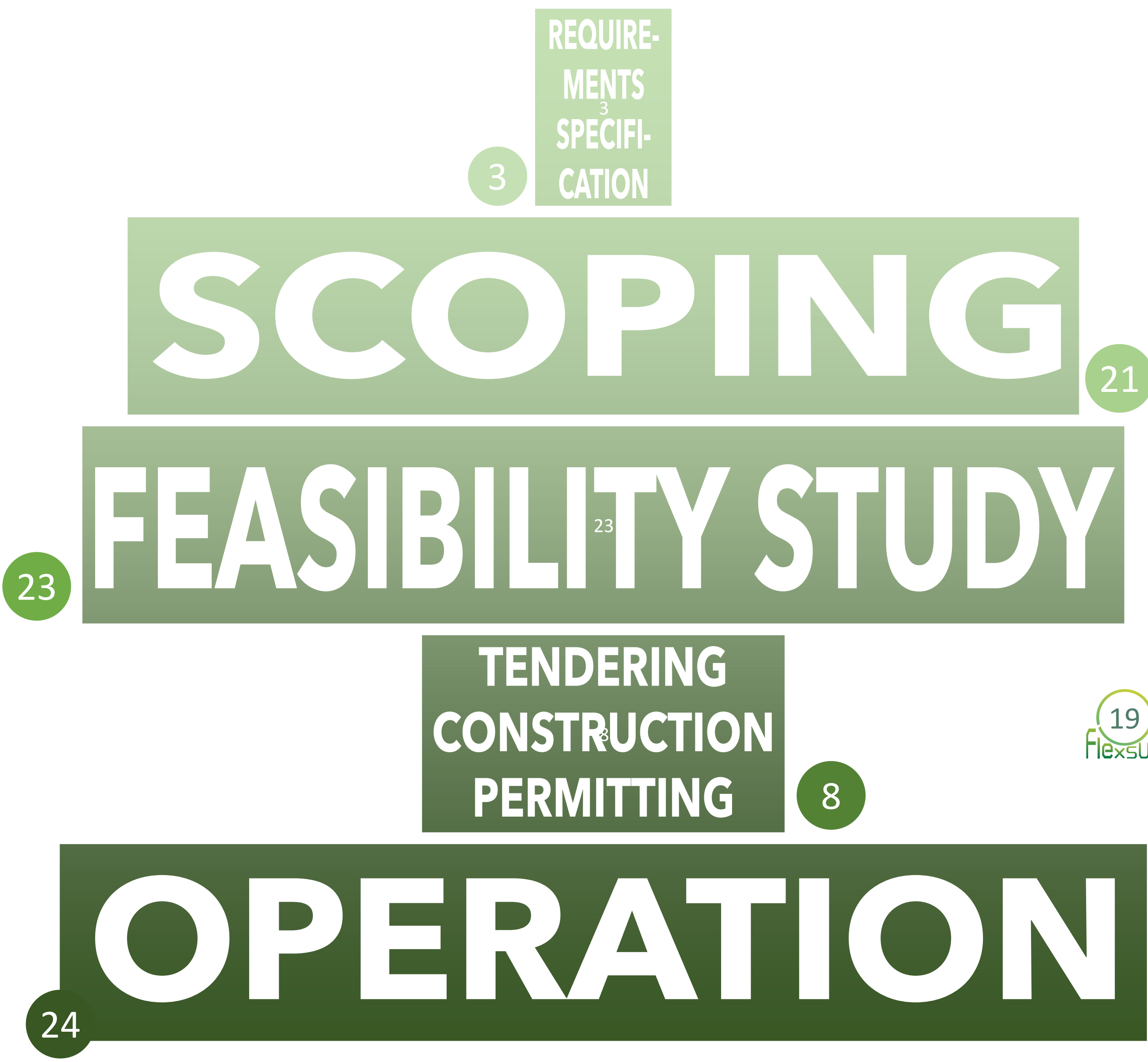
ACCEPTANCE	DESCRIPTION	SOLUTION	TECHNOLOGY TYPE	PROJECT LIFE CYCLE	LEVEL OF ORIGIN
Limitations from organisational acceptance	*Lack of acceptance and priority can arise from the perception that district energy is not the core business activity, e.g. in university microgrids or industry.*	*Map organisational needs to align information and company policies, subsequently reducing inertia.*			
Limitations from community acceptance	*Systems are subject to influence from the community, both the community covered by the district energy network and outside the area.*	*Well-managed process of information and dialogue, along with introduction of overall and local targets on environment, energy and economy.*			
Limitations from authority acceptance	*Negative perceptions on district energy projects regarding e.g. monopoly supply or reputation can reduce the acceptance among authorities.*	*Targets on environment, energy and economy. This impacts authorities by e.g. requirements on renewable energy integration.*			
Limitations from incumbent acceptance	*Entrance of flexible actors entails a shift in incumbent business models and structures. Potentially a direct competitor to the existing energy supply industry.*	*Level playing-field among incumbents and new entrants. Regulatory change by unbundling utilities and introducing aggregators*			
Limitations from individual plant staff's acceptance	*Absence of organizational power of the individual responsible for e.g. operation.*	*Empowerment of the individual decision-maker. Restructuring organisational hierarchies.*			

COUNTING BARRIERS: CHP AND PTH/C MOST AFFECTED

Overrepresentation of barriers among CHP and PTH/C indicates that these face the most challenges. Or that literature is biased towards these technologies. The latter applies here and in the subsequent counts.

COUNTING BARRIERS: LIFE CYCLE

While flexibility may intuitively be associated with operation, the strong representation within preceding phases shows that they are just as important. These can collectively be considered the investment phase.



COUNTING BARRIERS: ORIGIN

If you can - for a moment - distract yourself from the fact that this is a Christmas tree, the chart also shows that barrier-count increase from the provider level to the national level. National and regional actions are thus especially important.

CONCLUSION

The **primary barrier is *Absence of signal-providing scheme***. I.e. there must be signals in the first place, in order to respond with any kind of flexibility.

District energy projects are context-specific, and the impact of barriers may vary. An electricity tax can for example be very high on one country, low in another.

That said, **none of the barriers appear insurmountable** for an overall increase of flexibility in the interface between district energy and the electricity system.

FlexSUS

Smart
Energy
Systems
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