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Flexible Grid Integration with District Energy

CampusEnergy2020
THE POWER TO CHANGE
FEBRUARY 10-14 ▲ SHERATON DENVER DOWNTOWN ▲ DENVER, CO

Smart Energy Systems ERA-Net

FlexSuS

13 February 2020

"If something exists, then it must be possible"

- *Boulding's first law*

Grid integrated flexible district energy exists. But not everywhere.

What are the barriers for flexible campus DE systems to help – and be helped by – the grid to become more efficient + green?

Outline

PART I

- Defining flexibility

PART II

- Why is it relevant?

PART III

- Findings from research - 10 US universities

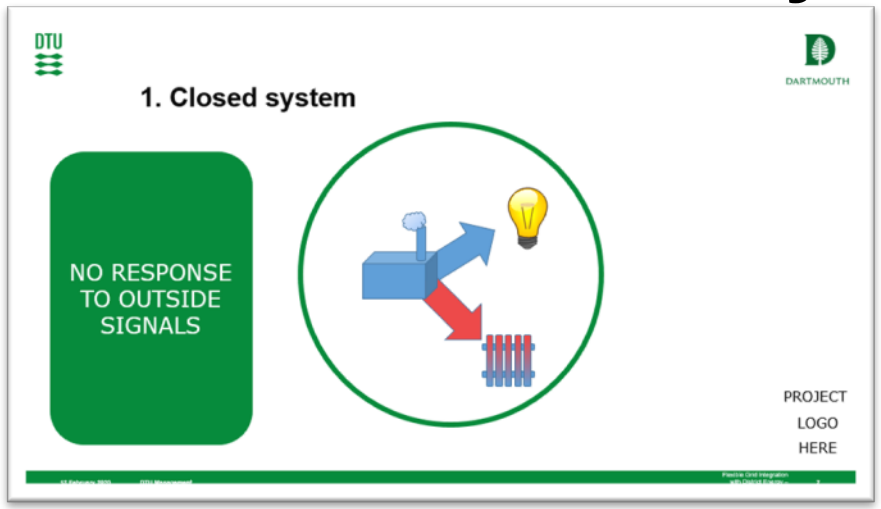
PART IV

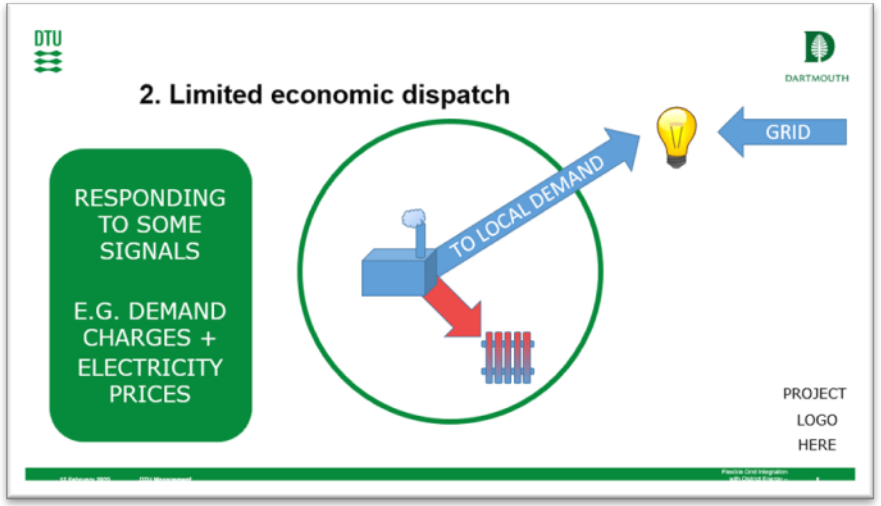
- Lessons learned

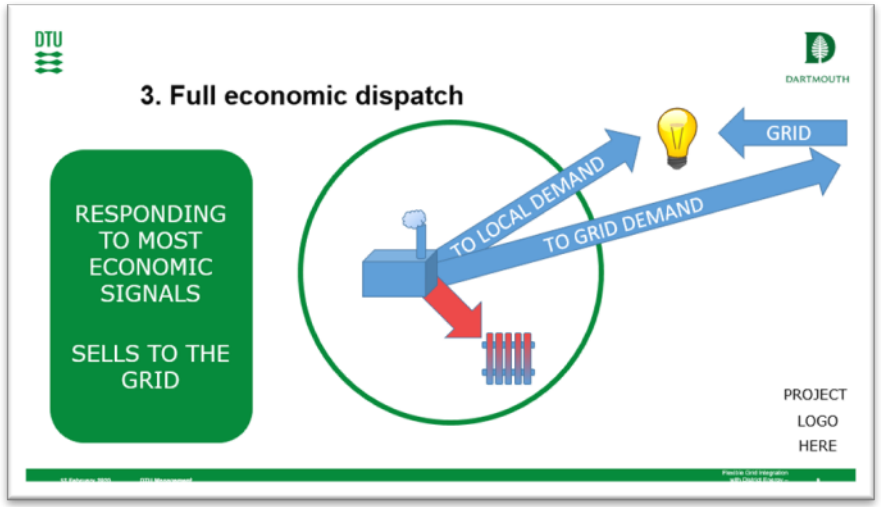
PART I

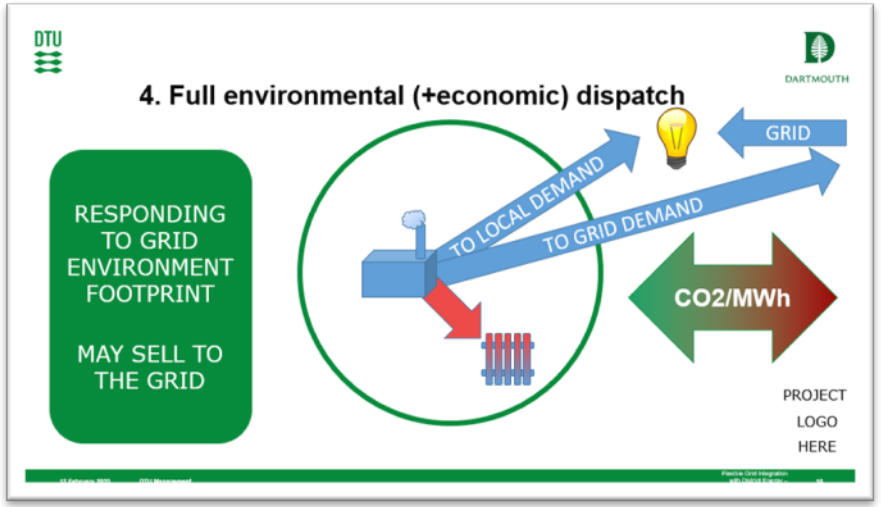
DEFINING FLEXIBILITY

Levels of flexibility



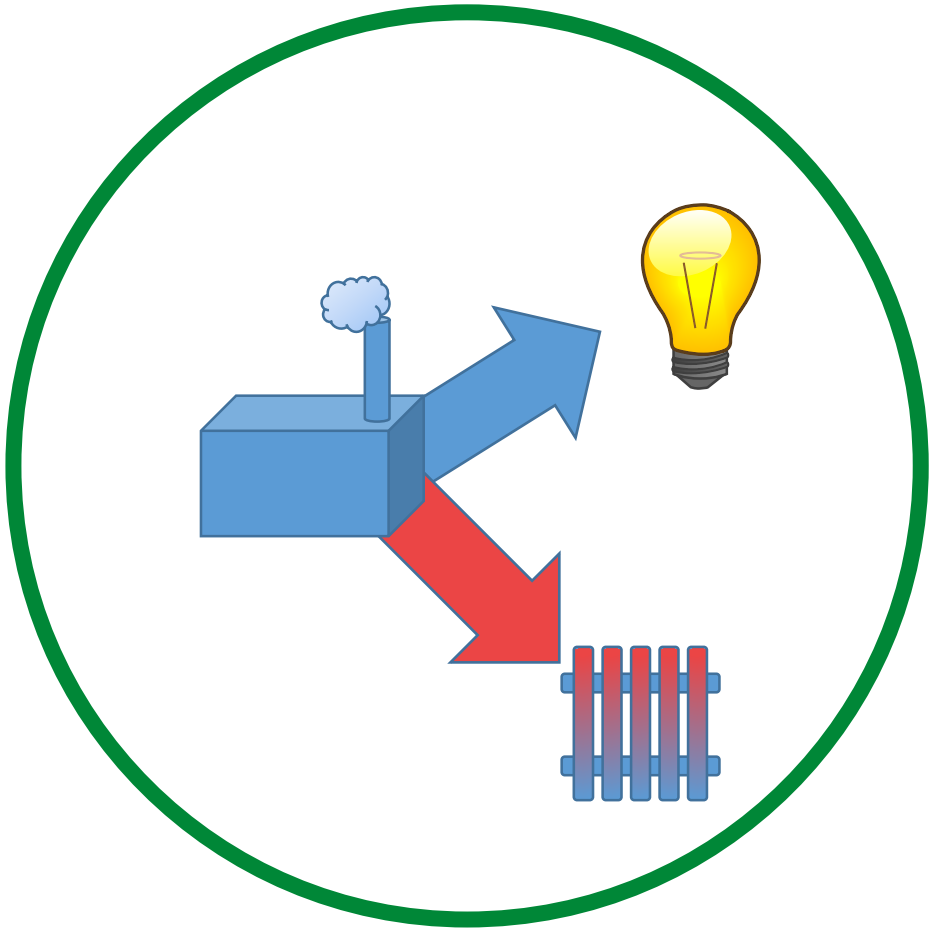






1. Closed system

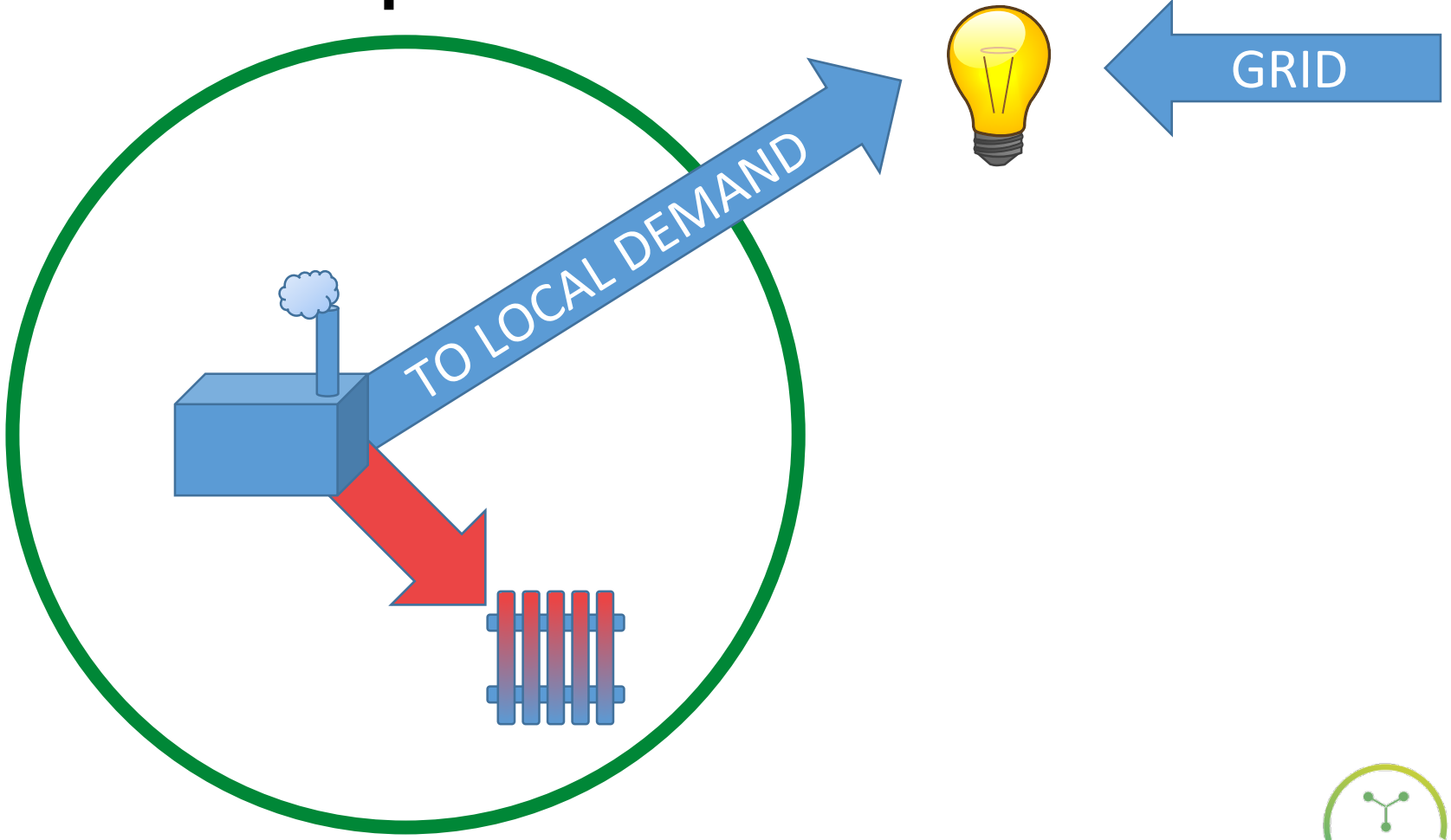
NO RESPONSE TO OUTSIDE SIGNALS



2. Limited economic dispatch

RESPONDING TO SOME SIGNALS

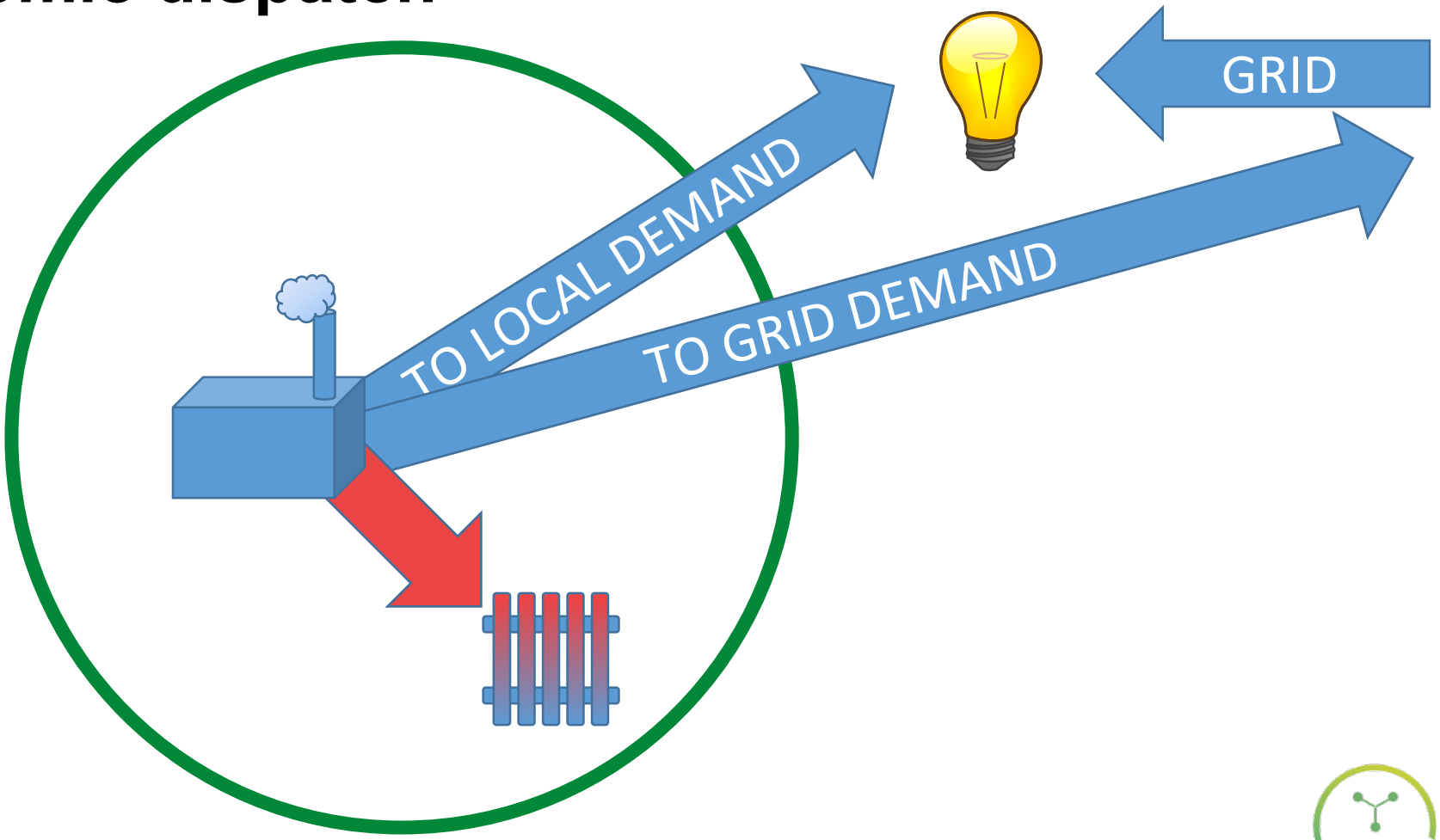
E.G. DEMAND CHARGES + ELECTRICITY PRICES



3. Full economic dispatch

RESPONDING TO MOST ECONOMIC SIGNALS

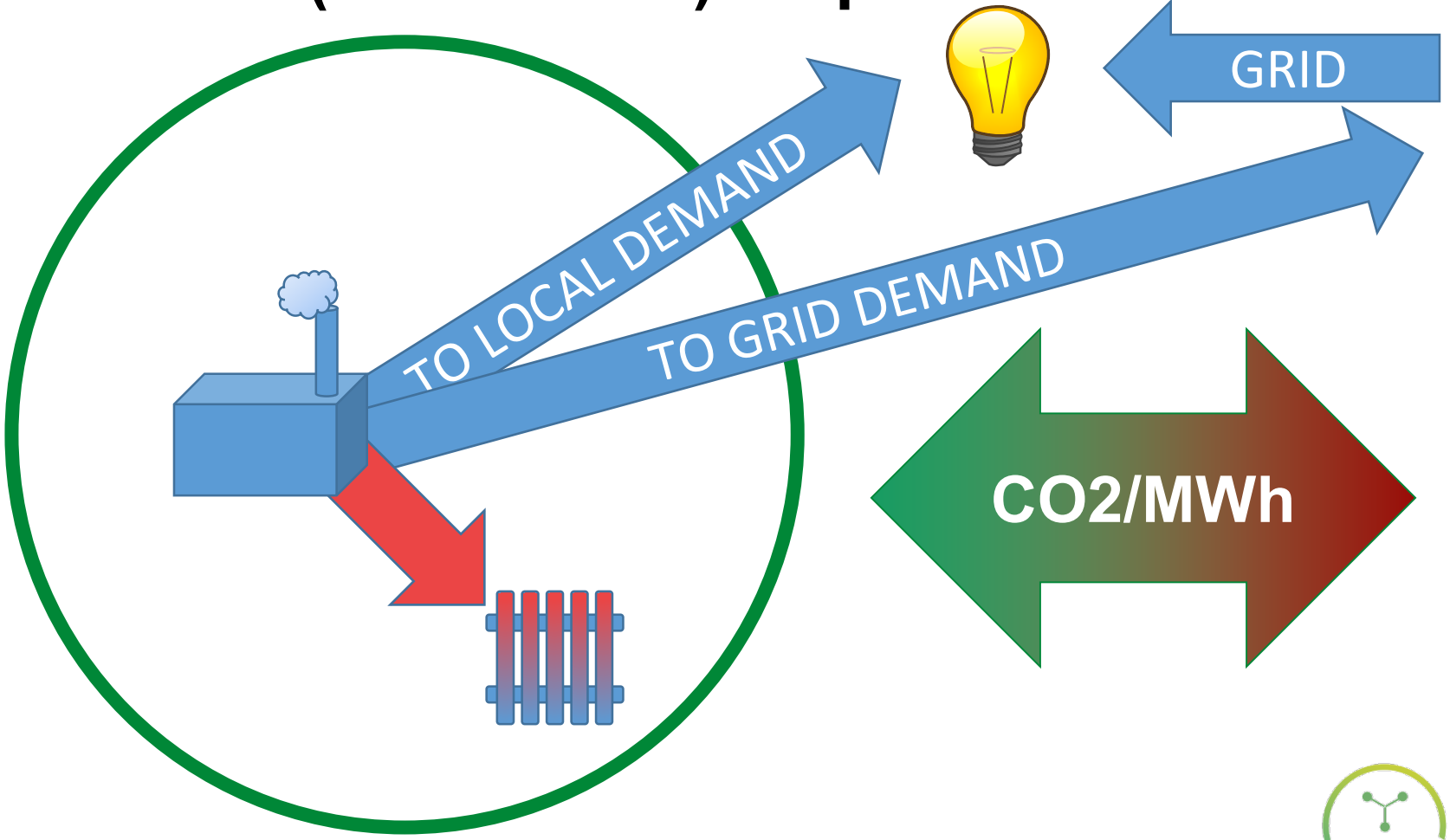
SELLS TO THE GRID



4. Full environmental (+economic) dispatch

RESPONDING TO GRID ENVIRONMENT FOOTPRINT

MAY SELL TO THE GRID



DE integrating renewables/operating on market

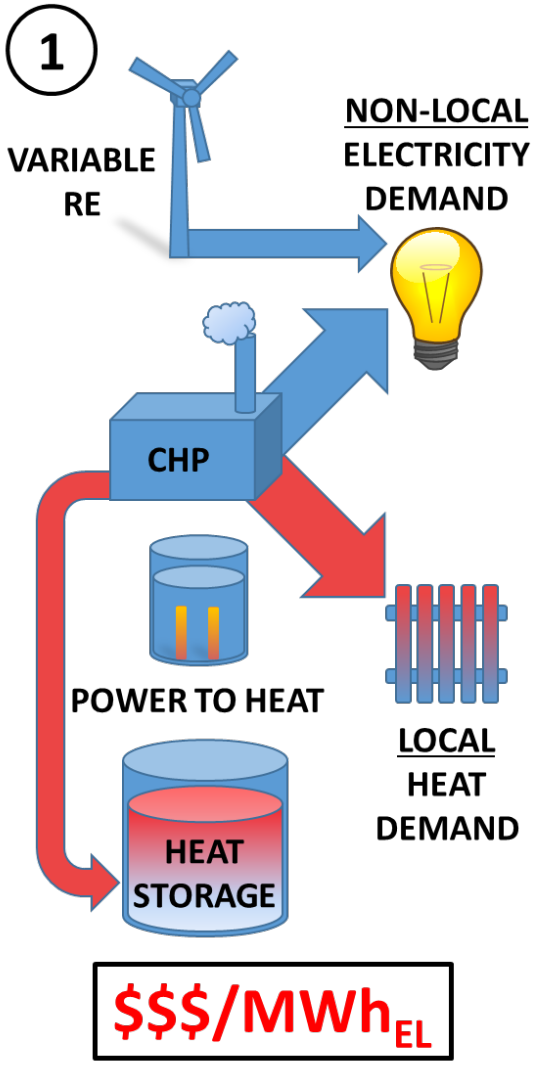


Figure: http://www.nordicenergy.org/wp-content/uploads/2016/10/Flex4RES-WP2-DH-report.pdf

PRACTICE: DE can operate on a market

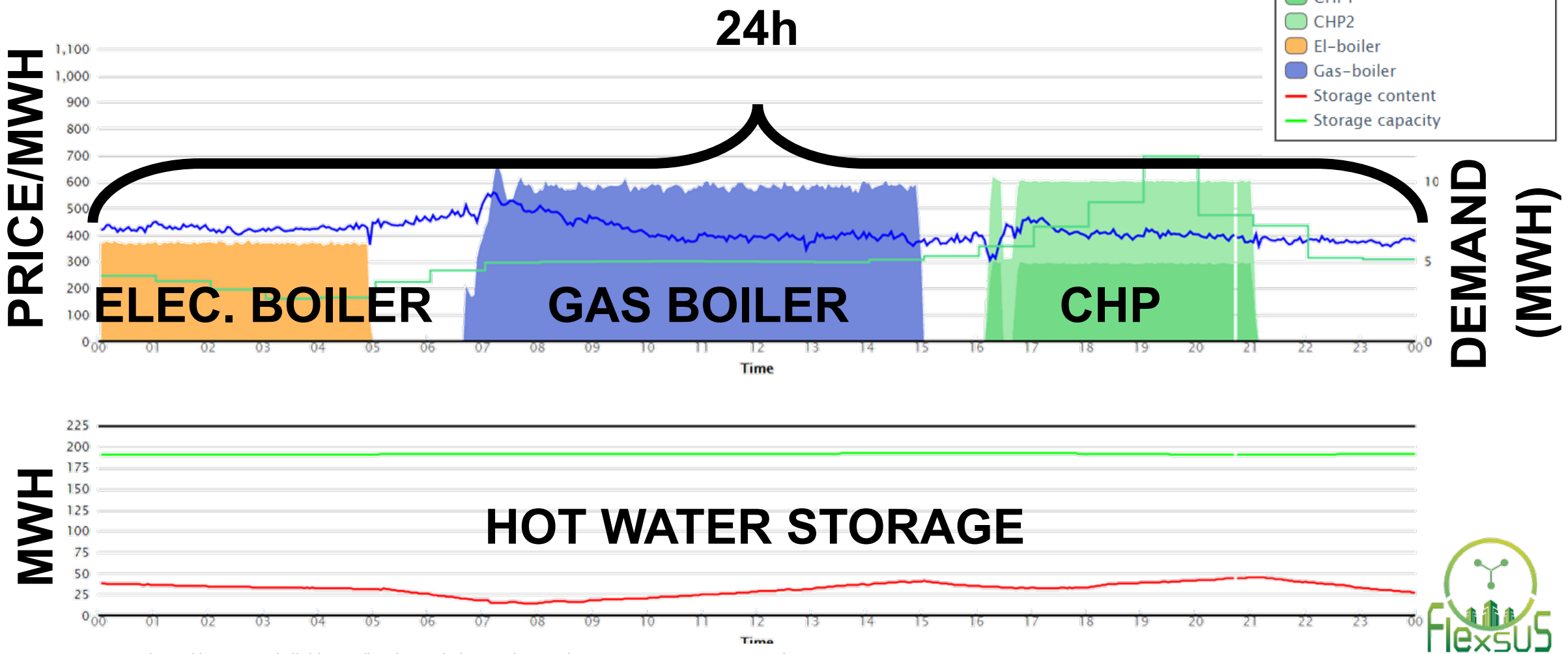
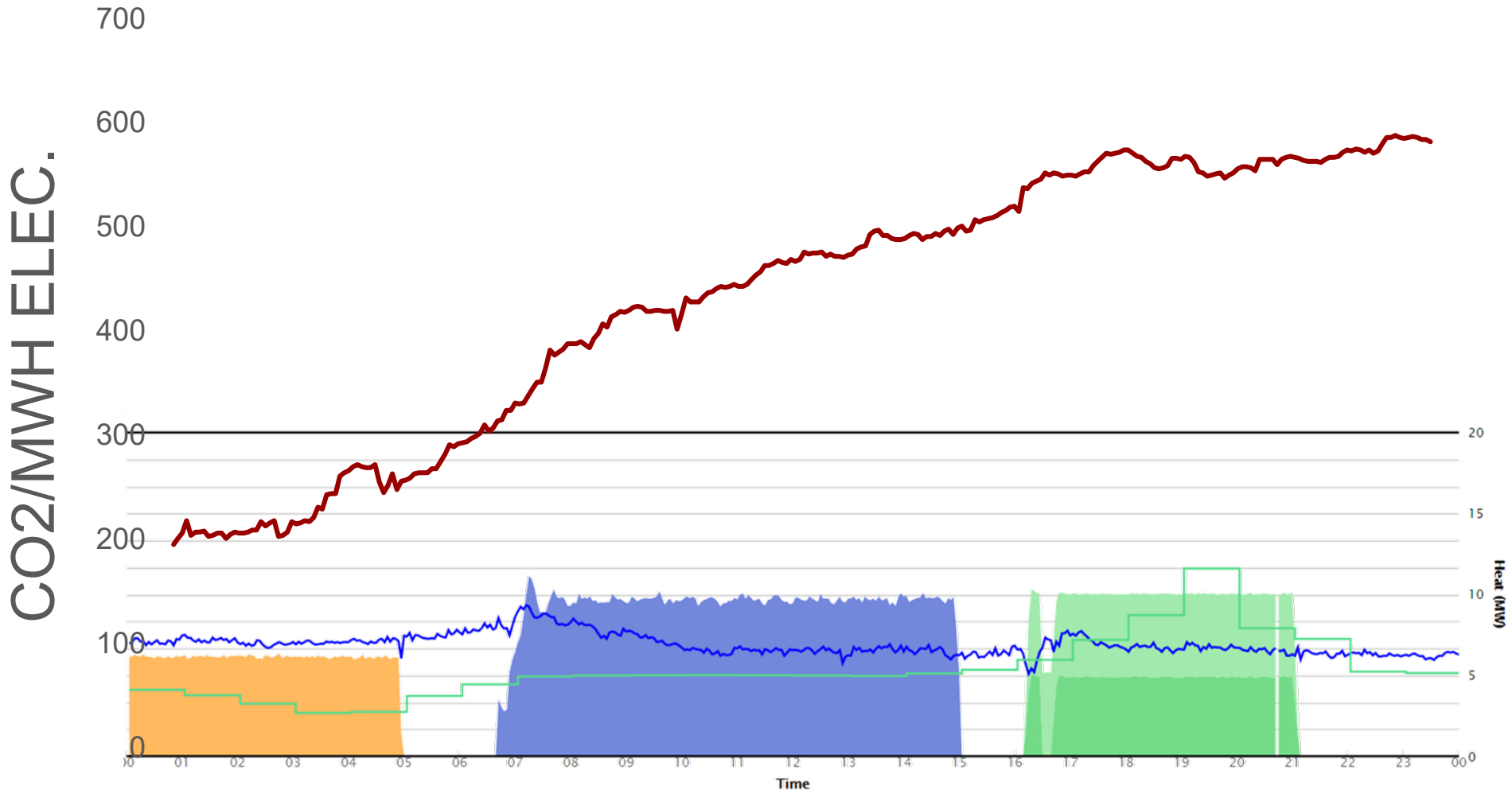


Figure: http://www.emd.dk/desire/hvidesande/ - Hvide Sande District Heating, 22 March 2018

PRACTICE: DE can integrate renewables



Figures: http://www.emd.dk/desire/hvidesande/ and https://www.energidataservice.dk

PART II

WHY IS IT RELEVANT?

Why care about grid integration and flexibility…

…when district energy is not the core product of universities?

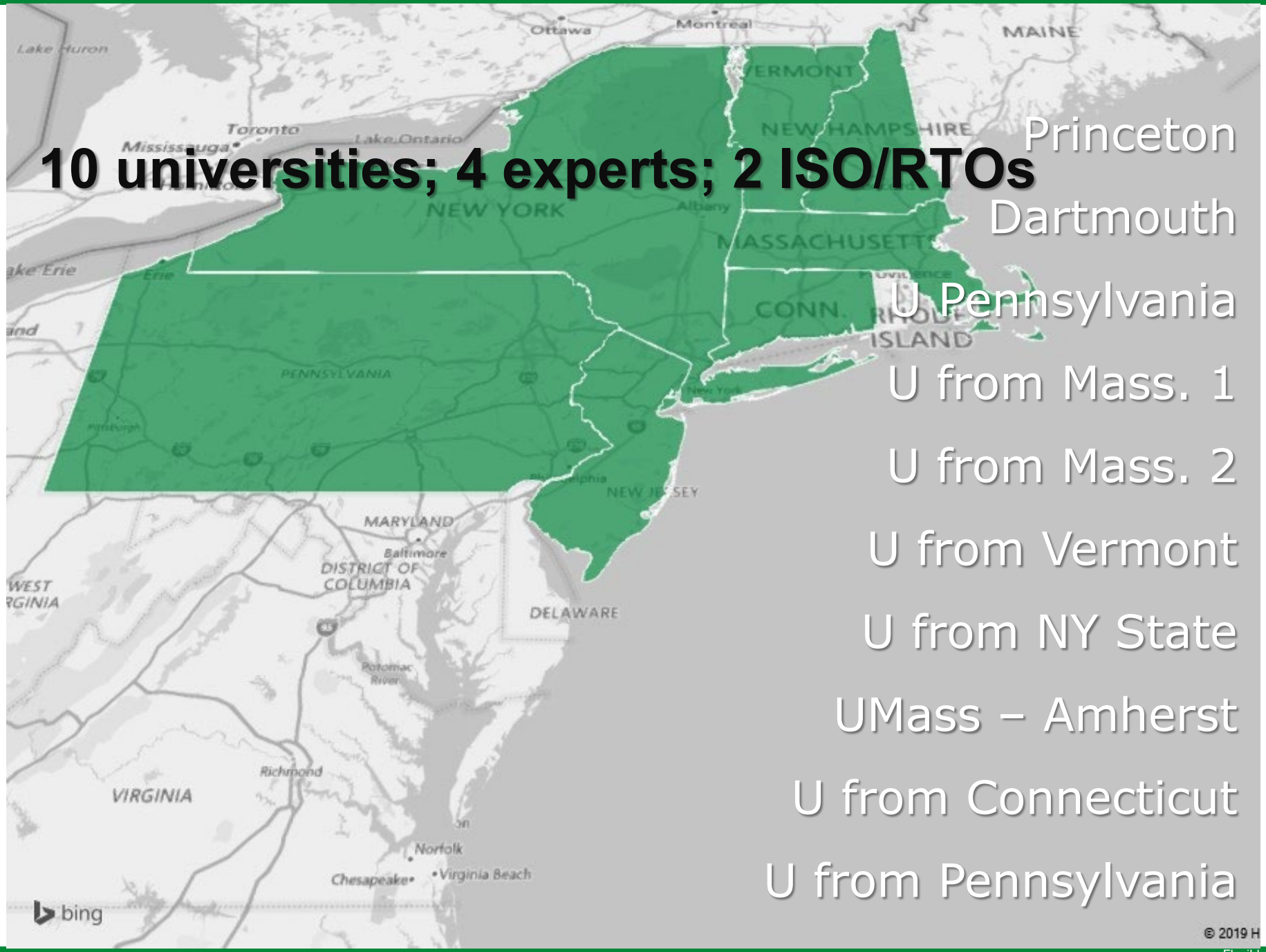
Beyond a resilient energy supply, universities are increasingly pushing district energy to

- Improve economics
- Align with green transition targets

PART III

FINDINGS FROM RESEARCH - 10 US UNIVERSITIES

10 universities; 4 experts; 2 ISO/RTOs



Princeton

Dartmouth

U Pennsylvania

U from Mass. 1

U from Mass. 2

U from Vermont

U from NY State

UMass – Amherst

U from Connecticut

U from Pennsylvania

9 categories; 40 barriers to flexible grid integration

1. Operational signalling
2. Investment
3. Permitting
4. Ownership
5. Technology conditions
6. Grid access
7. Physical environment
8. Bounded rationality
9. Acceptance

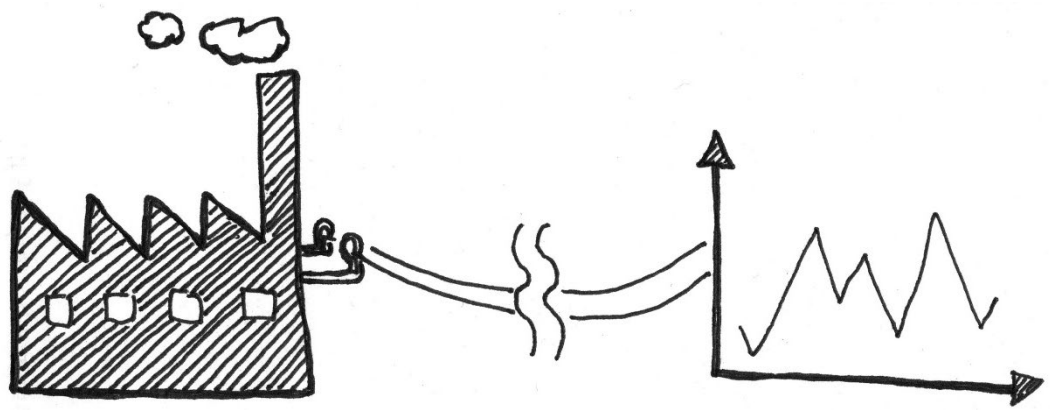
Category	Sub-category	Barrier name
Operational signalling	Dispatch signals	Absence of signal providing scheme
-	-	Electricity market: Absence of flexibility-need (involatile prices)
-	-	Electricity market: Fixed electricity prices
-	-	Physical vs. financial dispatch: Must-run operation
-	Operational taxes and subsidies	Operational taxes and levies on flexible assets
-	-	Favourable operational taxes and levies on inflexible DE
-	-	Inflexible operational subsidies for flexible DE
-	-	Operational subsidies for inflexible DE
-	Electricity grid tariffs	Electricity grid tariffs
-	Signal-related standards and procedures	Barriers for entry into signal-providing schemes
-	-	Barriers for operation in signal-providing schemes
Investment	-	Investment subsidies for inflexible DE
-	-	Limitations in capital for flexible DE
-	-	High risk premium for financing flexible DE
-	-	Limitations from pay-back time and internal rate of return/discount rate requirements
-	-	Limitations from regulated rate of return
Permitting	-	Technology bans and mandates
-	-	Inadequate legal framework for evaluation of projects related to DE
-	-	Friction in the permitting process
Ownership	-	Tax- and ownership regulation disincentivising grid integration
DE technology conditions	-	Limitations in adjustability, ramping and lead time
-	-	High technological cost
-	-	High business process costs
-	-	Low supply chain maturity
-	-	Limitations in control and visibility
-	-	High-temperature systems
Grid access	-	High grid-connection cost
-	-	Limiting grid codes
-	-	Limiting grid capacity
al environment	-	Limited access to energy sources
-	-	Land availability
Bounded rationality	-	Limitations from organisational bounded rationality
-	-	Limitations from community bounded rationality
-	-	Limitations from authority bounded rationality
-	-	Limitations from individual plant staff's bounded rationality
Acceptance	-	Limitations from organisational commitment
-	-	Limitations from community commitment
-	-	Limitations from authority commitment
-	-	Limitations from incumbent commitment
-	-	Limitations from individual plant staff's commitment

1. Operational signalling

SOLUTION

Incentives to participate through addressing sum of other barriers

Sub-category	Barrier name
Dispatch signals	Absence of signal providing scheme
-	Electricity market: Absence of flexibility-need
-	Electricity market: Fixed electricity prices
-	Physical vs. financial dispatch: Must-run operation



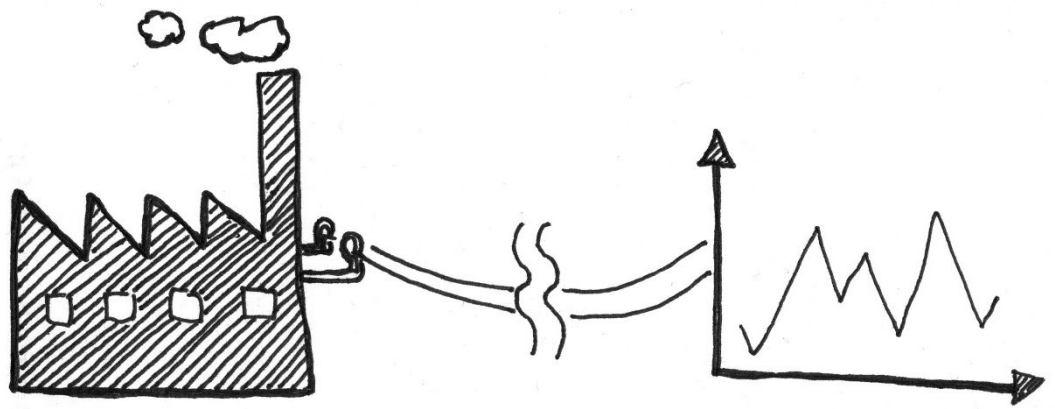
1. Operational signalling

SOLUTION

$/MW: Re-evaluating DE's contributions/strain to the grid – and the tariffs.

$/MWh: Dynamic/time-of-use tariffs

Sub-category	Barrier name
Electricity grid tariffs	Electricity grid tariffs
Signal-related standards	Barriers for entry into signal-providing schemes
-	Barriers for operation in signal-providing schemes



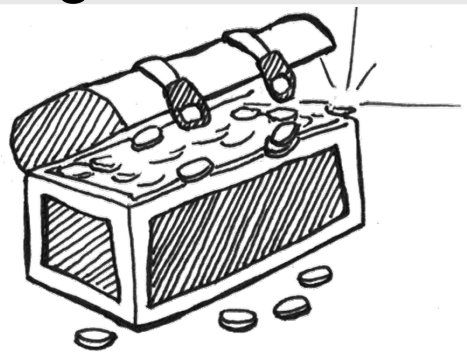
2. Investment

Barrier name
Investment subsidies for inflexible DE
Limitations in capital for flexible DE
High risk premium for financing flexible DE
Limitations from pay-back time and internal rate of return/discount rate requirements
Limitations from regulated rate of return

SOLUTION

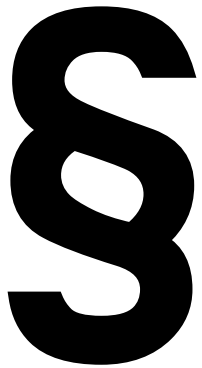
Re-educating budget offices + credit raters

Municipal/tax exempt bonds



3. Permitting

Barrier name
Technology bans and mandates
Inadequate legal framework for evaluation of projects related to DE
Friction in the permitting process



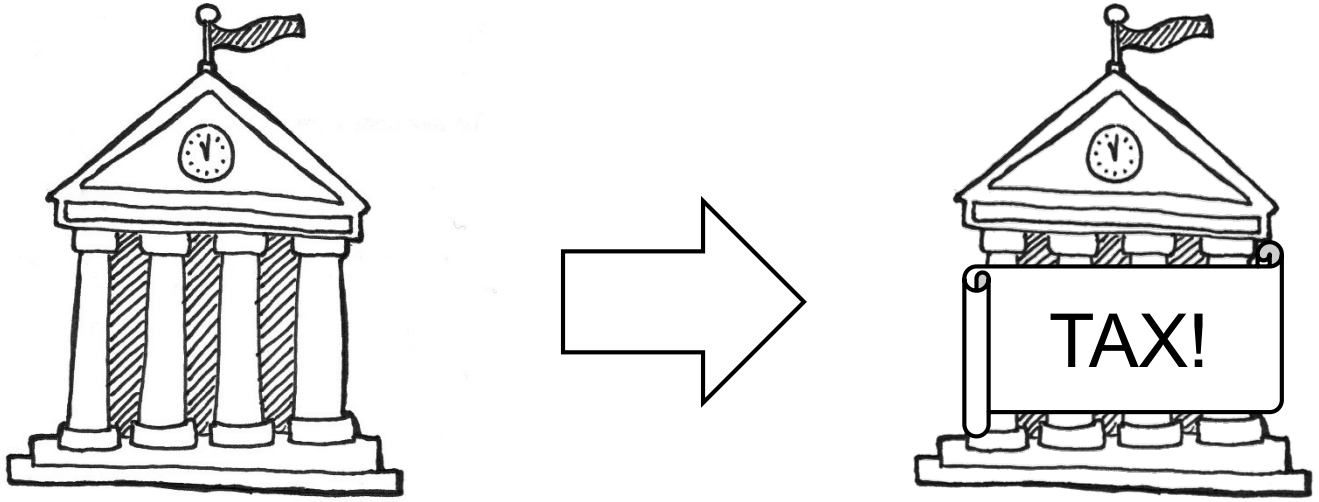
SOLUTION
(Enforced)
guidelines/standards

4. Ownership

SOLUTION
Deregulation like NJ (Princeton)
Waivers for DE

Barrier name

Tax- and ownership regulation disincentivising grid integration



5. Technology conditions

Barrier name
Limitations in adjustability, ramping and lead time
High technological cost
High business process costs
Low supply chain maturity
Limitations in control and visibility
High-temperature systems

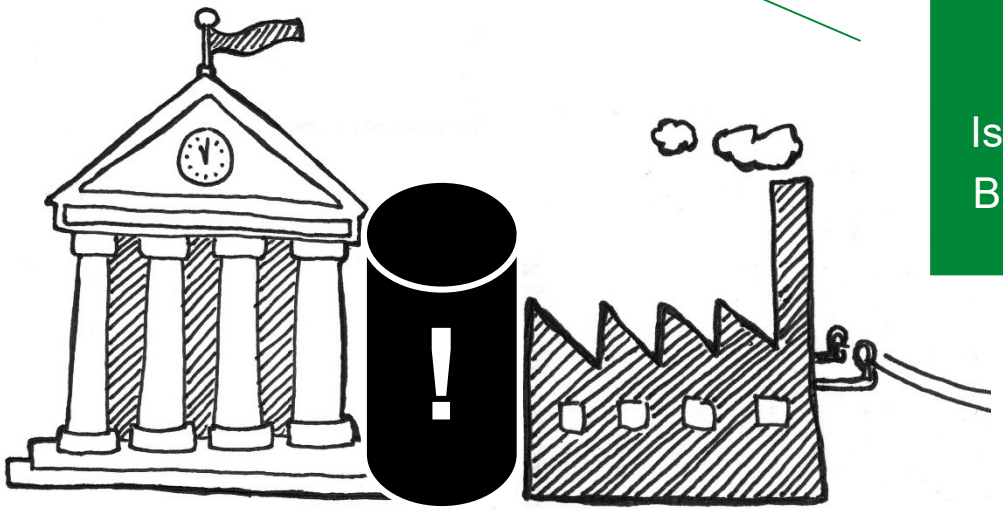
SOLUTION

Initially: Support for analysis

Then: Long-term financing

7. Physical environment

Barrier name
Limited access to energy sources
Land availability



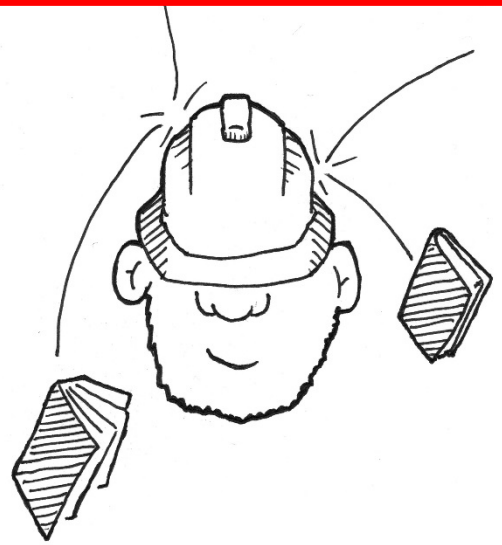
SOLUTION

Is ~1000 ft^2 (~90 m^2) a lot for 288 MWh?

Bury/integrate into existing infrastructure

8. Bounded rationality

Barrier name
Limitations from organisational bounded rationality
Limitations from community bounded rationality
Limitations from authority bounded rationality
Limitations from individual plant staff's bounded rationality



SOLUTION

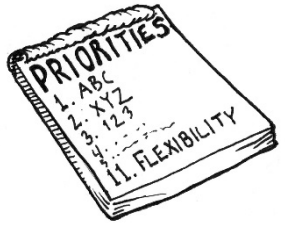
Get informed: Does it pay?

9. Acceptance

SOLUTION

Get informed + reduce risk by financing/target setting

Barrier name
Limitations from organizational commitment
Limitations from community commitment
Limitations from authority commitment
Limitations from incumbent commitment
Limitations from individual plant staff's commitment



PART IV

LESSONS LEARNED

Can campus DE help – and be helped by – the grid to become more efficient + green?

Reviewed DE systems integrate with the grid + somewhat flexible.

PERCEIVED factors hindering increased flexibility

- Feeding to grid → Regulated as utility
- Flexible demand: Electricity market price insignificant
- Tariffs potential disincentive for P2H/C
- Enough money, just not for hot water conversion
- Space for heat storage an issue
- Well-informed and well-funded enough to stay safe and cheap, while going green?

Acknowledgements

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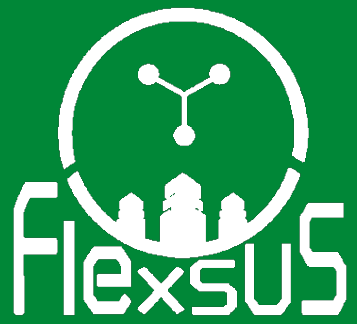

DTU

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Publications

THANK YOU

PROJECT LOGO

Questions?

Acknowledgement + Disclaimer

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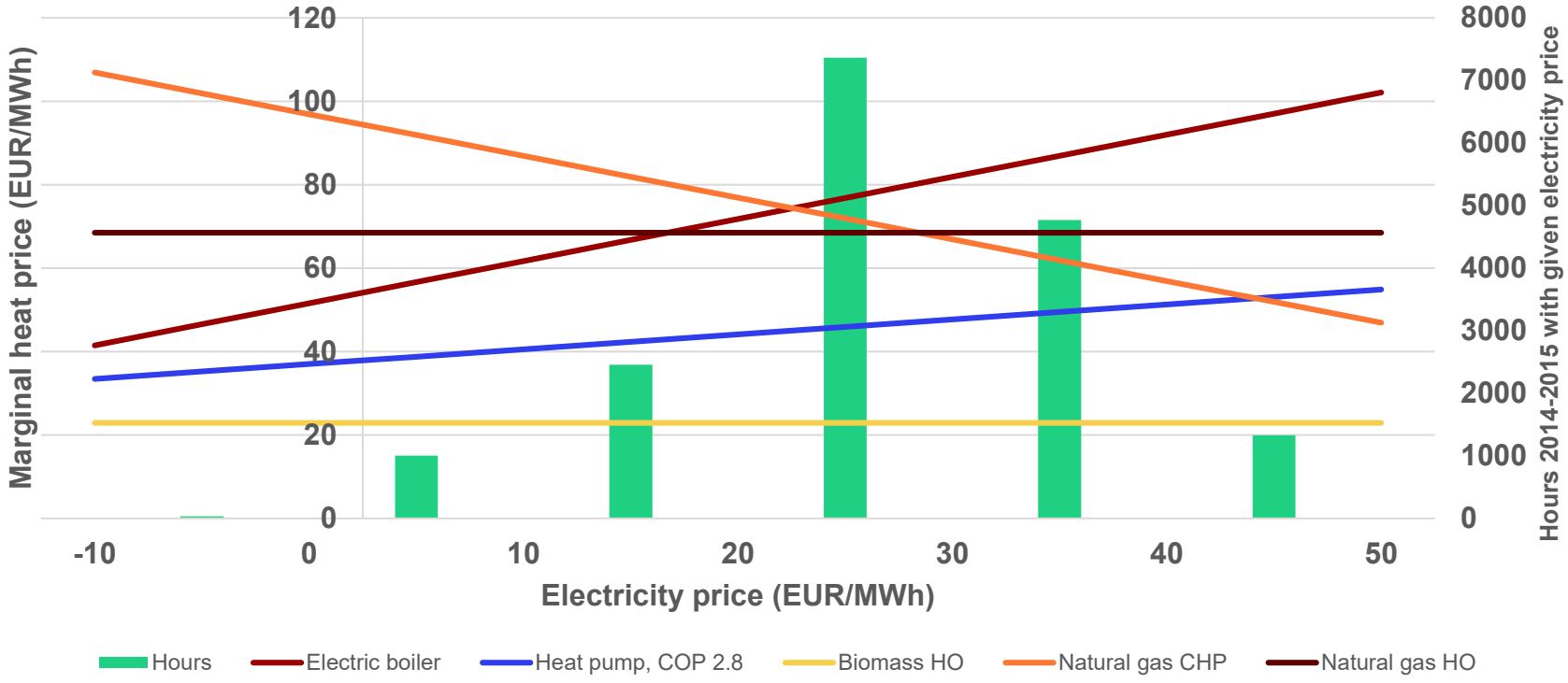
- *Disclaimer:* The content and views expressed in this material are those of the authors and do not necessarily reflect the views or opinion of the ERA-Net SES initiative. Any reference given does not necessarily imply the endorsement by ERA-Net SES.

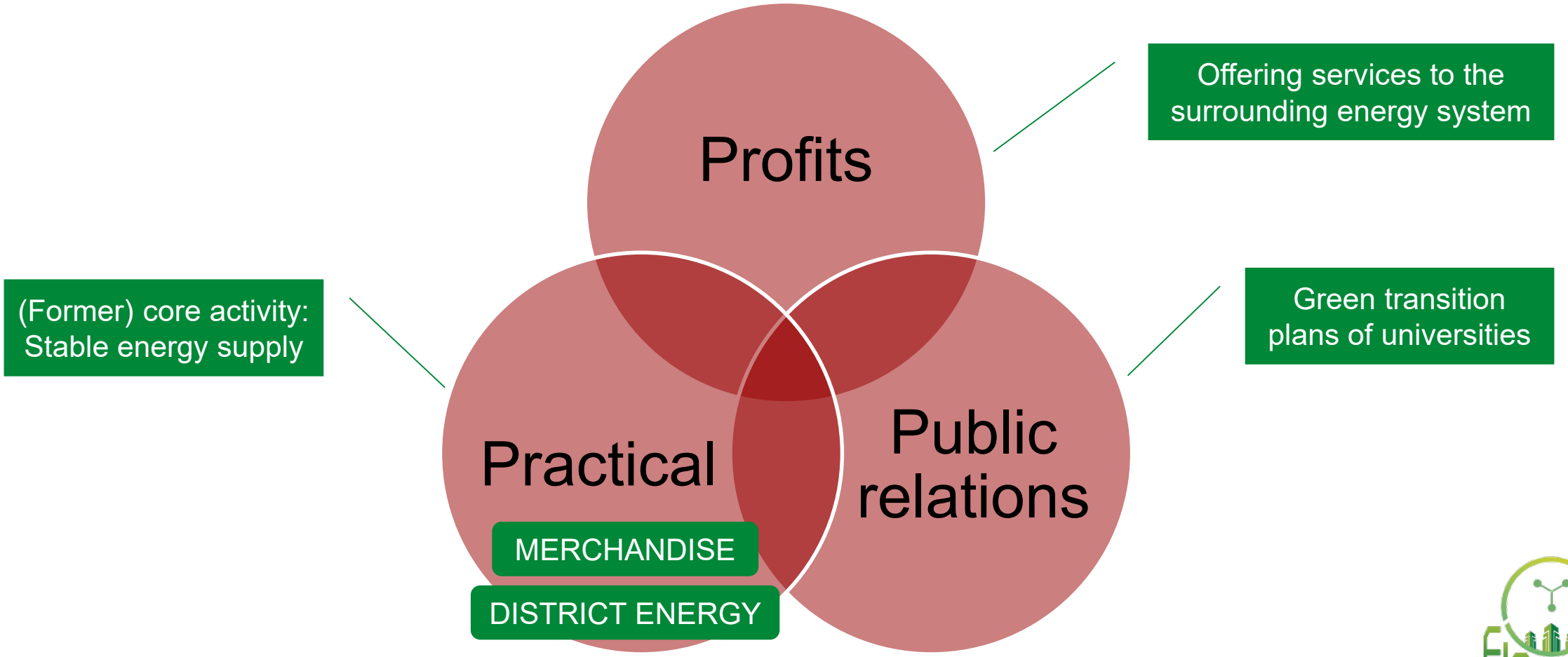
EXTRA: What is a flexible DE system?



EXTRA: Full taxonomy of barriers

Category	Sub-category	Barrier name	#	Tech. type	Project life cycle	Level of origin
Operational signalling	Dispatch signals	Absence of signal providing scheme	1	cogen + PTH/C		54-6
-	-	Electricity market: Absence of flexibility-need (involatile prices)	2	cogen + PTH/C		54-6
-	-	Electricity market: Fixed electricity prices	3	cogen		54+5
-	-	Physical vs. financial dispatch: Must-run operation	4	cogen + PTH/C		53-5
-	Operational taxes and subsidies	Operational taxes and levies on flexible assets	5	cogen + PTH/C		54+5
-	-	Favourable operational taxes and levies on inflexible DE	6	TO		54+5
-	-	Inflexible operational subsidies for flexible DE	7	cogen + PTH/C		54+5
-	-	Operational subsidies for inflexible DE	8	TO		54+5
-	Electricity grid tariffs	Electricity grid tariffs	9	cogen + PTH/C		53-5
-	Signal-related standards and procedures	Barriers for entry into signal-providing schemes	10	cogen + PTH/C		54+5
-	-	Barriers for operation in signal-providing schemes	11	cogen + PTH/C		54+5
Investment	-	Investment subsidies for inflexible DE	12	TO	2+3	4+5
-	-	Limitations in capital for flexible DE	13	cogen + PTH/C	2+3	2
-	-	High risk premium for financing flexible DE	14	cogen + PTH/C	2+3	2
-	-	Limitations from pay-back time and internal rate of return/discount rate requirements	15	cogen + PTH/C	2+3	2
-	-	Limitations from regulated rate of return	16	cogen + PTH/C	2+3	5
Permitting	-	Technology bans and mandates	17	cogen + PTH/C	2+3	3-5
-	-	Inadequate legal framework for evaluation of projects related to DE	18	cogen + PTH/C	2+3	3-5
-	-	Friction in the permitting process	19	cogen + PTH/C		43-5
Ownership	-	Tax- and ownership regulation disincentivising grid integration	20	cogen + PTH/C		55
DE technology conditions	-	Limitations in adjustability, ramping and lead time	21	cogen + PTH/C		52
-	-	High technological cost	22	cogen + PTH/C	2+3	1
-	-	High business process costs	23	cogen + PTH/C	2+3	2
-	-	Low supply chain maturity	24	cogen + PTH/C	2 through 5	1
-	-	Limitations in control and visibility	25	cogen + PTH/C		51, 4-6
-	-	High-temperature systems	26	TS		52
Grid access	-	High grid-connection cost	27	cogen + PTH/C	2+3	3-5
-	-	Limiting grid codes	28	cogen + PTH/C		54-6
-	-	Limiting grid capacity	29	cogen + PTH/C	2+3	3
Physical environment	-	Limited access to energy sources	30	cogen + PTH/C	2+3	3
-	-	Land availability	31	cogen + PTH/C	2+3	3
Bounded rationality	-	Limitations from organisational bounded rationality	32	cogen + PTH/C	1, 2, 3+5	2
	-	Limitations from community bounded rationality	33	cogen + PTH/C	3+4	3
	-	Limitations from authority bounded rationality	34	cogen + PTH/C	2 through 5	4+5
-	-	Limitations from individual plant staff's bounded rationality	35	cogen + PTH/C	1, 2, 3+5	2
Acceptance	-	Limitations from organisational commitment	36	cogen + PTH/C	2 through 5	2
-	-	Limitations from community commitment	37	cogen + PTH/C	3+4	3
-	-	Limitations from authority commitment	38	cogen + PTH/C	2 through 5	4+5
-	-	Limitations from incumbent commitment	39	cogen + PTH/C	2 through 5	3-5
-	-	Limitations from individual plant staff's commitment	40	cogen + PTH/C	1, 2, 3+5	2

University district energy = University merchandise

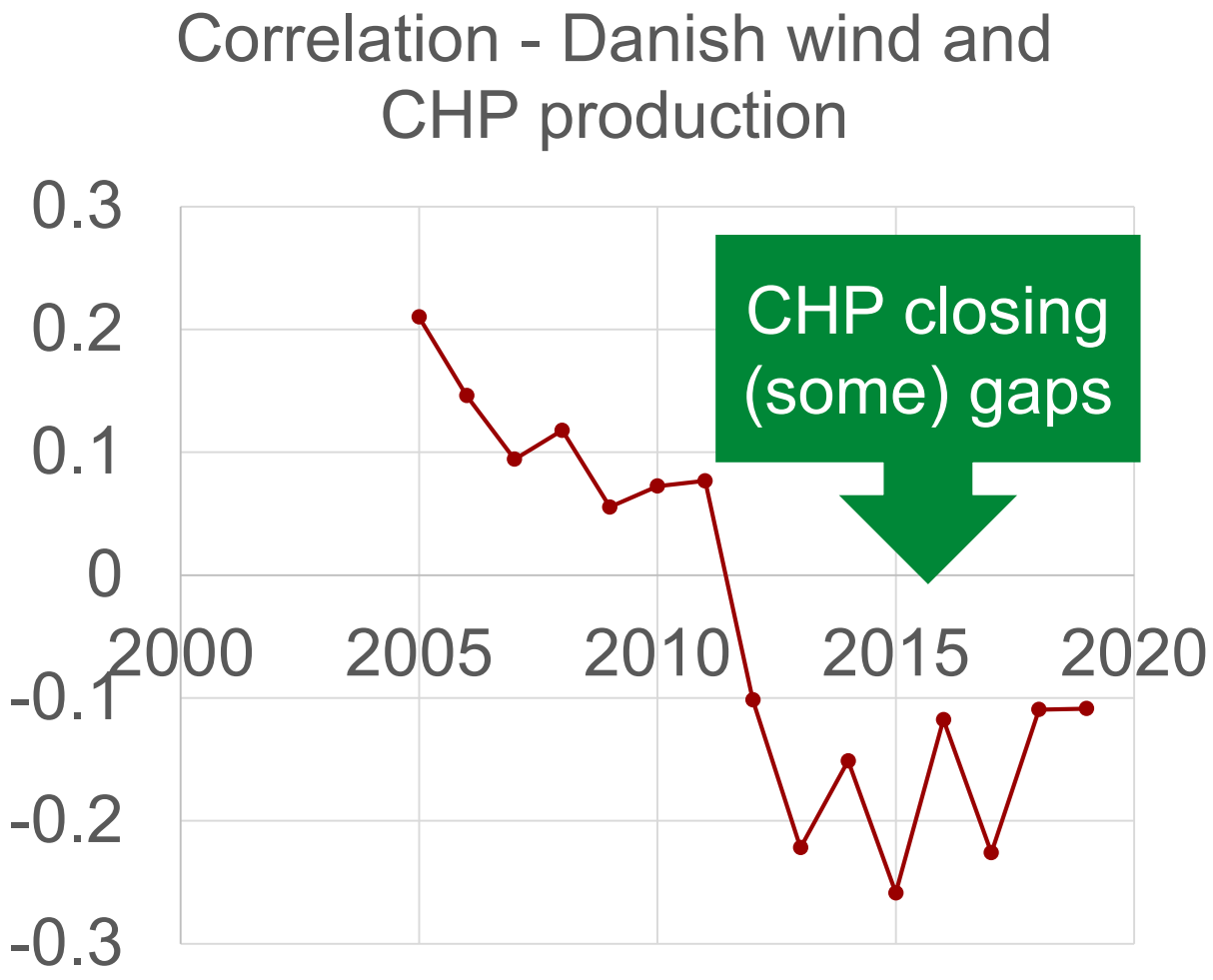


Why care about grid integration and flexibility? #1

ISOs/RTOs:

Integrating flexible capacity into their systems will make the

- Integration of renewables easier
- Market more liquid



Why care about grid integration and flexibility? #2

Utilities:

SHOULD think that integrating flexible capacity

- Makes local grid more resilient
- Saves investments in infrastructure

But do they have the incentive?

Market signal to plant and back