

# INFLUENCE OF CENTRALIZED AND DISTRIBUTED THERMAL ENERGY STORAGE ON DISTRICT HEATING NETWORK DESIGN

Innovation Engineer, Comsof, Belgium and PhD Researcher, Ghent University, Belgium



Joseph Jebamalai



comsof.com

## **OVERVIEW – STORAGE CONFIGURATIONS**

Centralized vs Distributed thermal energy storage

- Centralized storage •
- Substation level storage
- Building level storage

# Can we find an optimum Storage Size?



**Centralized storage** 





- What is the impact on total network cost, consisting • of:
  - Heat source cost 0
  - Storage cost Ο



### **Distributed storage**







## CASE STUDY – METHOD Comsof heat and excel based storage calculations



- Use of Excel for
  - Storage tank 0 dimensioning
  - Calculation of storage 0 costs



### Use of Comsof Heat for

- Automated network routing 0
- Pipe size dimensioning Ο
- Deployment cost calculation 0 (excl. storage costs)

A	utoSave On				SubstationLevelStorage_2MW_size_18Clusters - Saving 🝷						ebamalai 🗾 🌽 [	函 — 口
F	ile <b>Hom</b>	ne Insert D	raw Page Layout Fc	rmulas Data	Review View He	elp Chart Design	Format 🔎 Sea	ırch			🖻 Share	🖓 Comm
F	Paste	Calibri (Body) <b>B</b> I U	<ul> <li>10 &lt; A<sup>*</sup> A<sup>*</sup></li> <li>10 &lt; A<sup>*</sup> A<sup>*</sup></li> <li>10 &lt; A<sup>*</sup> A<sup>*</sup></li> </ul>		<sup>a</sup> ∽ ⋛ Wrap Text 	Number	• ←0 .00 Co	anditional Format as Cell matting ~ Table ~ Styles ~	Insert Delete Fo	The primate of the p	Sort & Find &	Ideas
mh	Clipboard	5	Font 🖙		Alignment	s Num	ber 🕞	Styles	Cells		Editing	Ideas
Ch	art 4	- : X J	fr									
		V		NA	N	0	D	0	D	c	т	
4	Storage lev	el Storage loss	Reduced production (100%)	VI Surplus/Deficit (100	N) Storage level (100%	Storage loss (100%)	Reduced production	(90%) Surplus/Deficit (90%	N Storage level (90%)	Storage loss (90%)	Reduced production (80%	() Surplus/De
5	8263.04	0 141490348	0.63	-0.98	1093 70	0.018727761	0.67	-0.93	987 9998028	0.016917805	0.72	-0
6	8263.04	0.141490421	0.63	-1.15	1092.54	0.018707815	0.67	-1.10	986.879668	0.016898624	0.72	-1.
7	8263.08	0.14149117	0.63	-1.11	1091.41	0.018688546	0.67	-1.06	985.7990438	0.016880121	0.72	-1.
6 0	8263.22	0.141493459	0.63	-1.02	1090.38	0.018670817	0.67	-0.97	984.8083685	0.016863157	0.72	-0.
9	8263.46	0.141497534	0.63	-0.91	1089.44	0.018654875	0.67	-0.87	983.9220483	0.01684798	0.72	-0.
10	8263.76	0.141502778	0.63	-0.84	1088.58	0.018640102	0.67	-0.80	983.1039956	0.016833973	0.72	-0.
11	8264.13	0.141509068	0.63	-0.78	1087.78	0.018626375	0.67	-0.74	982.3470265	0.016821011	0.72	-0.
12	8264.54	0.141516037	0.63	-0.74	1087.02	0.018613328	0.67	-0.70	981.6297408	0.016808728	0.72	-0.
13	8264.97	0.141523445	0.63	-0.72	1086.28	0.01860072	0.67	-0.67	980.9381278	0.016796886	0.72	-0.
14	8265.38	0.141530413	0.63	-0.74	1085.52	0.018587673	0.67	-0.70	980.2208605	0.016784604	0.72	-0.
15	0765 60	A 1/15250/0	U & 2	0 00	1084 67	0 018573092	0.67	-0.79	979.4140579	0.016770789	0.72	-0.
16		1	100% storage			90% storage			80% stor	age		-0.
17	2000.00				800	0		1000		0		-0.
18	1800.00 -			10	500			1600				-0.
19	1600.00 -				600			1400				-0.
20	1400.00 -			14	400			1200				-0.
21	1200.00 -			12	200			1000				-0.
22	1000.00			10	000			0 800				-0.
23	800.00 -				800							-0.0
24	600.00 -				600			600				
26	400.00				400			400				
27	200.00				200			200				-0.
28	0.00				0							-0.
29		366 731 1096 1461 1826 1826 1356	2286 2286 2286 2651 1016 1016 1016 1281 1746 1111 1746 1111 1746 1111 1206 13476 134	3031 3301 3301 3031 3396 3396	1 352 703 703 1405 1405 1405 1107 1107	2009 2511 2511 2511 2513 2513 2513 2564 2513 2566 2567 2566	5319 5319 5670 7372 7372 7723 7723 7723 7723 7723	1 314 627 940 566	879 192 505 505 131 131 444 757 757 070	696 696 009 322 635 635 635 574	887 200 513 826 452 452	-0.
30			 0 m m 4 4 4 10 10 10 10 10 10 10 10 10 10 10 10 10						0 0 0 0 0 0 0 0	4000000	0 1 1 1 0	-1.
31	8275.36	0.141701446	0.63	-1.11	1075.64	0.018418492	0.67	-1.07	971.1002384	0.016628429	0.72	-1.
	DPC	Cluster1 Cluster1	Cluster2 Cluster3 Clus	ster4 Cluster5 Clu	ster6 Cluster7 Cluste	er8 Cluster9 Cluster	10 Cluster11 Cluste	• (+) i 🔳				











## CASE STUDY - INPUTS

Selected 2328 buildings and heat source – Kortrijk, Belgium

### **BUILDING**:

- Street level gas consumption data
- Building types are categorized as:
  - Residential 0
  - Commercial 0
  - Industrial 0
- Synthetic load profiles

### HEAT SOURCE:

- Heat source: IMOG, waste incineration plant
  - 2 km from the network 0
  - Available heat  $\rightarrow$  130 GWh / year
  - 0 Source peak capacity  $\rightarrow$  15 MW (Continuous operation)





### **Case study area**







## CASE STUDY - NETWORK

Network demand and peak load

- Building demand  $\rightarrow$  Load profiles, annual gas consumption data
- Network demand  $\rightarrow$  Aggregation of building heat demand
- Network annual heat demand 95 GWh/year



comsof.com





storage)



### Daily profile of different building types



### Hourly network heat demand













## CASE STUDY – STORAGE

2 - layer network and storage design

- 2 LAYER NETWORK:
- Transport and distribution network

### **STORAGE DESIGN:**

- Production profile  $\rightarrow$  Constant throughout the year
- Consumption profile  $\rightarrow$  Winter peak
- Surplus / Deficit over certain time
  - Charge storage when there is surplus 0
  - Discharge storage when there is deficit 0
- Maximum storage size  $\rightarrow$  Energy produced ~= Energy consumed









C COMSOF









## CASE STUDY – CENTRALIZED STORAGE

Source peak power vs Storage size – Seasonal storage

- Source power reduction
- No change in pipe sizes
- Maximum storage size 450,000 m<sup>3</sup>
- Source power can be reduced up to 11 MW
- Minimum total network cost occurs at 1% storage
  - Source peak power around 22 MW 0
  - Storage size around **4500** m<sup>3</sup> 0
  - 3.5% cost reduction  $\bigcirc$















## CASE STUDY – SUBSTATION LEVEL STORAGE

Transport and total network cost – Seasonal storage

- Source power reduction
- Reduction in transport network pipe sizes
- Constant distribution network cost
- Increasing storage size (for every substation size)
  - Reduction in transport network cost 0
  - Minimum total network cost at 1% storage (4500 m<sup>3</sup>) 0
- Total minimum network cost
  - 2 MW substation and 1% storage (4500  $m^3$ ) 0
  - 7% cost reduction  $\bigcirc$









## CASE STUDY – BUILDING LEVEL STORAGE

Source power and total network cost – Daily and seasonal storage

- Source power reduction
- Reduction in transport network pipe sizes
- Reduction in distribution network pipe sizes
- Maximum daily storage size 1086 m<sup>3</sup>
  - Source power can be reduced up to 22.5 MW 0
  - Total network cost 10% cost reduction! 0
- Seasonal storage
  - Minimum total network cost at 22600 m<sup>3</sup> 0
    - 12% cost reduction!











## CASE STUDY – BUILDING LEVEL STORAGE

Network cost - Daily storage at different building types

Average storage tank size per building: 

Туре	Average storage size (Liters)	Total siz
All buildings	461	
Residential	400	
Commercial	286	
Industrial	3992	





**Building level storage (Daily storage)** 







## CONCLUSION

Overview and future work

- calculations

Storage location	Storage type	Storage size (m <sup>3</sup> )	No. of storage tanks	Cost reduction (%)
Centralized	Seasonal	4500	1	3.5
Substation level	Seasonal	4500	18	7
Building level	Daily	1086	2328	10
Building level	Seasonal	22600	2328	12

### **FUTURE WORK:**

• Investigate the effect of different profile types

Integration of the concepts in Comsof Heat

comsof.com



• Successful use of software package Comsof Heat in combination with manual excel based storage

### The more distributed storage. the lower the network cost (due to pipe size reductions):







comsof.com

Empower to create