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Energy Analysis and Energy Planning For Kindergartens Based On Data Analysis

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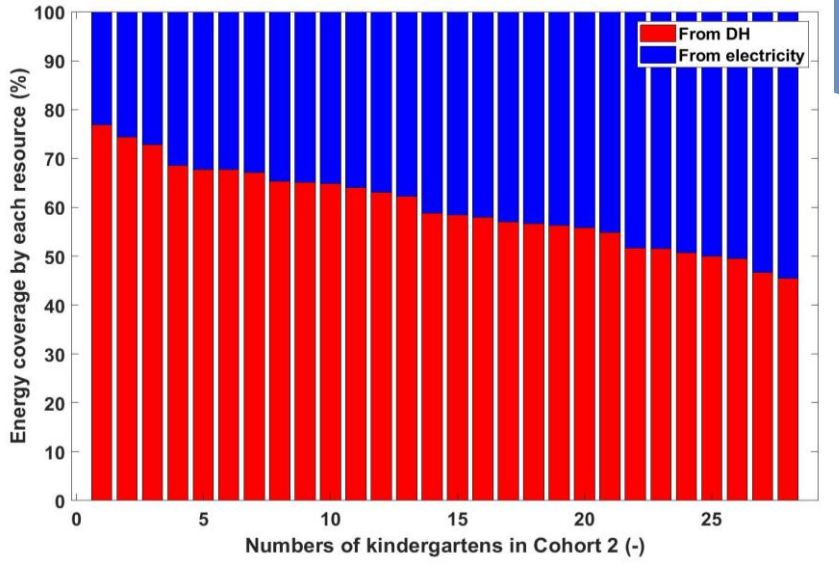
General information of kindergartens in Trondheim Municipality

- **Data source:** Energy monitoring platform of Trondheim Municipality
- 559 hourly files
- **Main objectives:**
  - Define energy duration curve
  - Calculation of CO_2 emission and future prediction

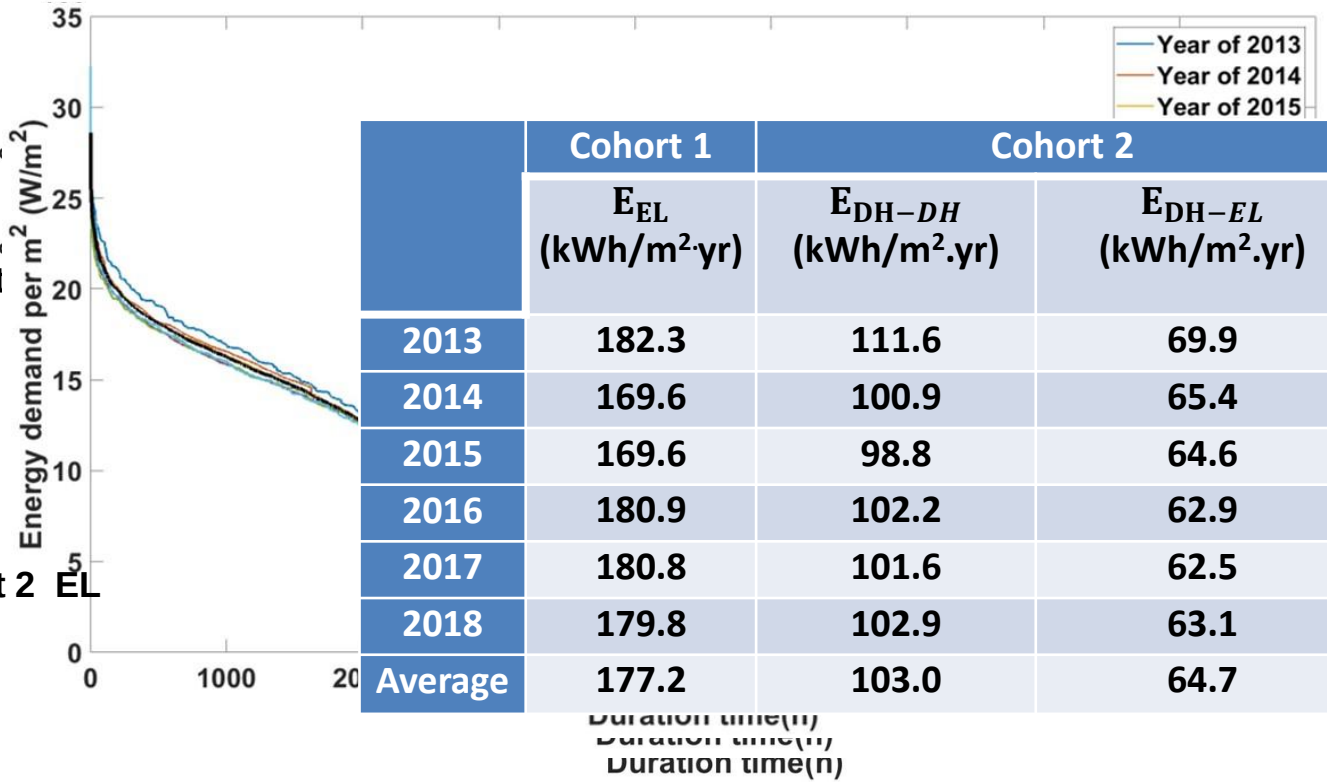


	Building numbers (-)		Building area (m^2)	
	Cohort 1	Cohort 2	Cohort 1	Cohort 2
2013	62	21	36 979	24 623
2014	66	23	38 855	26 317
2015	68	26	40 890	30 105
2016	68	27	40 890	31 766
2017	71	28	43 259	32 768
2018	71	28	43 259	32 768

	EL (%)	DH (%)
DH high share	23.0	77.0
DH low share	54.0	46.0
DH average share	40.0	60.0

Energy duration curve

Cohort 1



Cohort

Cohort 2 EL

	Cohort 1	Cohort 2	
	E_{EL} (kWh/m²·yr)	E_{DH-DH} (kWh/m².yr)	E_{DH-EL} (kWh/m².yr)
2013	182.3	111.6	69.9
2014	169.6	100.9	65.4
2015	169.6	98.8	64.6
2016	180.9	102.2	62.9
2017	180.8	101.6	62.5
2018	179.8	102.9	63.1
Average	177.2	103.0	64.7

Source: Norsk Energi

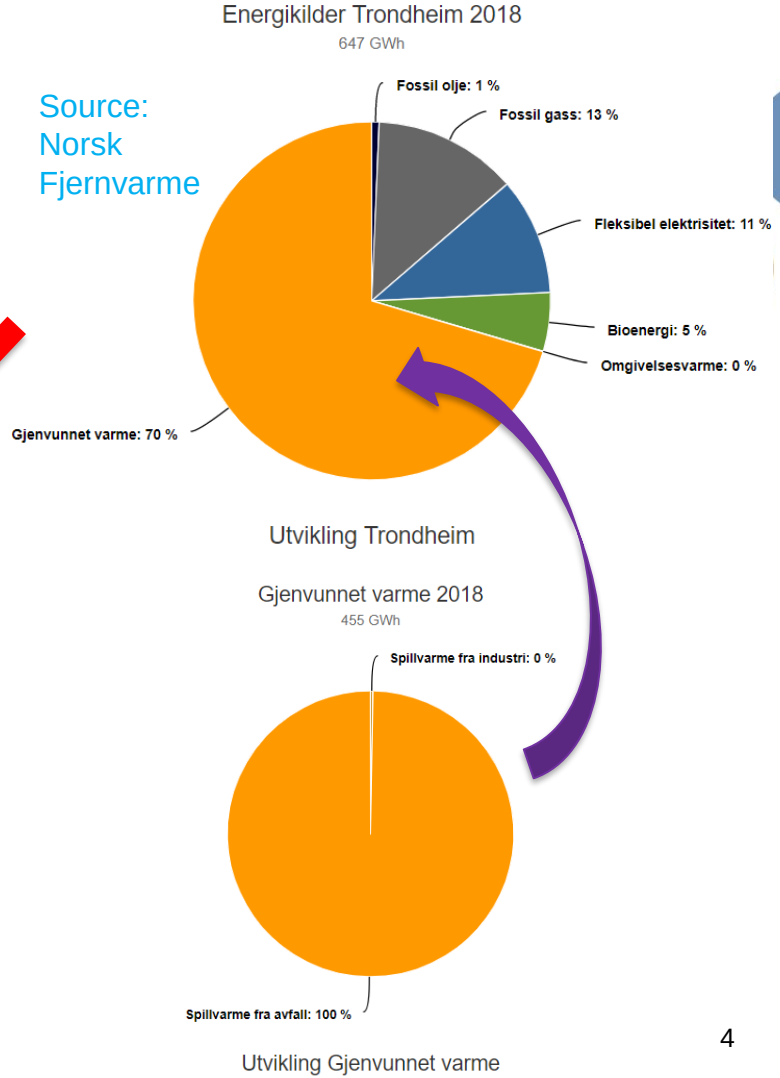
ANBEFALT FAKTORER gCO_2e/kWh

Energibærer**	Forbrenning	Produksjon og transport	Totalt
Elektrisitet	NA	NA	110
Avfall*	7	4	11
Lettolje	268	21	289
Tungolje	290	21	311
LPG	235	39	274
Naturgass (LNG)	203	40	243
Naturgass (tørrgass)	204	40	244
Energivekster	9	28	37
GROT og stubber	9	7	16
Skogsflis	9	9	18
RT-flis	9	3	12
Bark og spon	9	5	14
Pellets og trepulver	6	13	19
Briketter	6	15	21
Bioolje (med bærekraftskriterier)	6	4	10
Bioolje (uten bærekraftskriterier)	292	4	296
Spillvarme	0	0	0

0

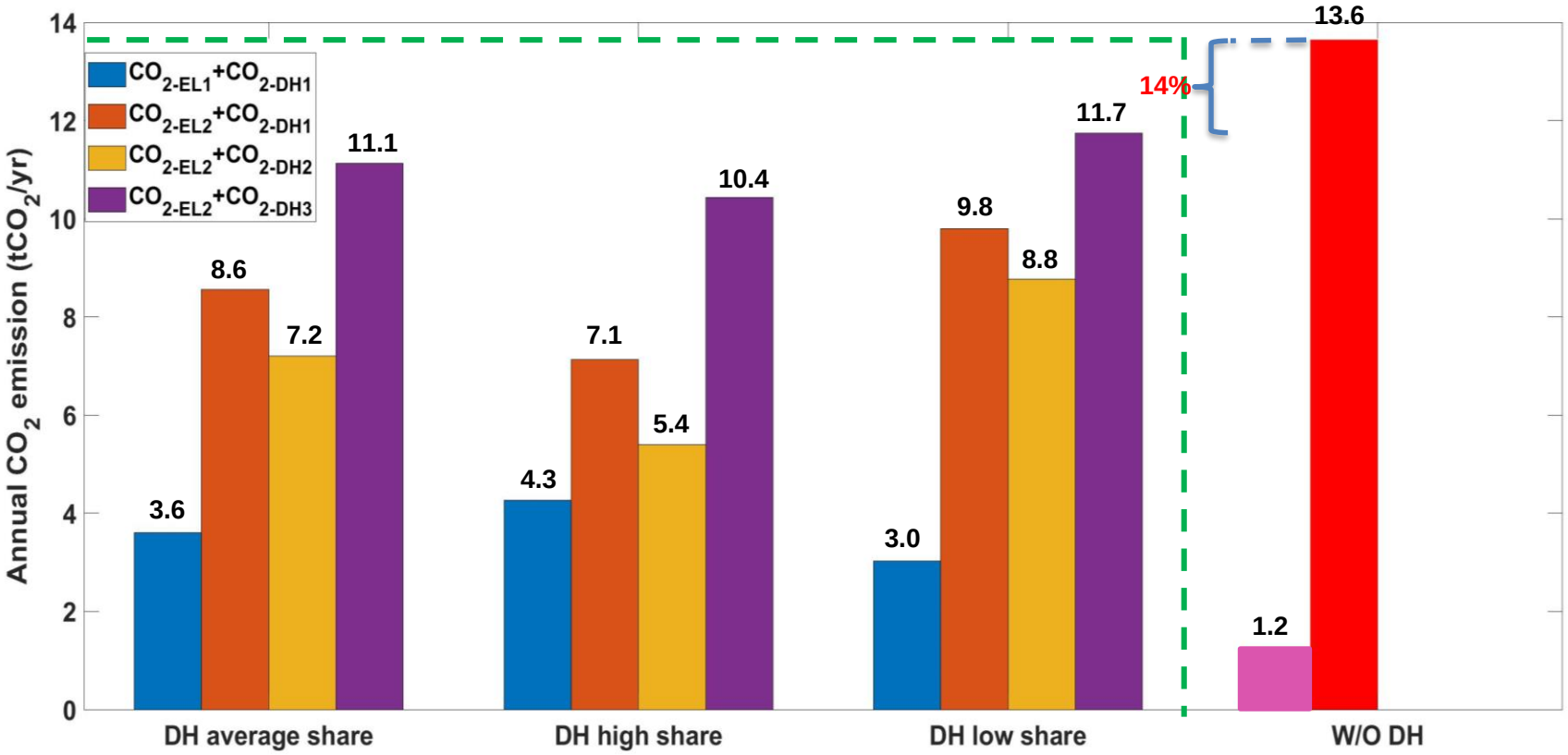
NS 3720-2018

Source: Norsk Fjernvarme

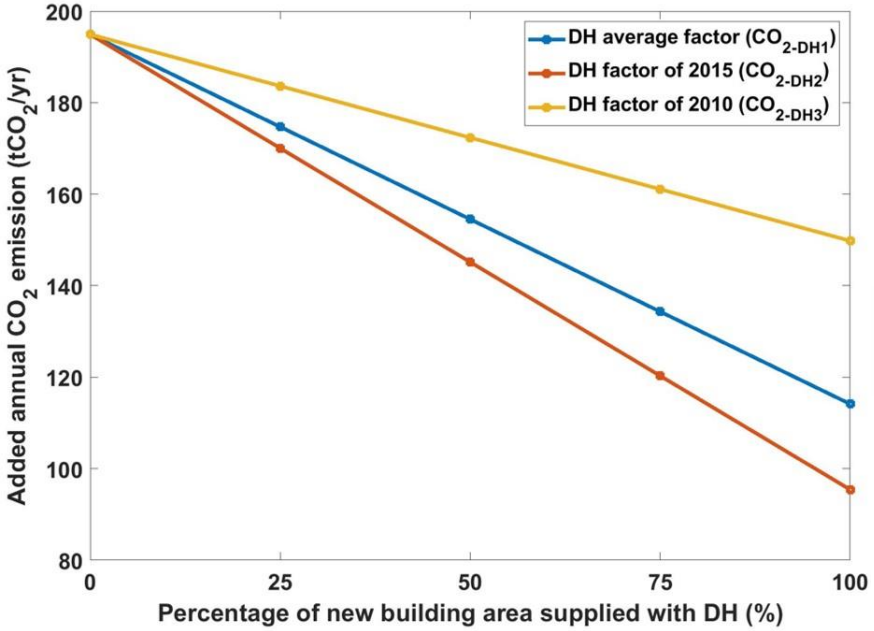


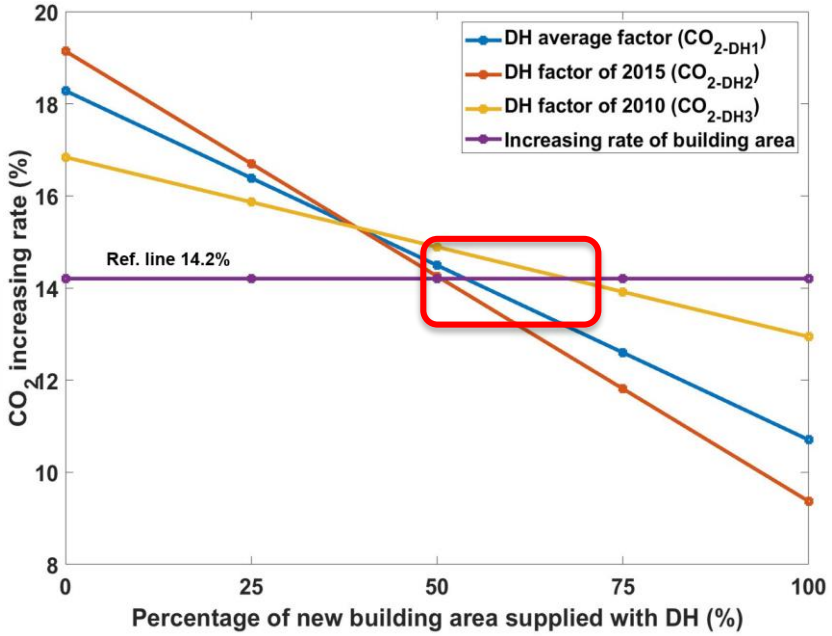
		2010-2018: $CO_{2\text{-DH1}}$	2015: $CO_{2\text{-DH2}}$	2010: $CO_{2\text{-DH3}}$
Composition of energy sources (%)	Waste	74.0	83.1	61
	Gas	10.8	5.9	20
	Electricity	8.5	5.0	6
	Bio-energy	4.0	4.0	5
	Ambient heat	0.8	1.0	1
	Fossil oil	1.9	1.0	7
CO_2 factors (gCO_2/kWh)		41.66	23.5	76.3

Annual CO_2 emission of one kindergarten of 700 m^2



Assessment of CO_2 impact of predicted new building area of 10 000 m^2





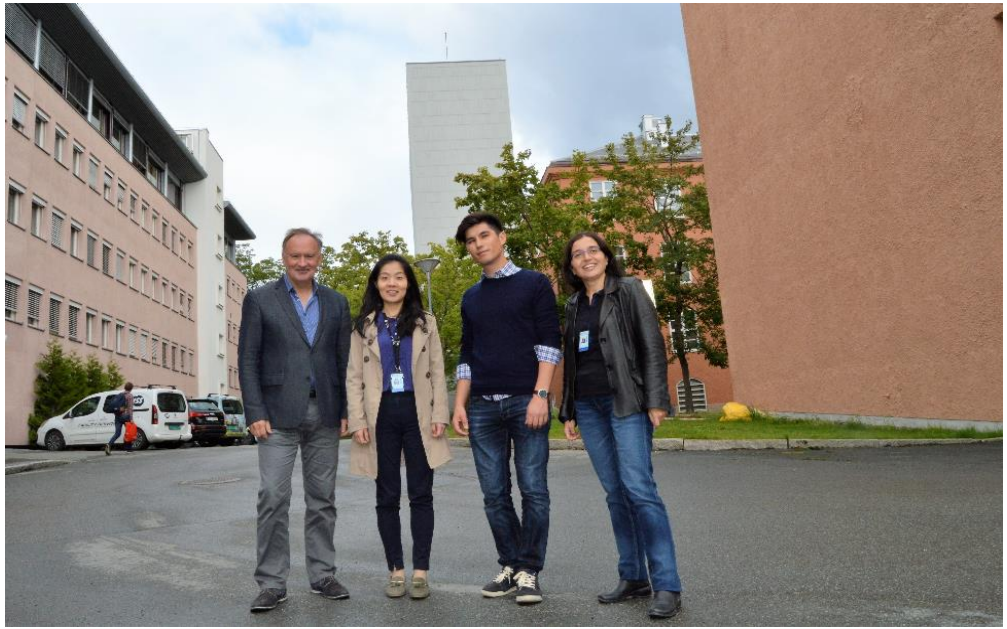
- 6-year average annual total building area (w/o new building area): 70 413 m^2
- Increasing building area rate: 14.2%
- Breaking point: 50 %- 67 % of new building areas with DH

Summary and Future work

- Half of building energy is used for heating due to cold climate
- Kindergarten with DH high share had almost lowest annual CO_2
- Kindergarten with DH low share or w/o DH had wider range of CO_2 due to dependence of electricity production mix
- Slower increase of CO_2 emission for new building area could be achieved with more than half DH penetration
- Energy data and profiles of other building types shall be analyzed
- Identified duration curves could be used to as reference for defining energy profiles of other building types, infrastructure sizing

Thank you for your attention!

May I have your questions and comments?



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