Intelligent Metering
Trondheim, Norway
10-11. October 2006

ECO-City
Joint ECO-City developments in Scandinavia and Spain
Supported by the EC **CONCERTO** Initiative

community presentation

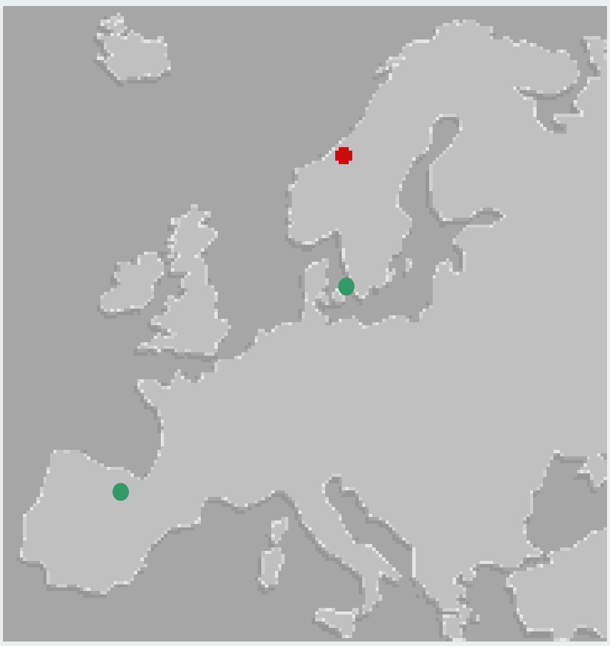
TRONDHEIM

Dagfinn Bell

COWI

TRONDHEIM

- Third largest city in Norway:
  - 170 000 inhabitants
  - 341 km^2
- 500 km north of Oslo (63.5 °N)
- Cold Nordic climate
- Historic importance
  - founded in 997
- Regional capital and a center for commerce and administration
- Center for technological education and research: NTNU & SINTEF
  - 30 000 students



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TRONDHEIM → ECO-City

TRONDHEIM'S MUNICIPAL CLIMATE ACTION PLAN

- Greenhouse gas emissions reduced by 20% from 1999 levels within 2010

Objective related to stationary energy consumption:

- Increase the amount of renewable sources in the energy system
- Reduce energy demand by improved energy efficiency
- Sustainable utilization of local resources for energy production

This shall be accomplished through:

- Municipal energy planning & active use of legislation
- Implementation of energy conservation initiatives
- Giving priority to sustainable use of renewable energy sources
- District heating supply in all parts of the city

ECO-City PARTNERS in TRONDHEIM

- **TRONDHEIM KOMMUNE**
  - Municipality of Trondheim — MUN-NO
- **TRONDHEIM ENERGIVERK**
  - Largest local ESCO (power & district heating) — UTIL-NO
- **HEIMDALSGRUPPEN**
  - One of the Leading property developers — BUILD-NO
- **TOBB**
  - Largest housing association in Trondheim — HOUSE-NO
- **SVARTLAMOEN BOLIGSTIFTELSE**
  - Trust : "ecological experimental area" — TRUST-NO
- **SINTEF**
  - Large independent research organization — RTD-NO
- **COWI**
  - Consulting: engineering, environmental science — IC-NO

WORK PACKAGES TRONDHEIM COMMUNITY (1)

WP 1.3: COMMUNITY INITIATION

WP 2.3: COMMUNITY ENERGY EFFICIENCY

- 2.3.1 Analysis of Concerto Concepts
- 2.3.2 Polygen cooling concepts
- 2.3.3 Intelligent energy metering, registration and reporting
- 2.3.4 Concepts for seasonal storage of municipal waste

WP 3.3: DEMONSTRATIONS

WP 4.3: COMMUNITY MONITORING

- 4.3.1 Community monitoring system
- 4.3.2 Energy Monitoring

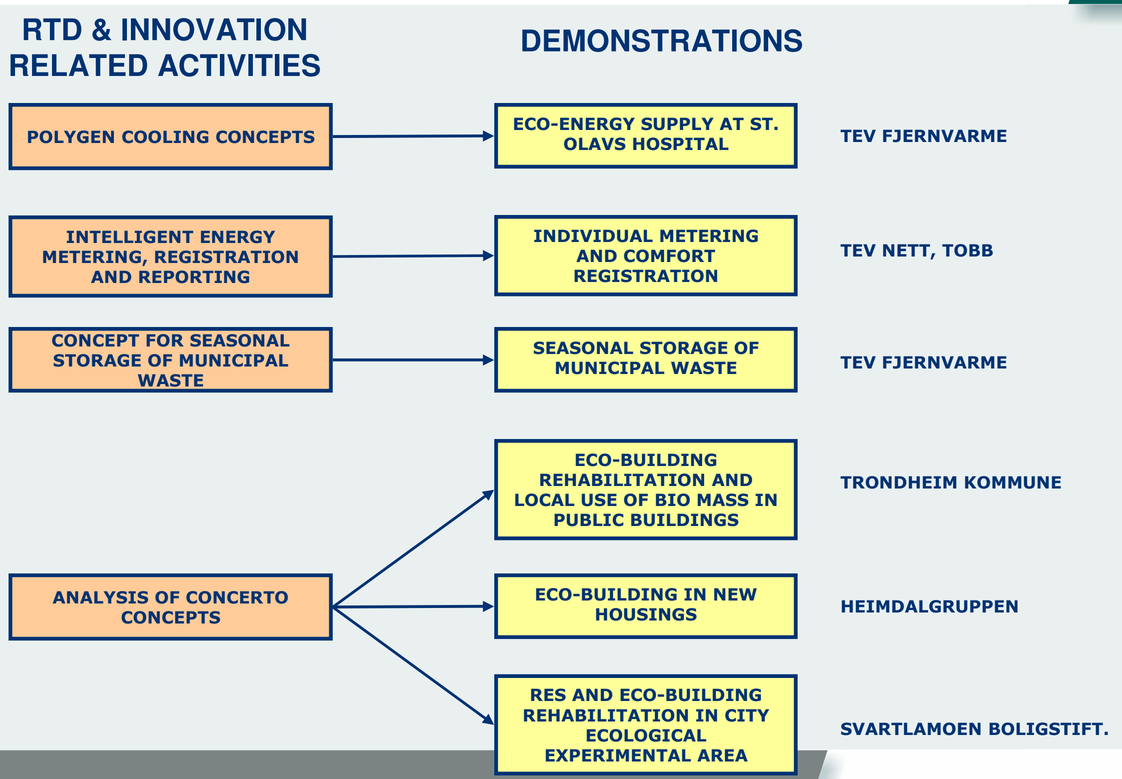
WORK PACKAGES TRONDHEIM COMMUNITY (2)

WP 5.3: TRAINING

- 5.3.1 Benchmarking in private households
- 5.3.2 Eco-lighthouse certification in SME
- 5.3.3 Energy teaching module for elementary schools

WP 6.3: COMMUNITY DISSEMINATION

DIRECT PARTNER ACTIVITIES



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WP 2.3
COMMUNITY ENERGY EFFICIENCY (1)

T.2.3.1
Analysis of Concerto concepts

- Analysis of alternative total eco-energy concepts for eco-building projects, both new buildings and renovation projects, applying an integrated approach focussing on energy, emissions, life cycle costs as a whole building approach.
- A set of guidelines will be developed for this whole building approach.

TABLE OF CONTENTS

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Whole building approach

DEMAND SIDE, SINTEF - Building and Infrastructure
SUPPLY SIDE, SINTEF - Energy Research
USER BEHAVIOR, SINTEF - Technology and Society

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Whole building approach

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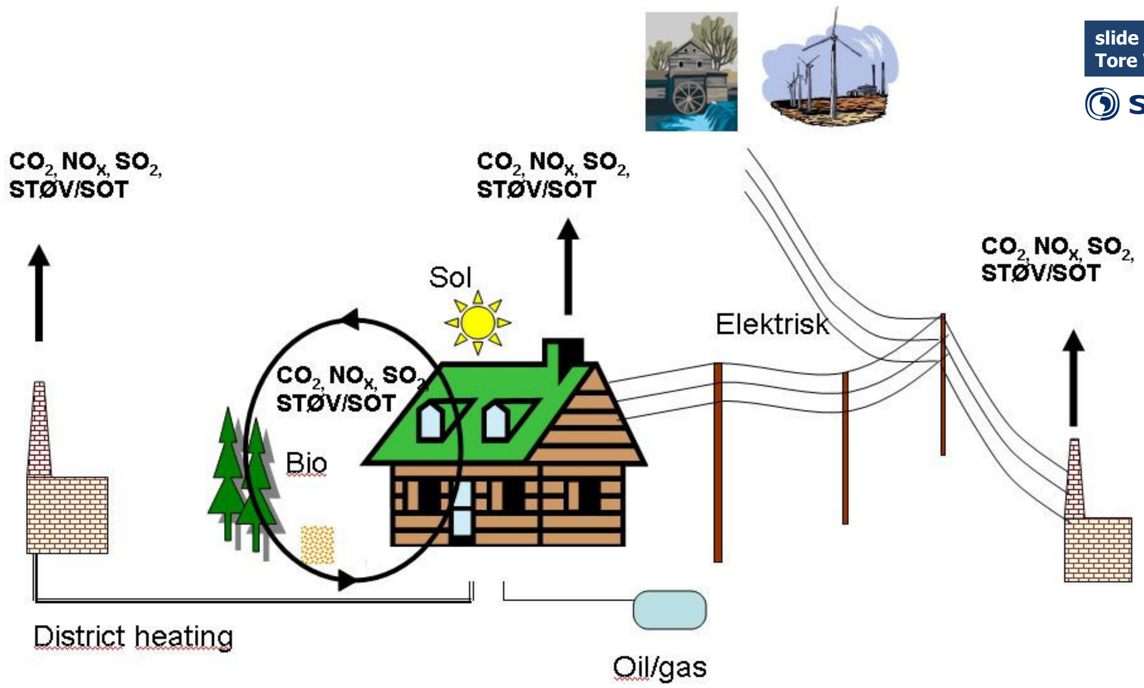

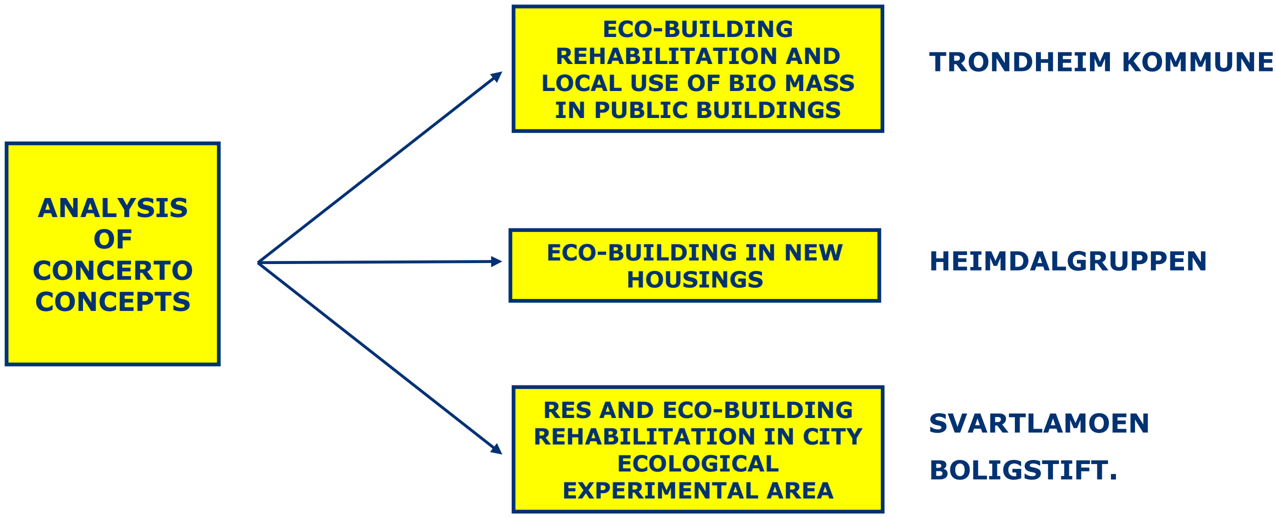

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Trondheim kommune:

ECO-BUILDING REHABILITATION AND LOCAL USE OF BIO MASS IN PUBLIC BUILDINGS

- Improved energy efficiency in renovation projects 17.600 m^2 public buildings comprising 3 schools.
- Upgrading facades and technical installation to energy efficient systems.
- Local use of biomass and solar heating.

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Trondheim kommune:

ECO-BUILDING REHABILITATION AND LOCAL USE OF BIO MASS IN PUBLIC BUILDINGS

Energy Demand	Measures to be adopted in CONCERTO building	Regulation / normal practice* [kWh/m²yr]	CONCERTO specification [kWh/m²yr]	Energy savings [%]
Total space heating excl. boiler eff.	Total Building Approach, average in buildings	**153**	**101**	**34**
Other	Average in buildings	**67**	**53**	**21**
Total Energy	Electricity savings	**220**	**154**	**30**

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Heimdalgruppen:

ECO-BUILDING IN NEW HOUSINGS

- Eco-building in new housings 350 dwellings
- Optimised insulation, balanced demand based ventilation, passive solar design, intermediate climate zoning, etc. optimised design.
- Investigation of small scale wind power systems integrated into the building structure in" Town House" at a new ECO-Building site.

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Heimdalgruppen:

ECO-BUILDING IN NEW HOUSINGS

Energy Demand	Measures to be adopted in CONCERTO building	Regulation / normal practice* [kWh/m²yr]	CONCERTO specification [kWh/m²yr]	Energy savings [%]
Total space heating excl. boiler efficiency.	Total Building Approach average for Cubic buildings i.e. buildings with low surface/volume ratio.	**78**	**28**	**64**
Other	Average in buildings	**93**	**74**	**20**
Total Energy	Electricity savings	**171**	**102**	**40**

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SINTEF

Svartlamoen boligstiftelse:

RENEWABLE ENERGY SUPPLY (RES) AND ECO-BUILDING REHABILITATION IN CITY ECOLOGICAL EXPERIMENTAL AREA

- Eco-building in rehabilitation in City Ecological Experimental Area. 24 dwellings and 3000 m^2 commercial building.

- Optimised insulation and ventilation, active & passive solar design, intermediate climate zoning, etc. optimised design.

- Local use of biomass and solar heating

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Svartlamoen boligstiftelse:

RENEWABLE ENERGY SUPPLY (RES) AND ECO-BUILDING REHABILITATION IN CITY ECOLOGICAL EXPERIMENTAL AREA

Energy Demand	Measures to be adopted in CONCERTO building	Regulation / normal practice* [kWh/m²yr]	CONCERTO specification [kWh/m²yr]	Energy savings [%]
Tot. space heat excl. boiler eff.	Total Building Approach average in buildings	**170**	**117**	**31**
Other	Average in buildings	**91**	**63**	**31**
Total Energy	Electricity savings	**273**	**189**	**31**

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DEMAND SIDE

SINTEF - Building and Infrastructure

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EPLEHAGEN - GRANÅS

CASE:

EPLEHAGEN - GRANÅS

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EPLEHAGEN - GRANÅS

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EPLEHAGEN - GRANÅS

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EPLEHAGEN - GRANÅS

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U-verdi

Vindu	:	1,60 W/m² K
Tak	:	0,15 W/m² K
Yttervegg	:	0,22 W/m² K
Gulv	:	0,15 W/m² K

Balansert ventilasjon
Fjernvarme

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EnergiSimulering: Midtleilighet

Energibudsjett (netto energibehov) [kWh]		
Beskrivelse	Før tiltak	Før tiltak/gulvareal
1. Romoppvarming	3024 kWh	36 kWh/m²
2. Varmebatterier	772 kWh	9 kWh/m²
3. Vannoppvarming	2540 kWh	31 kWh/m²
4. Vifter og pumper	292 kWh	4 kWh/m²
5. Belysning	1939 kWh	23 kWh/m²
6. Teknisk utstyr	2424 kWh	29 kWh/m²
7. Romkjøling	0 kWh	0 kWh/m²
8. Kjølebatterier	0 kWh	0 kWh/m²
Totalt energibehov	10991 kWh	132 kWh/m²

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EnergiSimulering:

	EPLEHAGEN AS BUILT	Eco-City tiltakspakke
Yttervegg	U-verdi: 0,22 W/m² K (200 mm)	0,14 W/m2 K (300 mm)
Yttertak	U-verdi: 0,15 W/m² K (300 mm)	0,11 W/m2 K (400 mm)
Gulv på grunn	U-verdi: 0,15 W/m² K (200 mm)	U-verdi: 0.11 W/m2 (250 mm polystyren + 50 mm kantisolasjon)
Vindu	U-verdi: 1,6 W/m² K (4-15luft-E4))	U-verdi: 1,1 W/m2 K (4E-12arg-4-12arg-4E)
Infiltrasjon	n_{50} = 2 oms/h. Infiltrasjon: 0.15 oms/h	n50 = 1 oms/h. Infiltrasjon: 0.07 oms/h
Ventilasjon	Årsvirkningsgrad for varmegjenvinner på 60 %. SFP-faktor 1.5 kW/m³ /s	Årsvirkningsgrad for varmegjenvinner på 80 %. SFP-faktor 1.5 kW/m³ /s. Halv luftmengde natt.
	Ca 145 kWh/m2 år	(se neste side…)

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EnergiSimulering: "ECO-City Standard"

Energibudsjett (netto energibehov) [kWh]		
Beskrivelse	Før tiltak	Før tiltak/gulvareal
1. Romoppvarming	1555 kWh	19 kWh/m²
2. Varmebatterier	62 kWh	1 kWh/m²
3. Vannoppvarming	2540 kWh	31 kWh/m²
4. Vifter og pumper	211 kWh	3 kWh/m²
5. Belysning	1939 kWh	23 kWh/m²
6. Teknisk utstyr	2424 kWh	29 kWh/m²
7. Romkjøling	0 kWh	0 kWh/m²
8. Kjølebatterier	0 kWh	0 kWh/m²
Totalt energibehov	8730 kWh	105 kWh/m²

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SUPPLY SIDE

SINTEF - Energy Research

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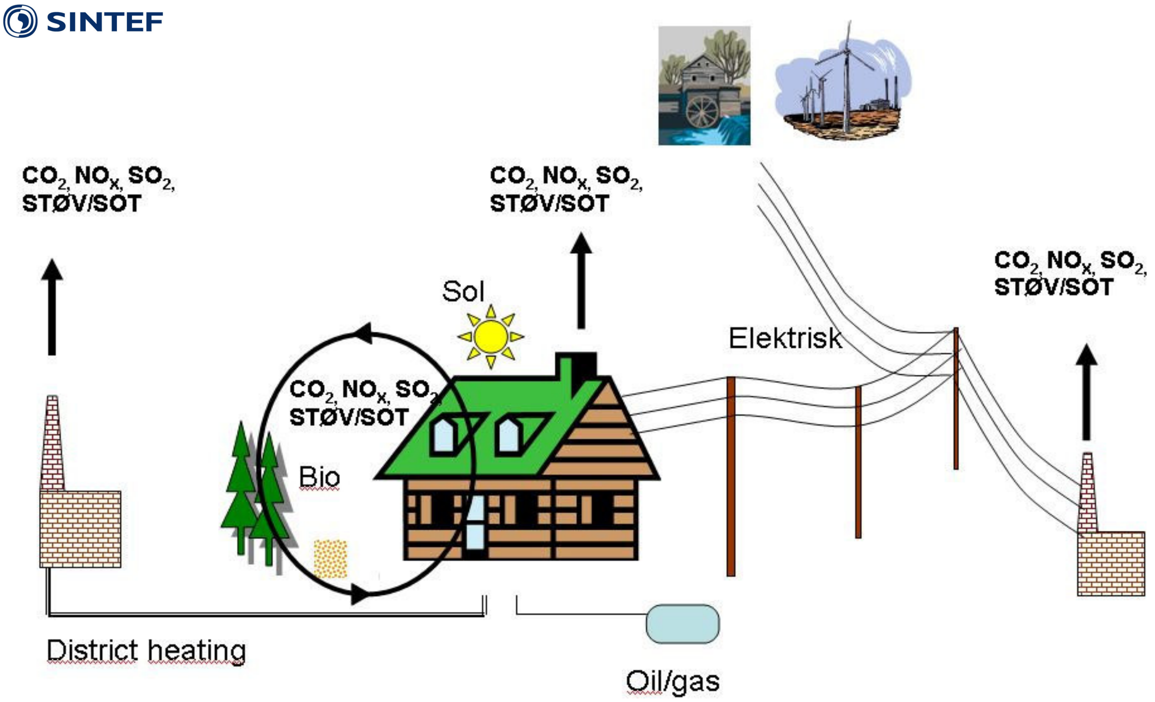
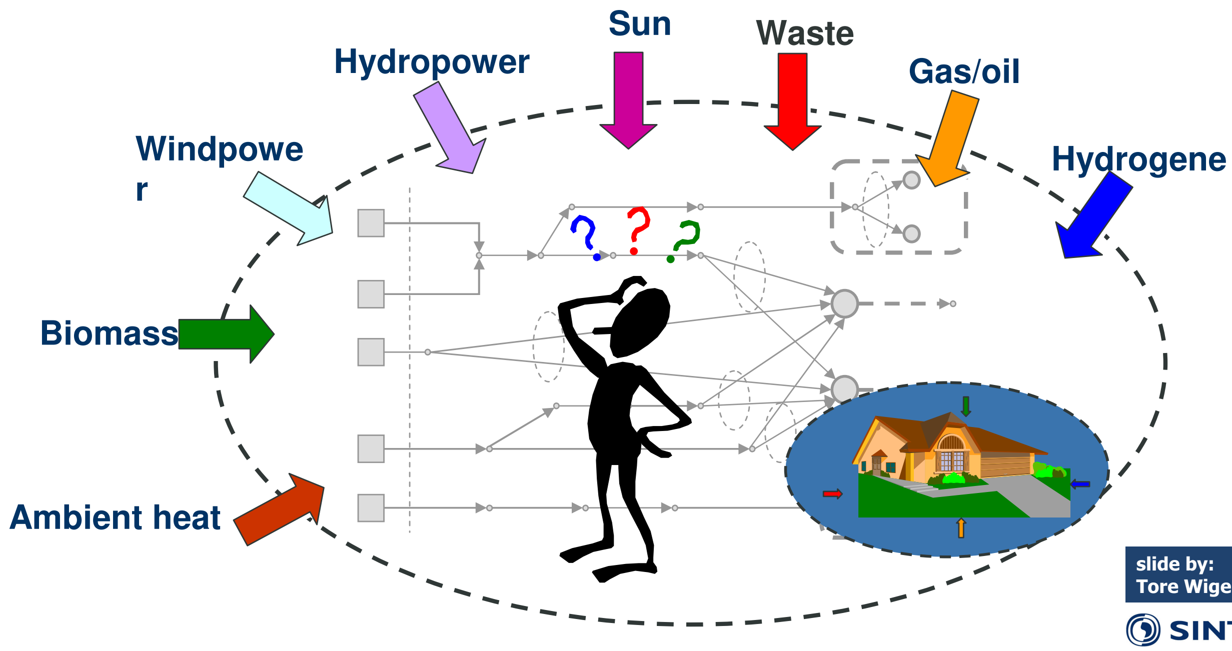
Supply side
A mixture of possibilities…



The challenge
Optimal use of local energy resources



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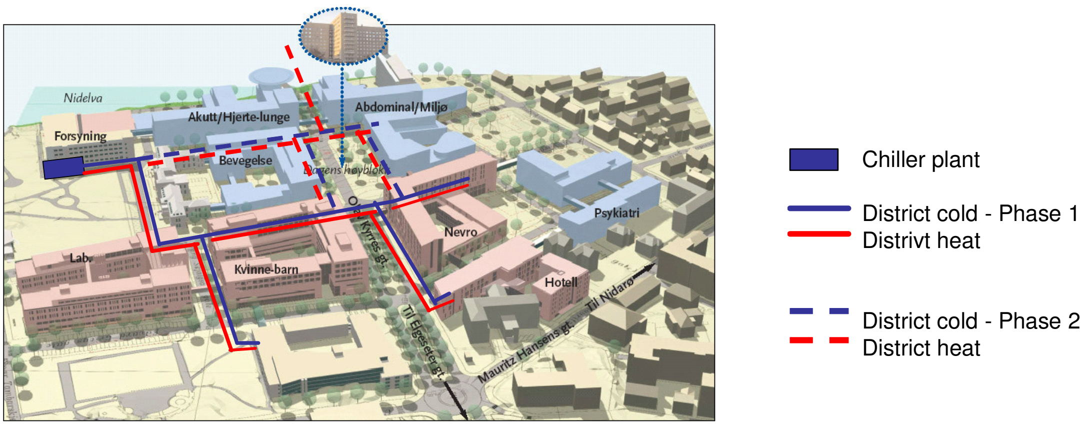
GUIDELINES

- THE MOST ECONOMIC ENERGY SOLUTION DEPENDS ON THE COSTS OF THE INSTALLATION, TOTAL ENERGY-DEMAND AND ENERGY-PRICE.
  (all seen in a lifetime perspective)
- LESS ENERGY DEMAND => RELATIVELY HIGHER ENERGY COSTS EXPRESSED IN CAPITALKOSTS + CONSUMPTION ($\$_{TOT}$/kWh$_{TOT}$)
  (in low energy concepts, capital costs is far the major part in the economic LCC-calculations)
- IN NORWAY, DIRECT ELECTRIC ENERGY IS THE SIMPLEST AND USUALLY THE LESS EXPENCIVE INSTALLATION
  (but this energy is far to valuable to use in heating)
- THE EFFICENCY OF BIOENERGY DEPENDS ON PROPER COMBUSTION.
  (small or distributed stokes and frequent start/stop, tends to contribute to local pollutions)

WP 2.3
COMMUNITY ENERGY EFFICIENCY (2)

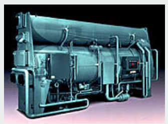


T.2.3.2 Polygen cooling concepts

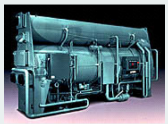
- Analysis and design of large-scale integrated polygen cooling concepts based on state-of-art and emerging technologies.

District Heating and Cooling in Trondheim

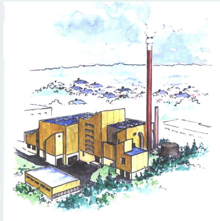
- TEV Fjernvarme started to deliver district heating (DH) in 1982, and today, it covers 25% of the heating demands in Trondheim.
- The base heat production is from a waste incineration plant.
- In summertime, there is surplus of waste heat in the system. This excess heat is used as the driving energy for absorption chillers in two district cooling plants.
- The first district cooling plant was established at Nedre Elvehavn in 2000.
- The second district cooling plant was established at St. Olavs Hospital in 2004



Absorption chiller Nedre Elvehavn



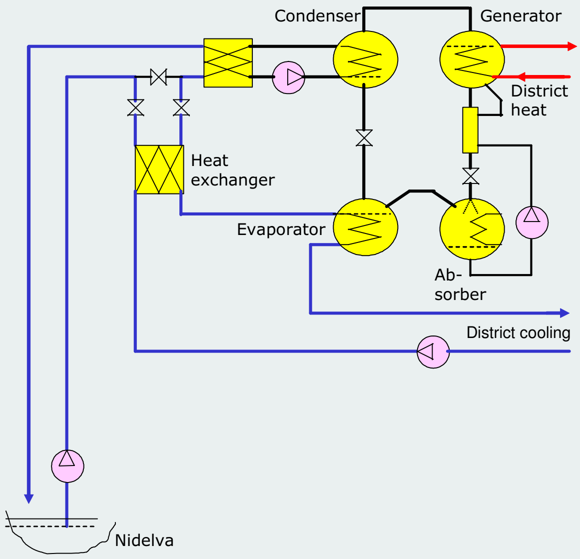
Absorption chiller St. Olavs Hospital



Waste incineration plant Heimdal Varmesentral

Principle of absorption cooling

- The district cooling production plant consists of a heat exchanger for pre-cooling from river water, and an absorption chiller for post cooling with district heat as the driving energy.
- The condenser is cooled by the same river water system, which is used for precooling.
- In the absorption chiller, the mechanical compressor is replaced by a solution circuit with an absorber and a generator. Water is the refrigerant, and lithium bromide – LiBr, is the absorption fluid.
- The lowest district heating temperature is approximately 85°C



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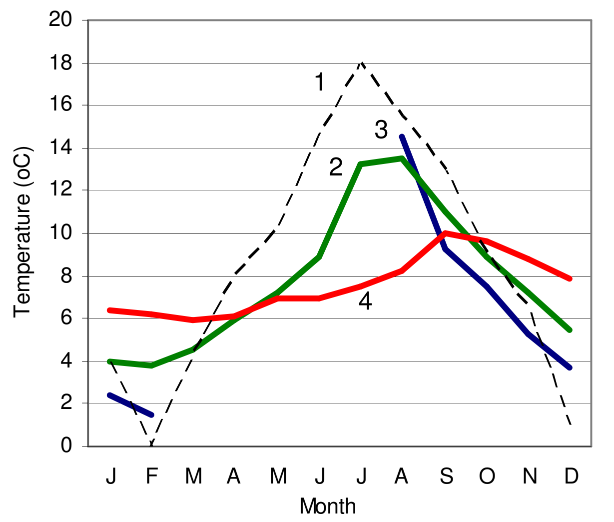
Natural cooling from river or sea

- At Nedre Elvehavn, which is located 1.5 km from the river mouth, the river water is brackish water
- At St. Olavs Hospital, which is located 4 km further up along the river, the water is fresh water without any influence from the sea water.
- Another opportunity is to use the sea water for cooling purposes. The average monthly sea water temperatures from 80 m depth is quite constant throughout the year.

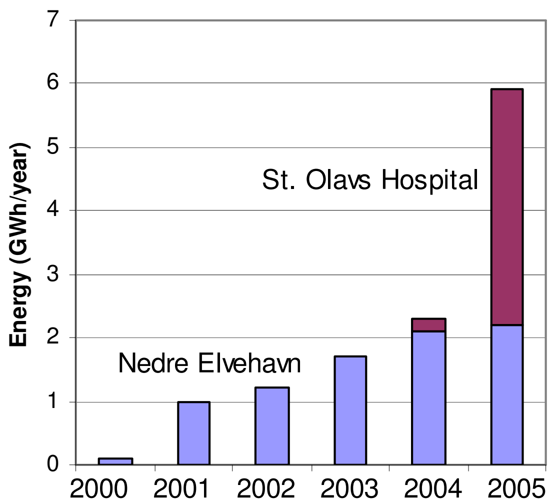


1 Air temperature
2 River water at Nedre Elvehavn
3 River water at St. Olavs Hospital
4 Sea water temperature at 80 m depth

Eco City

Status of District Cooling in Trondheim

- The first district cooling plant at Nedre Elvehavn was established in october 2000
- The first 1.5 MW absorption chiller was started in june 2001
- Another absorption chiller was built at Nedre Elvehavn in 2003
- The district cooling plant at St. Olavs Hospital with one 3 MW absorption chiller was established in autumn 2004



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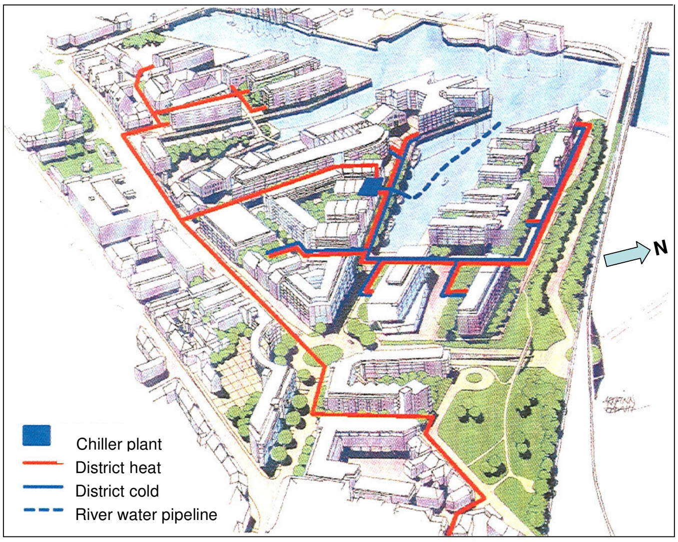
Experiences from the district cooling plant at Nedre Elvehavn

Experiences from five years of operation:

- The maximum cooling demand has been 2.3 MW on 5th july 2005, which was the warmest day that year
- Problems with fouling in the sea water/river water system, especially during the very hot summer in 2002
- Cavitation of river water pump due to clogging of the river water filter
- Poor control of absorption chiller at small capacities



District heating and cooling system at Nedre Elvehavn

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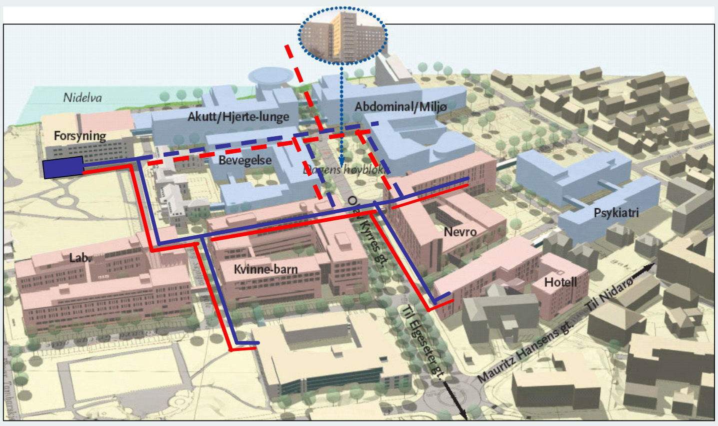
Experiences from the district cooling plant at St. Olavs Hospital

Experiences after the first year of operation:

- Phase 1 with approximately 50% of the district cooling system is built, but the new hospital buildings has up to now been in test operation
- The average winter cooling demand with 100 000 m² building area in use is about 500 kW
- Up to now, 65% the cooling demand is covered by "free" cooling from river water



District heating and cooling system at St. Olavs Hospital

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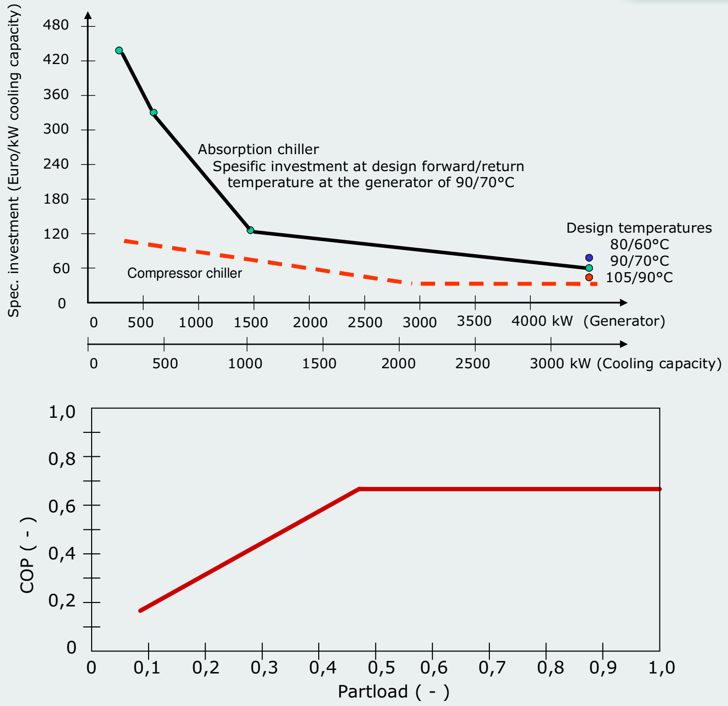
Challenges

The specific investsments for absorption chillers (Euro/kW cooling capacity) will increase considerably for chillers smaller than 1 000 kW Compressor chillers are much cheaper at small capacities,but for large capacities, the price difference is only 10% (Upper Figure).

The efficiency for the absorption chillerswill decrease considerably at partload operation below 50% (Lower Figure).

Therefore, absorption chillers should be large and they should operate at high capacity.



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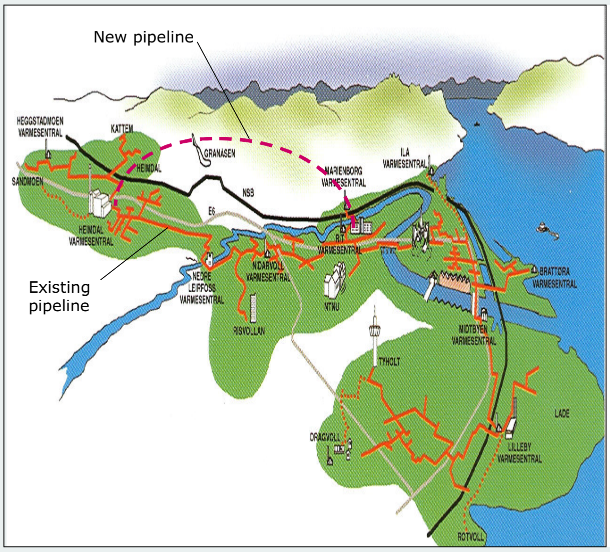
Challenges

One problem is hydraulic restrictions of maximum water flow in the district heating transmission pipeline to the city. The existing transmission pipes are designed for heating demand in winter with forward/return temperatures of 120/70°C, i.e. 50°C temperature difference.

In the summer, the forward water temperature is normally lower, e.g. 90°C, and the temperature decrease in the absorption chiller may be restricted to 10 or 15°C. This small hot water temperature difference and the low COP of the absorption chiller may result in restrictions in hot water supply.

However, a new district heating transmission pipeline is being constructed from the waste incineration plant to the city, and this will probably solve the problem.



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WP 2.3
COMMUNITY ENERGY EFFICIENCY (3)

T.2.3.3
Intelligent energy metering, registration and reporting

- Development of a cost efficient concept for metering, registration and reporting of energy consumption in private households.
- The concept shall comprise both power and heat consumption and will be developed with a primary focus reducing energy consumption. Cost efficient indirect methods like comfort registration will be evaluated.

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Faktorer som påvirker bruken av energi i bygg

- Klima
- Tekniske løsninger
- Kunnskap om hva som påvirker forbruk
- Kunnskap om andres energiforbruk
- Fokus på energibruk i media og blant folk
- Holdning til ressursbruk
- Energipris

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Måling gir kunnskap

Får vi forbruket presentert på en god måte kan vi finne ut:

- Hvor, når og hvordan brukes energien
- Energibruk i forhold til areal
- Energibruk i forhold til aktivitet
- Energibruk i forhold til utetemperatur
- Hvor effektivt jeg bruker energien i forhold til andre
- Hva jeg kan gjøre for å redusere mitt energiforbruk

Fjernvarme i borettslag

- Store borettslag med fjernvarme til oppvarming og varmtvann har i dag fellesmåling av fjernvarme.
- Varmen distribueres langs fasader og i felles rør i sjakter slik at måling er komplisert fordi hver leilighet har mange tilførsler
- Betaling skjer sammen med husleie og er fordelt på areal
- Den enkelte beboer mangler forhold til sitt forbruk og har ingen incentiver for nøktern ressursbruk

Måling av strømforbruk i boliger

- I Norge har vi lange tradisjoner med strømmålere i hver bolig
- Mange har god oversikt over hvor mye dem vanligvis betaler til kraftleverandør og nettselskap
- Det er usikkert hvor mange som har et forhold til sitt forbruk i kWh

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Concerto aktiviteter

Trondheim og omegn boligbyggelag (Tobb), Trondheim Energiverk AS

(TEV), SINTEF og COWI AS skal sammen

- Vurdere metoder for måling av fjernvarmeforbruk i borettslag
- Etablere metoder for presentasjon av energiforbruk til beboere

- Tobb skal i samarbeid med et borettslag med fellesmåling implementere måling av fjernvarme i den enkelte leilighet
- TEV skal i samarbeid med et eller flere borettslag etablere måling med automatisk innhenting av målerdata
- TEV og Tobb skal presentere måleravlesningene til beboerne

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WP 2.3
COMMUNITY ENERGY EFFICIENCY (4)

T.2.3.4
Concept for seasonal storage of municipal waste

- Analyse and specification of a cost efficient concept for seasonal storage of municipal waste.
- A system description shall be developed, comprising compacting, packaging, transportation and storage.
- Selection of optimal technical solution and logistics will be given particular focus.

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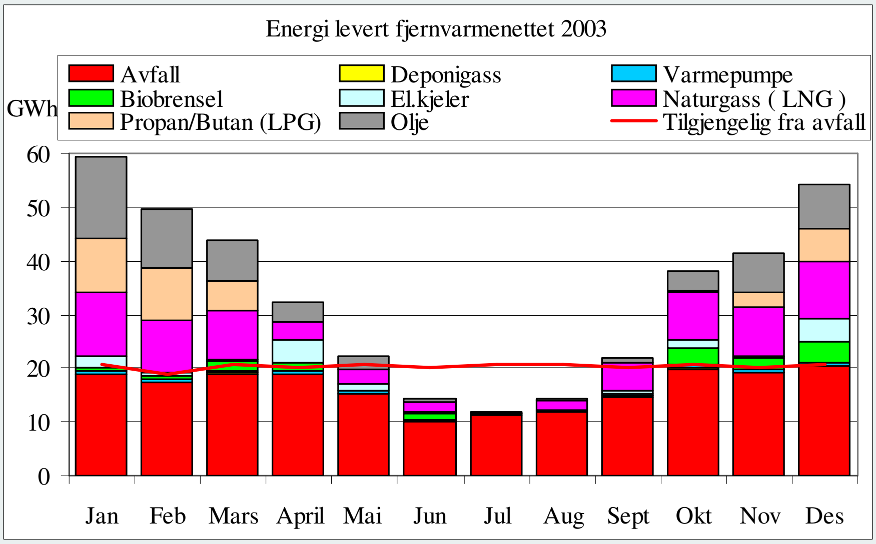
Dagens situasjon

En stor del av tilgjengelig energi fra avfallet må kjøles bort om sommeren.
Om vinteren må en stor del av energien leveres med andre energibærere.



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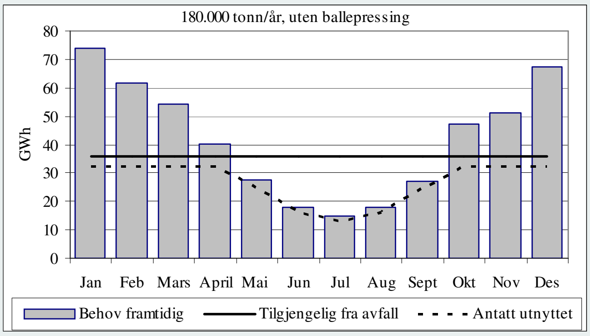
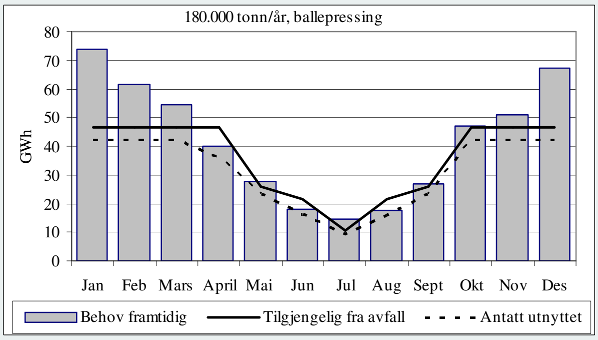
Framtidens situasjon

Økt energibehov i fjernvarmenettet og økt avfallsmengde

Alt. 1:
TEV kan utvide kapasiteten til å dekke behovet og fortsette å brenne alt avfallet fortløpende som nå. Energiutnyttelse: 74%
Alt. 2 (valgt):
TEV kan bygge større forbrenningsanlegg og ballepresse og lagra avfall fra sommer til vinter. Energiutnyttelse: 87%

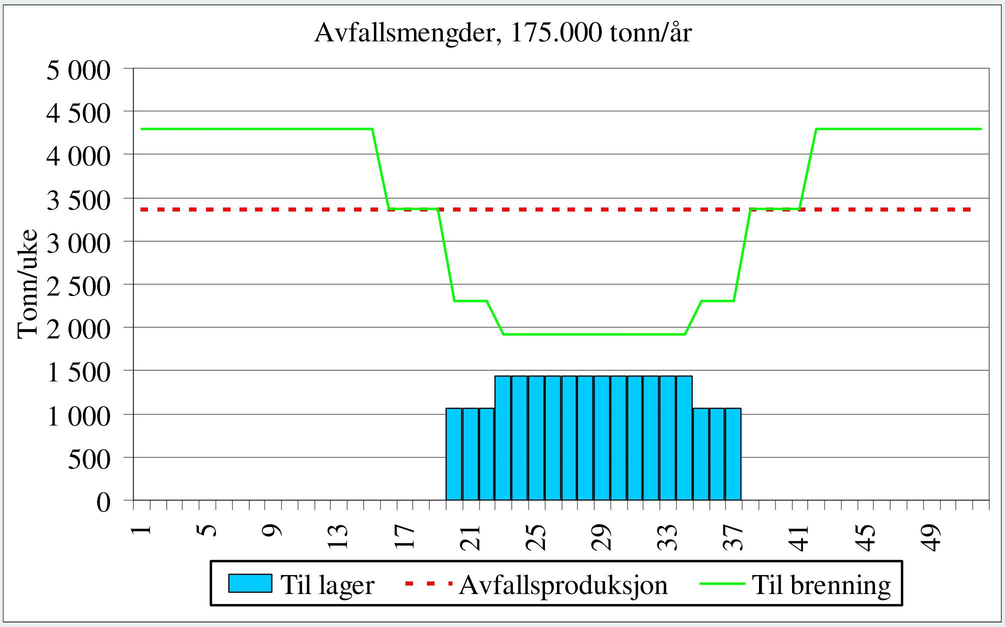




Planlagt utvidelse av Heimdal Varmesentral i Trondheim.
Forventet oppstart sommer 2007.

Mulige avfallsmengder over året

Til lager fra sommer til vinter: ca. 20.000 tonn/år. 1 tonn avfall tilsvarer ca. 2,4 MWh energi ved forbrenning.



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Emballering av ballepresset avfall

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Hegstadmoen sommeren 200 med ballepresse og avfall på lager

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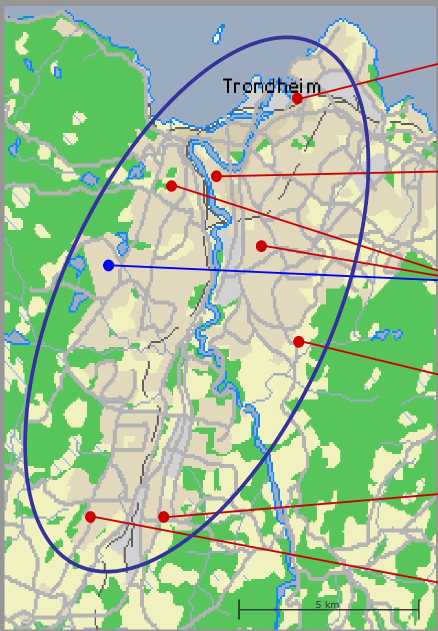
Status

- Avklarende møter avholdt med alle som ga tilbud i nov. – des. 2005.
- Foreløpig beslutning er å gå videre med forhandlinger med to av tilbyderne
- Nødvendig å utrede evt. problemer med lagring, brannfare, energistabilitet, forbrenningstekniske forhold mm.

COWI

WP 3.3 DEMONSTRATIONS

ECO-CITY TRONDHEIM



RES IN CITY ECOLOGICAL EXPERIMENTAL AREA
- ECO BUILDINGS REHAB
- LOCAL RES, BIO & SOLAR
- 24 DWELLINGS AND 3.000 m2 COMMERCIAL

ECO ENERGY SUPPLY AT ST. OLAV HOSPITAL
- POLYGENERATION
- 200.000 m2

RUE & RES IN PUBLIC BUILDINGS
- ECO BUILDINGS REHAB
- LOCAL RES, BIO
- 3 SCHOOLS

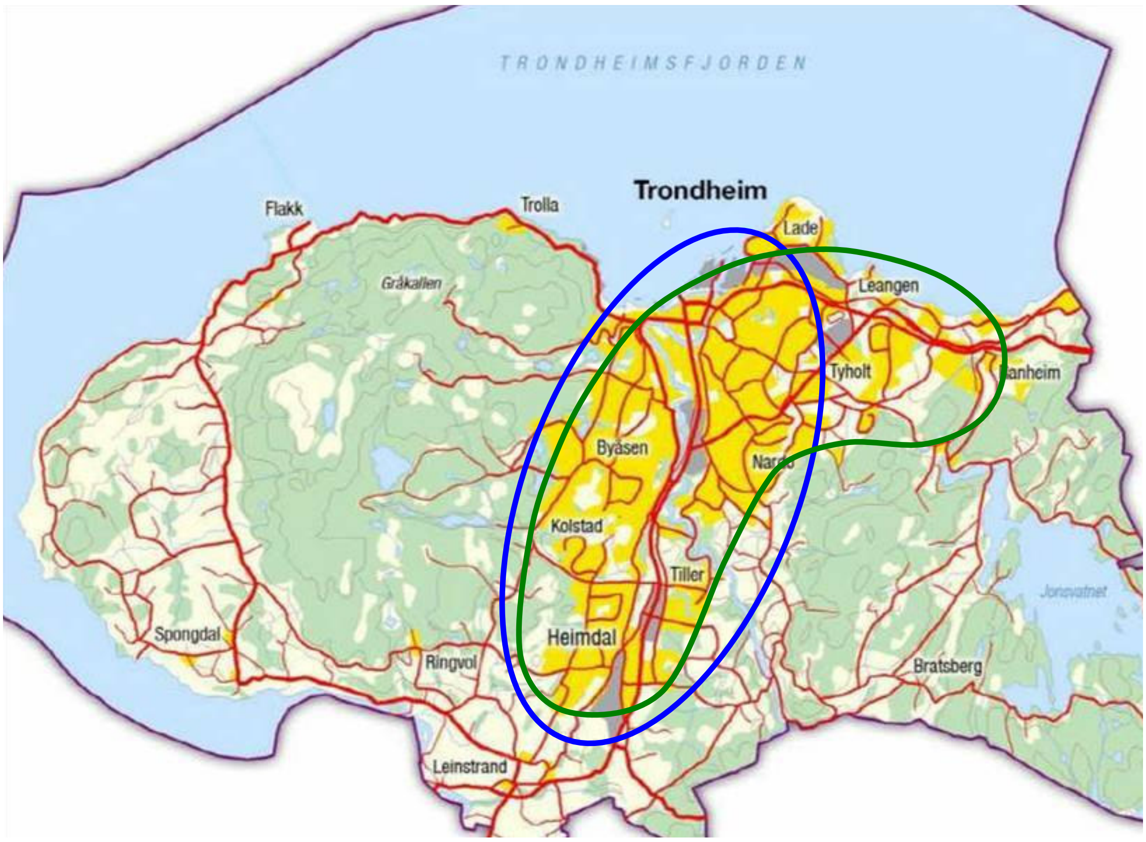
ECO BUILDINGS IN NEW HOUSINGS
- ECO BUILDINGS
- 350 DWELLINGS

SEASONAL STORAGE OF MUNICIPAL WASTE
- INCREASED RES IN DISTRICT HEATING
- 50 GWh RES REPLACING FOSIL FUELS

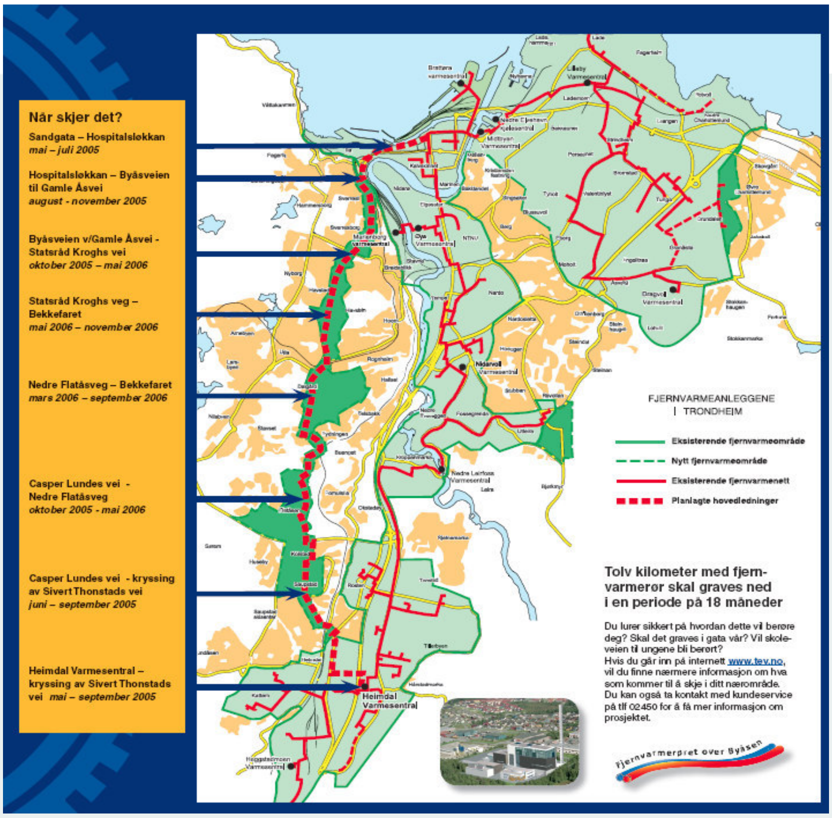
INTELLIGENT METERING AND COMFORT REGISTRATION
- RUE HEAT & ELECTRICITY
- 670 DWELLINGS

INSIDE DISTRICT HEATING AREA

OUTSIDE DISTRICT HEATING AREA



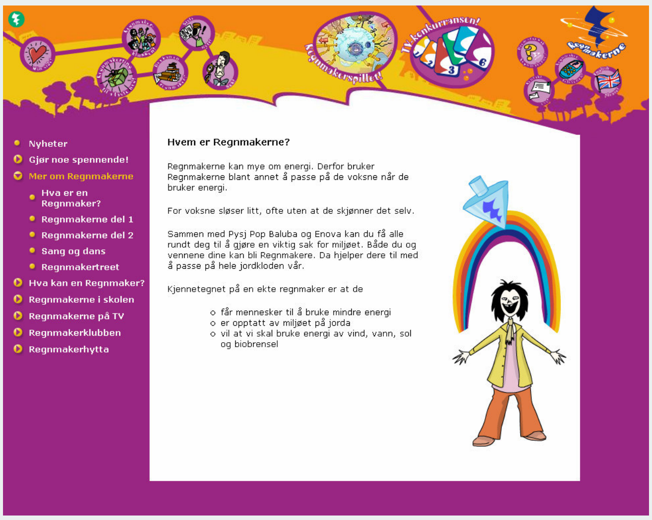
Utvidet fjernvarme



WP 5.3 TRAINING

5.3.3 Energy teaching module for elementary schools

- ENOVA: REGNMAKERNE (www.regnmakerne.no)
- TEV / Trondheim kommune (www.tev.no/skole)



ENERGY BALANCE - TRONDHEIM

ENERGY SUPPLY		Thermal	Electrical
Seasonal storage of waste (90% eff.)		45 000	
Local RES heating (bio and solar)		700	
Total supply		**45 700**	**-**

ENERGY DEMAND	Area	Thermal	Electrical
St. Olav Hospital	200 000	44 600	(1 500)
New eco-buildings	22 000	660	1 120
Eco-building rehabilitation, RUE	21 560	(1 470)	(110)
Eco-building rehabilitation, RES (conv.)		1 730	(1 730)
Intelligent metering and comfort reg.	53 600	(520)	(420)
Total demand	**243 560**	**45 520**	**(2 220)**

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The Mayor's Endorsement

Eco City

Hele 2/3 av strømforbruket i en vanlig norsk husholdning går til oppvarming av bolig og vann. I Norge er vi avhengige av strøm og vi bruker vi mer enn vi produserer selv. Det er på tide å tenke nytt. Derfor er handling rundt hvordan vi kan bruke mindre energi i bygninger viktig. Eco-City er et EU prosjekt med målet å demonstrere innovative integrerte energi løsninger både for brukere og leverandører i tre byområder i Europa. Tudela (Spania), Helsingborg/Helsingør (Sverige/Danmark) og Trondheim (Norge). Deltakerne i Trondheim er Trondheim Kommune, Trondheim Energiverk, Heimdal Eiendomselskap, TOBB, Svartlamon Boligstiftelse, SINTEF og COWI.

Miljøbyen Trondheim står beskrevet i vår kommuneplan. Dialog og samarbeid er en forutsetning for å lykkes i målet om å være en miljøby. Med CONCERTO programmet kan vi samarbeide innad i kommunen, med utbyggere og forskningsinstitusjoner. Vi kan drive framtidsrettet byutvikling i praksis.

Sincerely yours,

Rita Ottervik
Mayor of Trondheim

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