Local Heat, Local Food

Utilising District Heating Systems for Urban Farming

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Outline

District Heating can provide opportunities to develop farming in urban areas

Urban farming can create possibilities for DH in areas where heat demand is low.

- Hydroponic Farming
- Interest and investment in urban farming
- Case studies: how is urban farming being implemented
- Integration with 4^{th} generation DH systems
- Models for building integrations

The costs of feeding urban populations

By 2050, approx. 70% of the world's population will live in cities
- increased need for fresh food in urban populations

Transport of food long distances has environmental and nutritional costs
- vegetables lose 30% of nutritional content 3 days after harvest
- Sweden imports 50% of its food
  - accounts for 70% of total food production energy
  - The average plate of food has travelled 2400 km by the time you eat it

How do we move food production closer to population centres?

How do we increase food production for a growing population?

Hydroponic Farming

Growing plants without soil

- flowing or replenishing nutrient-rich water
- Advances in hydroponic farming and reduced cost of LED lighting has spurned on urban farming
- New methods always being developed
  - Aquaponics
  - Aeroponics
  - Anthroponics (pee-ponics)

Energy use of hydroponic farms

Low energy LED lighting

- Specify precise wavelength for growth
- Regulate day length for faster growth

Reduced water usage

- 80% less than conventional farming

No need for pesticides

- behavioral controls and natural pests often sufficient

Vertical beds increase effective area

Low temperature requirements

- Typically 22 – 27^{o}C

Benefits of hydroponic urban farming

Water Usage

Reduced transport

No pesticides used

Performed year round

Highly adaptable – able to work around seasonal changes

Alleviates farmland to return to ecological functions

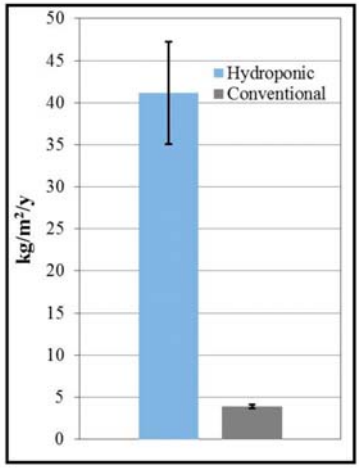
Can increase greenery in recreational spaces

Trädgård på Spåret, Stockholm

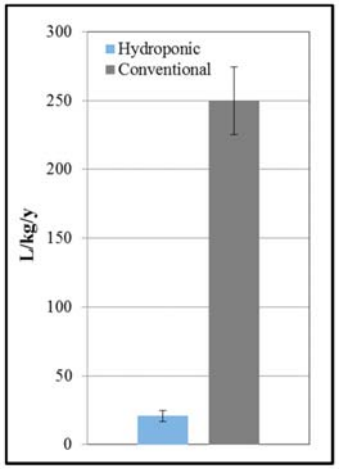
Sky Garden, New York

Comparisons to conventional farming

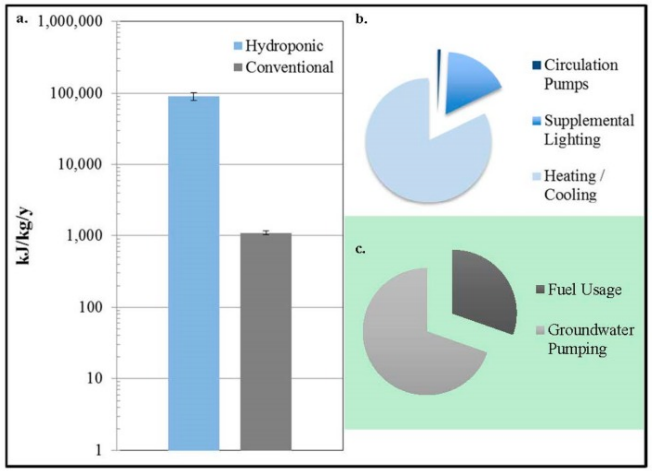
- Lettuce farming in Arizona, US.
  - Currently allocates 69% of freshwater to agriculture
- Decreasing day-length can lead to many more harvests per year
- Energy usage is higher especially when cooling is required
  - strong area for improvement



Yield



Water



Energy

Barbossa et al. 2015

Costs of inner-city hydroponic farming

High overhead costs involved in being closer to urban areas

Many startups forced to move to larger facilities away from cities to grow

Need intelligent integration with existing buildings to make city farming more economically feasible

Growup, UK

Investment in Urban Farming

Sweden's increasing investment in urban farming shows increasing awareness

Malmö

VINNOVA

Stadsbruk

Malmö stad

SLU
Swedish University of Agricultural Sciences

xenofilia

9.5M SEK investment

Gothenburg

GOTHENBURG GREEN WORLD 2016

The Food LAB

Göteborgs Stad

Stockholm

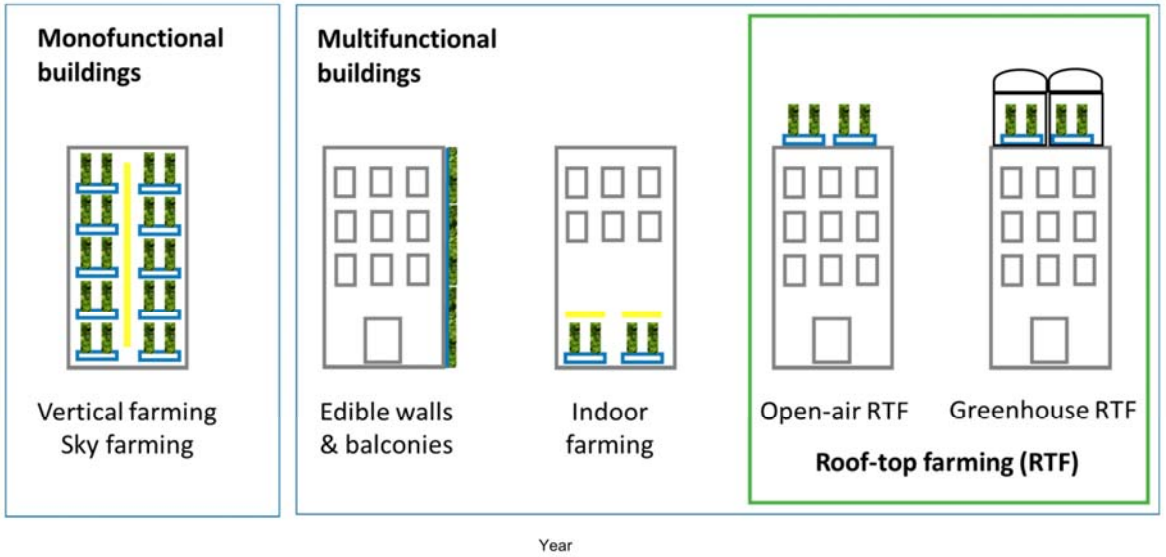
URBAN OASIS MARKET
SAVE TIME. SAVE MONEY. EAT FRESH

GRÖNSKA
STADSODLING

venture cup

Integration in cities

While Swedish projects are getting off the ground, urban hydroponic farms have taken off around the world



This depends on how public and private space in cities can be utilised

Increased integration of 4th gen DH systems opens new ways to integrate farming into cities

Buehler & Junge, 2016

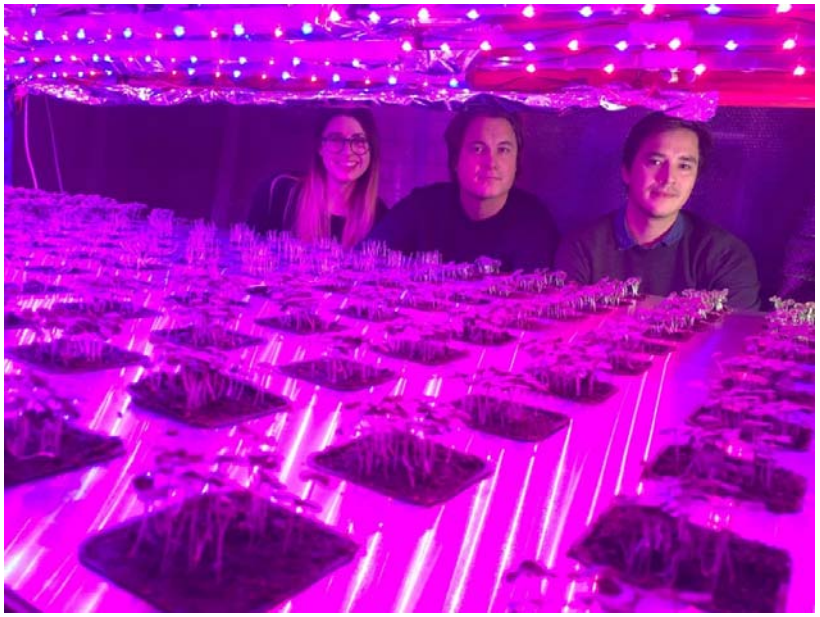
Case Study: GRÖNSKA

Grönska AB

- Winner of Venture Cup start-up competition 2015
- Currently supplying 7000 plants per month
- Expanding to 400 m^2 plantation
  - 64,000 plants per month
- Located in central Stockholm

LED lighting: 100-150W per m^2

- Current compact design creates a heat excess
  - above required 24^oC



Case Study: GROWING UNDERGROUND

Utilising wasted space in London

Located 30m underground in WWII bunkers below Clapham Common

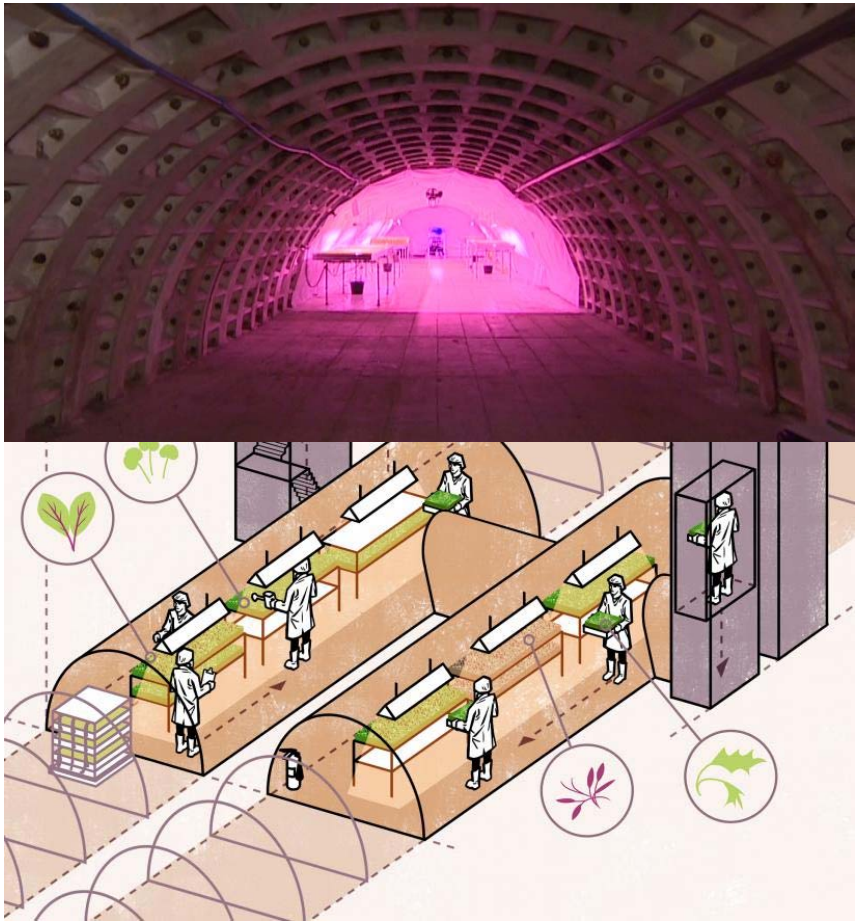
- 2,200 m^2 unused growing space

Initial investment of £1.2M

- private investment and crowdfunding

Initiated with Michellin starred Chef

Just partnered with Marks & Spencer supermarket



Gotham Greens and Wholefoods

Run 4 rooftop farms in New York

- 52,000 sq m growing space in inner city
- Integrated with business as show-piece farms
- use 20x less water than conventional farming

Greenpoint, Brooklyn

"from food miles to food footsteps"

Gowanus, Brooklyn

Corporate Interest

Pasona Corporation, Japan

Showpiece farm – example of aesthetic property of urban farming

Demonstrates how urban farming can improve recreational spaces

Supplies food for the company canteen – hyperlocal food

Integration with 4th generation DH

Urban Farming is at a developing stage

- cannot be treated as a normal heat consumer – complicated value chain

Low temperature requirements

- Can be used to reduce return temperature in the DH grid, increasing efficiency

Opportunity for increased biomass to feed into systems

- Possibility to store energy as pellets

High density farms can create excess heat and feed back into the system

Feeding back into the system

Excess heat production

- indoor farms with tight stacking can produce excess heat above the required 24°C
- Provides an opportunity for sharing heat back into the system or to adjoining buildings

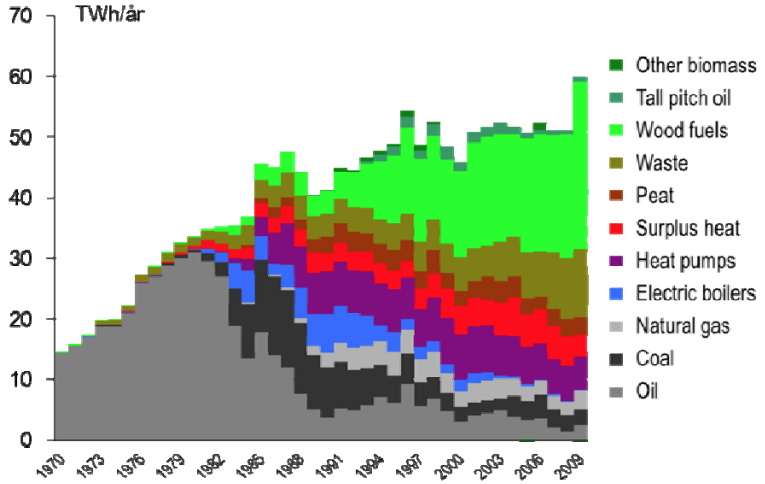
Feedback into supply line to end of line buildings in low flow summer periods

Waste biomass

- becoming an increasing source of energy for DH systems
- Urban farming can create local biomass production

Energy storage

- Carbon pellet production via hydrothermal carbonisation



Henning & Gebremedhin 2012

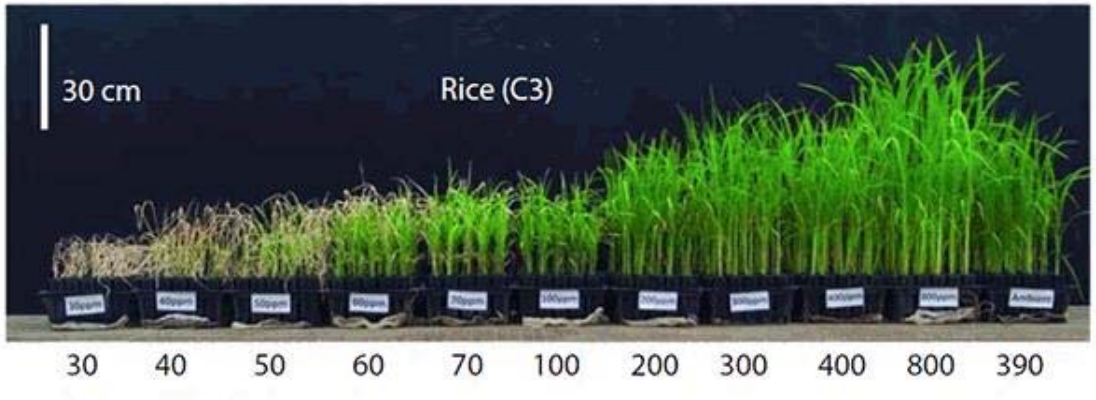
CO_2 re-pumping

Increasing atmospheric Carbon dioxide can increase plant growth

- Method used by large scale greenhouse, e.g: Thanet Earth and DutchGreenhouses

Opportunity to re-route harmful CO_2 emissions

- Plants grown act as a carbon sink



CO_2 Concentration

von Caemmerer et al. 2012

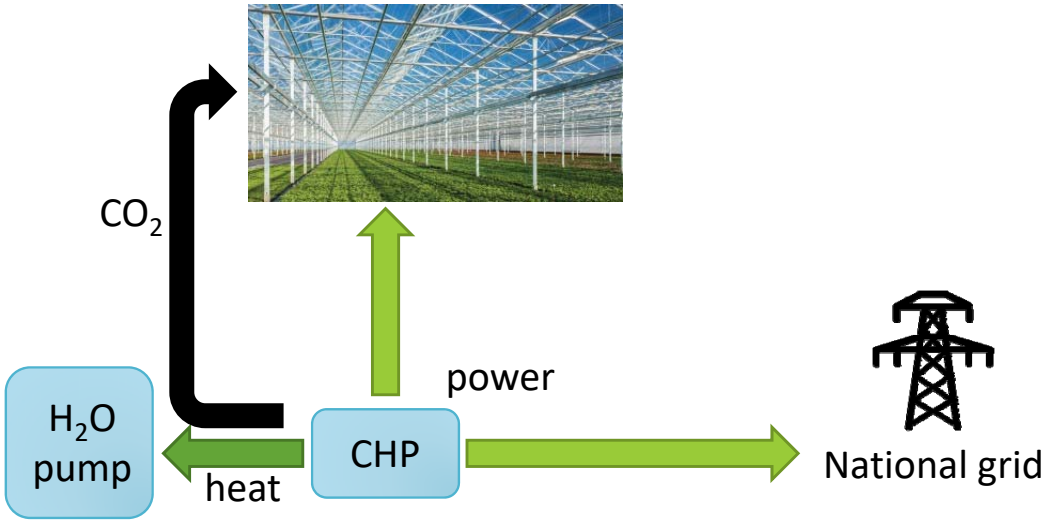
Integration examples

thanet earth™ Kent, UK

Large-scale greenhouse hydroponic farming

Use CHP system – power station in each greenhouse (natural gas)

CO_2 pumped back into greenhouses to increase growth



Plantagon

- Example of large-scale integration with DH
- Ambitious Agritechture projects
- Conceptualise building retro-fits.
  - residential, office and underground

Plantagon Linköping greenhouse

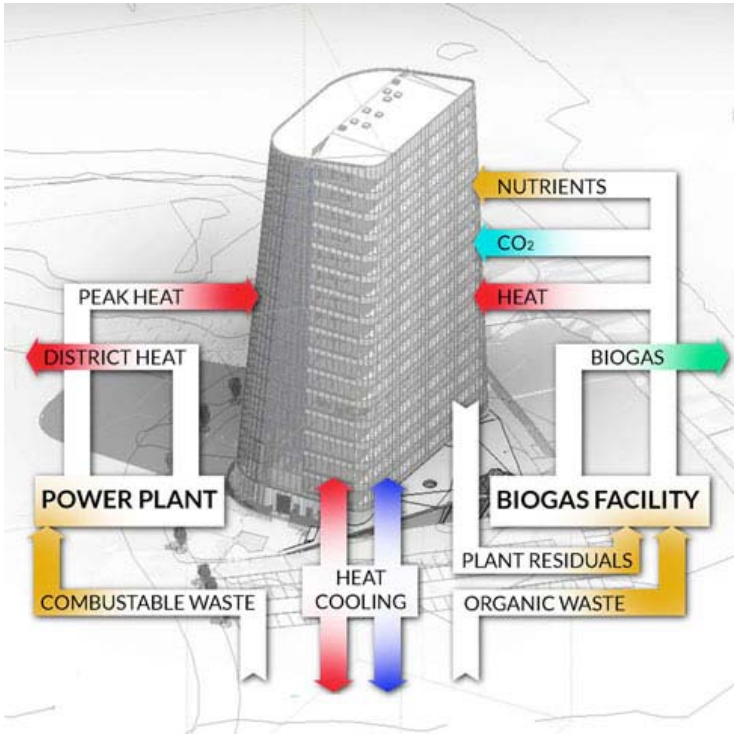
Construction begins late 2017

4,335 m^2 cultivation area

1,547 m^2 facility footprint

Partially heated with excess heat from surrounding buildings

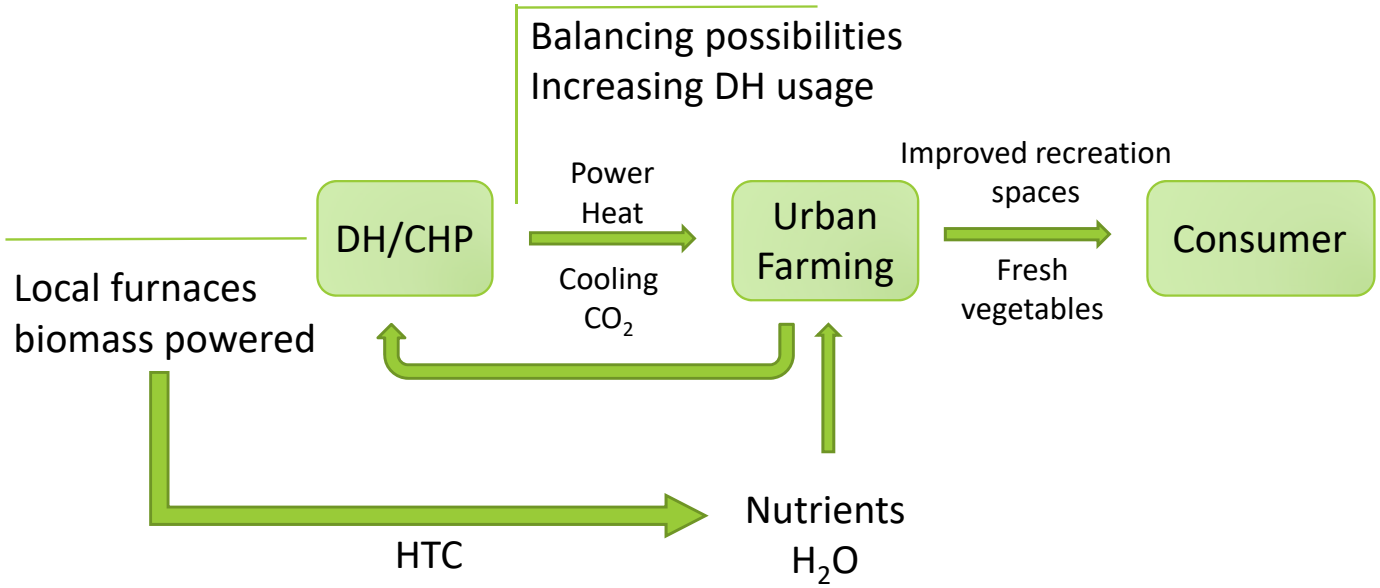
Feeds back plant matter to biogas facility



Models for building integrations

How does it work on a smaller scale integration into cities

Can we take the lessons from Plantagon and apply them on a small scale?



Conclusions

Urban Farming can produce fresh food and improve recreational and work spaces in cities

Doing so increases the quality of food and reduces the transport costs and energy

Inner city farming faces obstacles of high overhead costs – efficiency is needed

- Integration with DH can help optimise these costs
- Partnering with companies can create a mutually beneficial arrangement

Urban Farming has the possibility to feedback into the DH system and improve optimisation

Integration depends on the local DH layout, the two need to develop together to find the best solution

- communication between developers and local actors

Thank you

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