RENKEI Summer School 2014

Project title: *Pathways towards a community inspired city: the future is now!*

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Introduction

The following work summaries our ideas for developing an energy system for a sustainable city in a near future. We decided to add the word "now" to emphasize the urgency that we, as community, need to apply sooner than ever. Many projects have used 2020 as a target year however we are getting closer to the date with a significant global change. We propose to maintain an optimistic point of view while choosing a mix of technologies and policies, which we analyzed as the ones to take into account for a carbon neutral society.

Objectives

The project investigates pathways towards the creation of a community inspired city by immediate actions. It looks at the development of a community-based energy system and sustainable solutions for the future cities.

- Design an ideal city which can be referred to while comparing ideal with reality
- Propose the energy technologies and policies needed to achieve a carbon neutral society
- Recognize the risks and limitations when going "all renewable"

Motivation

After the March-2011 earthquake and tsunami in the east coast of Japan, many lessons were learnt about how unpredictable events can impact our community. Besides, several cities have been looking forward to become low carbon. When integrating such desire with known risks and past experiences around the world, we designed our city based on such knowledge. We decided to design a future city named Fukuhampton which will have the same climate as Fukushima and Southampton, warm temperate (6). Fukuhampton is about 400km^2 with a population of 270 000 people.

Main design principles

The main design principles are built upon the ideals of public wellbeing, community engagement, behavior shift towards a one earth living and highly efficient regionally designed power generation and consumption. Some key considerations are outlined:

- Climate change resilience and weather proof design: flexible urban structure with the capacity to recover fast from extreme events, allocate sources to the most efficient use and protect the citizens.
- Self-sufficient urban communities with local power generation according to the locally available resources and economical security through wide cooperation networks.
- Compact cities with mixed use, public transport and walkability that will inspire the minimization of fuel consumption and carbon emissions.
- Modularization of key urban infrastructure to shift
- Decentralized distribution networks in combination with micro-generation technology and smart management systems to increase energy use efficiency and maximize the potential of local resources.
- Waste management towards an integrated city metabolism based on a closed system with high rates of recycling to recover materials and energy while at the same time decrease the embodied carbon.
- Biodiversity conservation.

Fig. 1 Concept design of Fukuhampton（see in appendix）

Urban planning

1)**Land use:**

Efficient use of land resources

- Compact building: permits more open space to be preserved, encourages buildings to expand vertically rather than horizontally.
- Preservation of land and natural resources: compact building forms, moderation in street (Neuman, 2005). Total housing area is less than 50% of the total area.
- Density lowers the per capita costs of infrastructure capital and operating costs, and reduces per capita use of all types of energy including energy for transportation and heating and cooling buildings. A minimum density of 50 dwellings per hectare is applied as a necessary baseline to support public transportation (Applegath, 2012).
- Locate stores, offices and services within walking (cycle) distance
- Create local works that will ultimately reduce people mobility and transportation energy

Transport

Convenient and interesting; Encourage walking and cycling ; Provide a variety of transportation choice ;Include bicycle lane and transit; Promotion of public transport ;Use connected network with alternative routes and bypassing of heavy traffic (Neuman, 2005)

Building

- Promoting long lasting materials and well-designed sustainable habitation

Infrastructure

For the basic infrastructure of a city, such as water treatment and waste treatment, we can try to find ways to do contribution for energy area. Such as ecological water treatment using anerobic method; and we can also use waste to produce energy. The other thing is we can use green roof or green garden to drain the rainwater and absorb the CO_2.

Energy

Fukuhampton relies on renewable energy and is carbon neutral. The system components have enough independence so that damage or failure of one component of a system is designed to have a low probability of inducing failure of other similar or related components in the system. The city has co-generated district energy plants. Each plant provides power for its surrounding area but also can be called upon to provide excess power to back up neighboring plants, should a failure occur. Each piece is independent (modular) yet also networked (redundant), thus optimizing both energy production and security. Community owned energy management system controls the local power distribution between the districts (cf Appendix).

Fukuhampton relies on solar, geothermal, biomass, wind, ocean (wave and tidal) and hydro energies. The net use of fossil fuel for electricity and heat generation is close to zero. The city produces 125% of the required energy and 25% of this is exported to the national grid.

Conclusion and recommendations

Based on current green solutions available for energy system development, we have taken a whole perspective for a city, which is to look into several sectors, such as land use, transportation, buildings and infrastructure to explore the opportunities of energy saving and production. The other highlight of our approach is based on community, which is a decentralized way to develop the whole energy system, but at the same time, we also have built EMS in the central of the city, to monitor and manage the energy supply and demand. The model has been developed for Fukuampton, but can also be referred to other similar cities development. There do exist risks in real cases, such as willingness of the people participated, high cost of technological integration and as well as natural disasters and other possible unpredictable risks.

Appendix

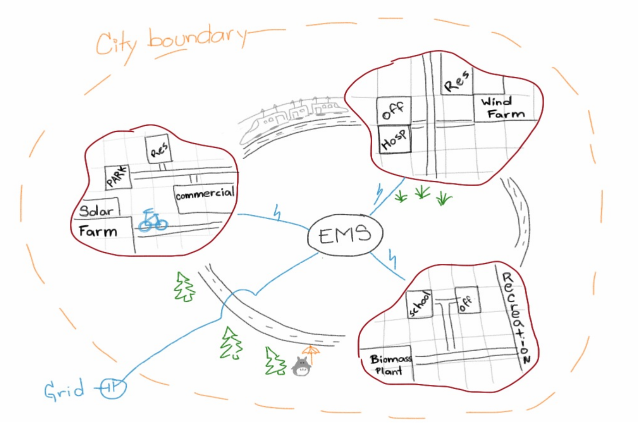

Figure 1: Concept design of Fukuhampton

References

[1] Center for International Earth Science Information Network - CIESIN - Columbia University, International Food Policy Research Institute - IFPRI, The World Bank, and Centro Internacional de Agricultura Tropical - CIAT. 2011. Global Rural-Urban Mapping Project, Version 1 (GRUMPv1): Urban Extents Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4GH9FVG as found in Watts Anthony (2010) Watts up with that? The world's most viewed site on global warming and climate change. Available from http://wattsupwiththat.com/2010/12/23/3-of-earths-landmass-is-now-urbanized/. Date Accessed 10 Sept 2014

[2] Bahaj A.S., James P.A.B. and Jentsch M.F. (2008) Potential of emerging glazing technologies for highly glazed buildings in hot arid climates. *Energy and Buildings,* vol. 40 (5), p.p. 720-731

[3] Applegath, C.F., 2012. Future proofing cities. Strategies to help cities develop capacities to absorb future shocks and stresses.

[4] Neuman, M., 2005. The Compact City Fallacy. Journal of Planning Education and Research 25, 11-26.

[5]OECD,2012. “The compact city concept in today's urban contexts”, in Compact City Policies: A Comparative Assessment, OECD Publishing. http://dx.doi.org/10.1787/9789264167865-6-en

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Pathways towards a community inspired city for the future...now!

Marisabel
Leonidas
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Jin

Outline

Outline

- Aim and objectives
- Baseline Condition
- Key design actions
- Community inspired “clean” city
- Conclusions

Aim

Develop the energy system for community based sustainable future cities.

Objectives

To design an ideal city that can be a global example for regional resources management

To propose an energy mix and green technologies to achieve a carbon neutral society

To Recognize the risks and limitations when going "all renewable "

Motivation

- Better city
- Problems of cities
- Case study of new and existing
- Opportunities
- Act now to build community and sustainability
- Set the global example

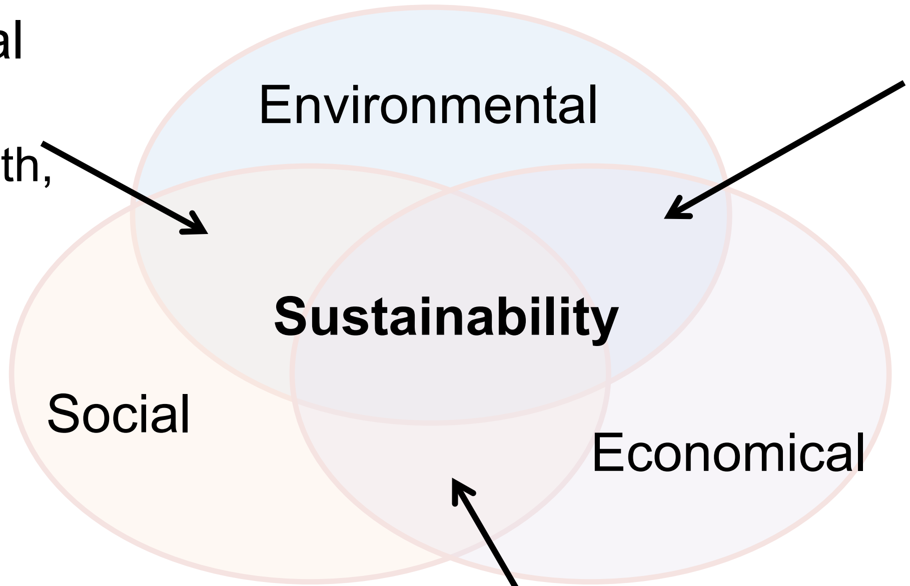
Urban Sustainability

Social – Environmental

wellbeing, health, community engagement

Environmental – Economical

Public transport, regional energy generation, urban agriculture, waste management



Social – Economical

Job opportunities, co-operations, training and support

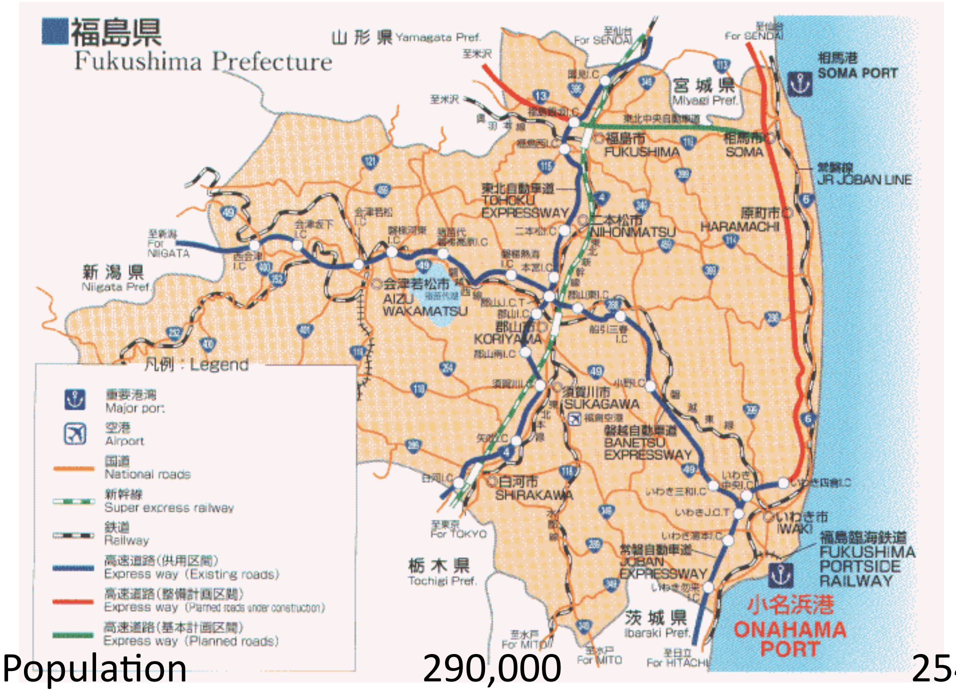
Adapted from : Teli D & James P.A.B. 2013 *Urban Space,* MSc Energy and Sustainability ,University of Southampton

Key design actions

- ✓ Describe the current conditions
- ✓ Assess technological community-based solutions
- ✓ Evaluate different policy initiatives to attract private investment
- ✓ Build a framework for innovation and collaboration between universities, stakeholders and industry
- ✓ International paradigms
- ✓ Future plans : Fukuhampton

Fukushima and Southampton

Two cities looking forward to go “green”



	Fukushima	Southampton
Population	290,000	254,000
Area	747 km²	73 km²
Climate	Warm Temperate- Hot summer	Warm Temperate- Warm summer

Fukuhampton – closer to heaven

Population	270,000
Area	400 km²

Annual Electricity demand:
2,200 kWh/person

Annual Total Electricity demand:
594 GWh

Fukuhampton – closer to heaven

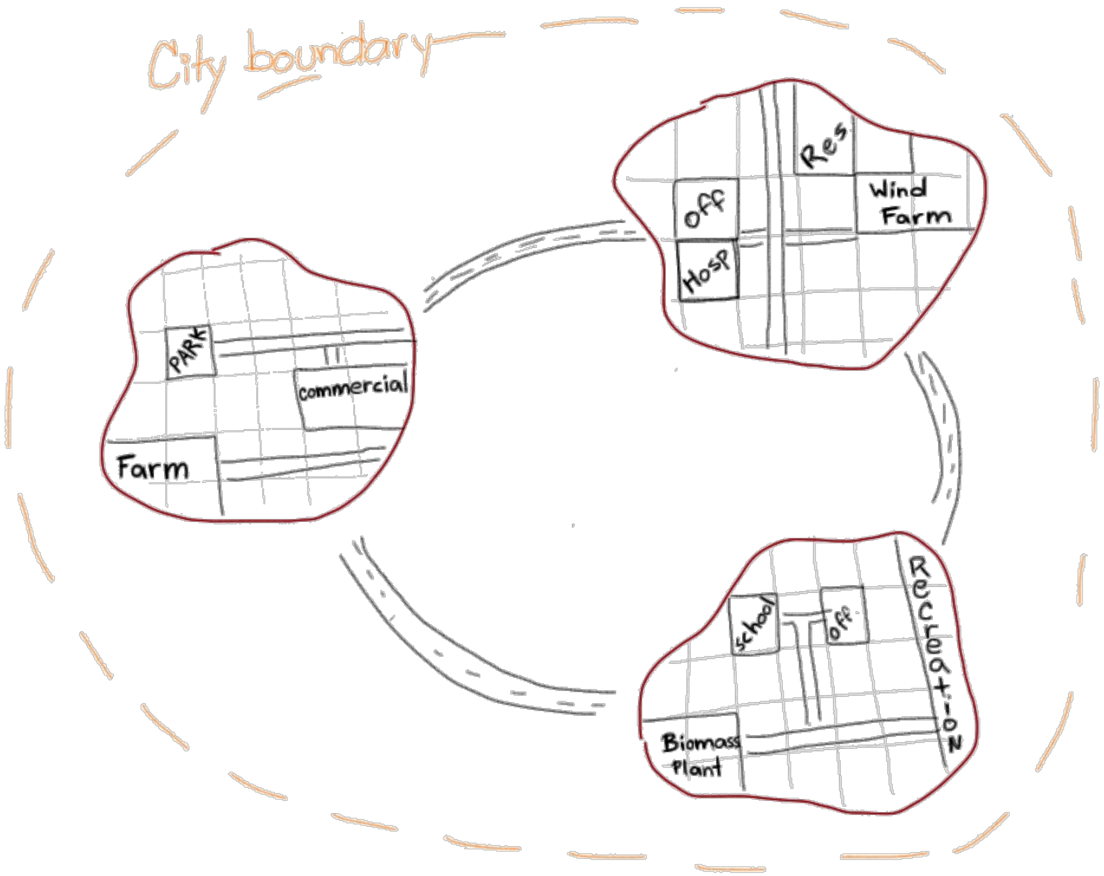
Population	270,000
Area	400 km²
Climate	Warm Temperate

Baseline mix – Business as usual

Technology	e^-	Heat	Japan Energy fuel mix (2012)*	UK Energy fuel mix (2012)*
Hydro	O	X	3%	2%
Solar	O	O	2%	
Wind	O	X		
Geothermal	O	O		
Ocean energy (tidal and wave)	O	X		
Biomass	O	O		
Oil			47%	37%
Natural Gas	O	O	24%	33%
Coal	O	O	23%	16%
Nuclear	O	O	1%	12%

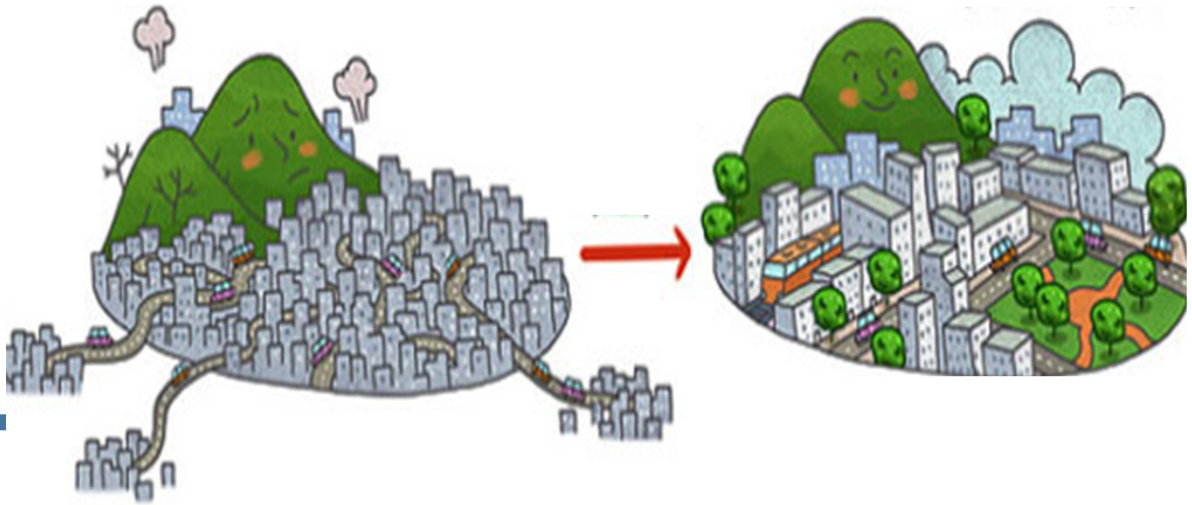
• US Energy Information Administration (2012) Independent statistic analysis for Japan and UK

Urban planning – A place to call home



- ✓ Protect and support biodiversity
- ✓ Optimise density and enhance mixed-use
- ✓ Reassure Economic security for citizens
- ✓ Support cooperative networks
- ✓ Preserve local ecosystems and promote sustainable food production

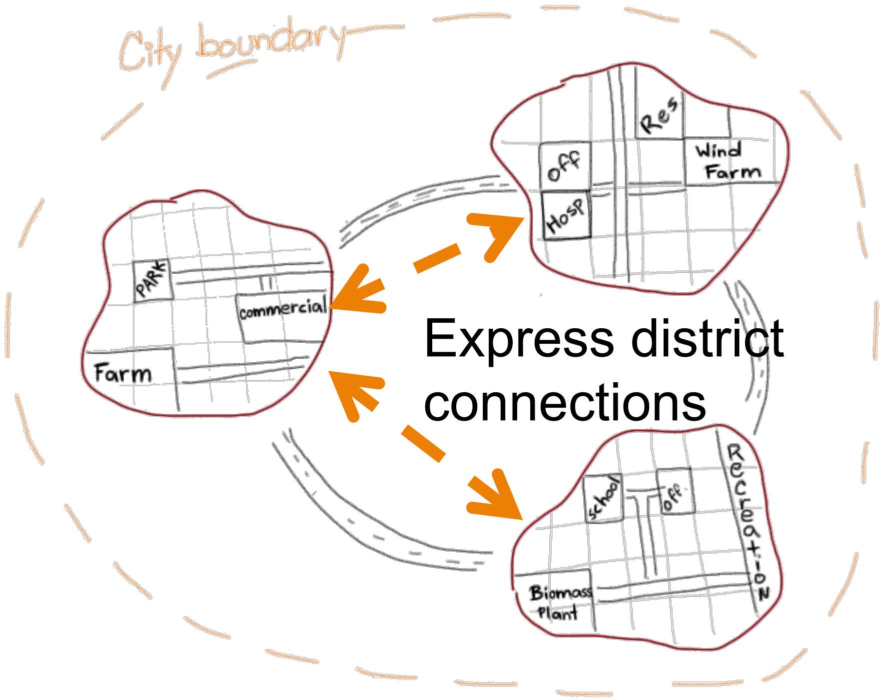
Urban planning - Land use



- Compact, walkable or cycle distance
- Mixed land use (agricultural, housing, green space and recreation),
- Preserve green space and critical habitat for biodiversity
- Total housing area < 60%

Source: theenvironmentalblog.com

Urban planning - Transport in the city



Express district connections

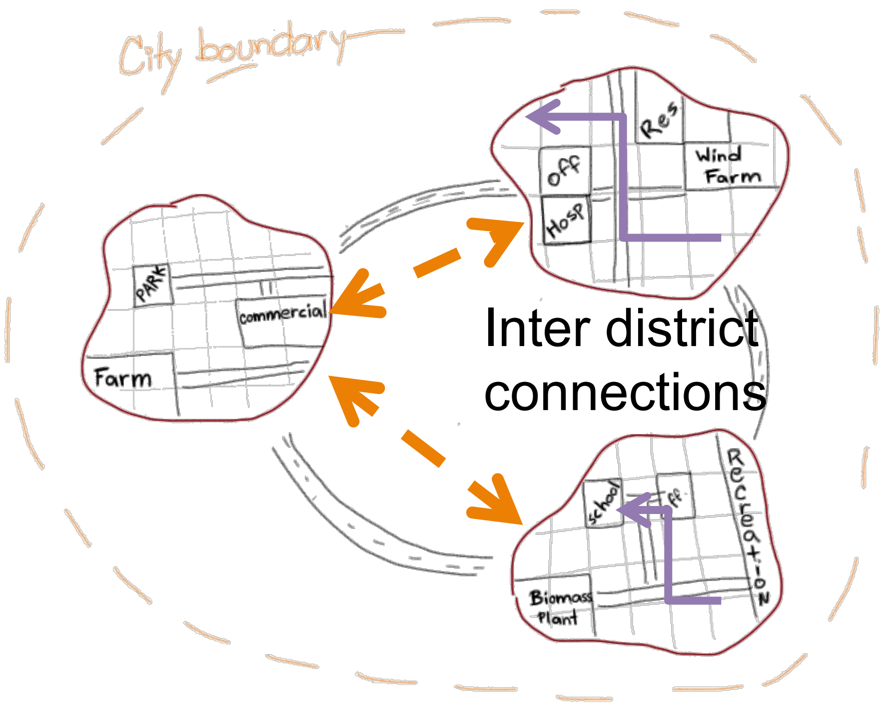
Primary roads – arteries (4 – 6 lanes with planted central reservation and side "green" verges.

Electric, H_2 fuel cell buses, tram

Catchment area the district/ community ~5,000 to 10,000 persons

Non local travel

Urban planning - Transport in the city



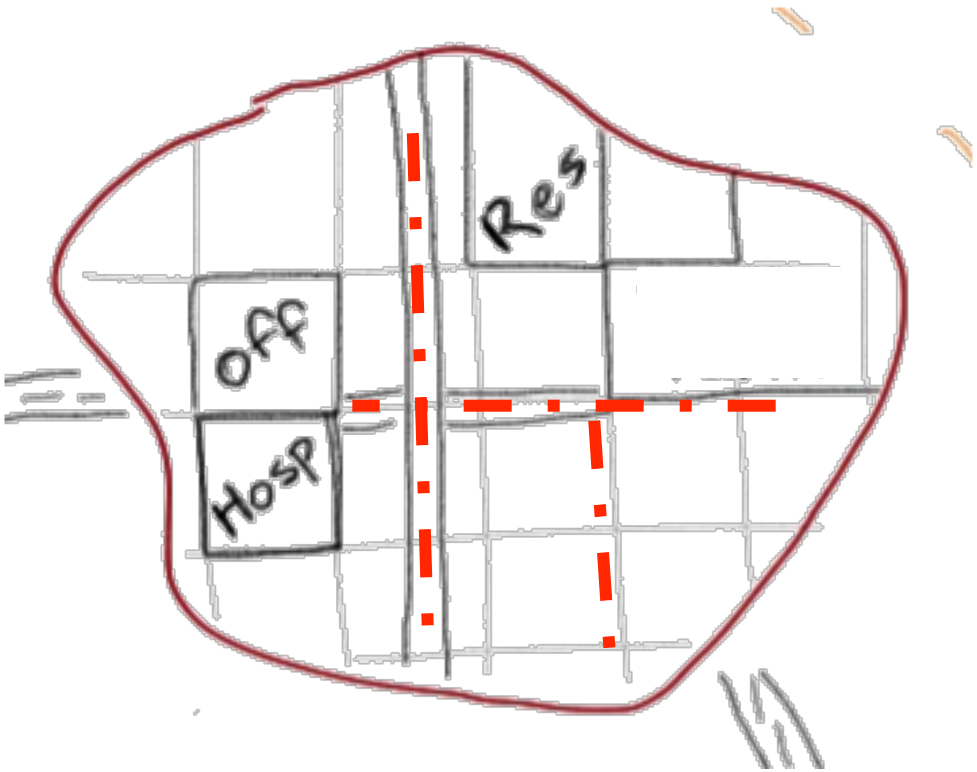
Fast Inter district connections - Electric buses

Secondary roads (2 – 3 lanes with side planted pedestrian walks (increased permeable surfaces with rain run off collection)

Catchment area parts of the district ~2,000 to 3,000 persons

Travel to schools, local commercial centre

Urban planning - Transport in the city



Bicycle lanes/ walkable distances (~800m to main local facilities such as grocery, post office etc)

Secondary and tertiary roads (1-2 lanes with pedestrian walks, public open space, local parking

Catchment area parts of the neighbourhood ~500 to 2,000 persons

Travel to shops, food supplies, entertainment

Urban design - Principles

Places with character and identity

Continuity and enclosure – Private space is distinguished from public

Quality of public places – attractive, well used space

Ease of movement – accessibility and safe connection with surroundings

Adapted from CABE “Commission for Architecture and the Built Environment

Urban design - Principles

Legibility – Easy to find and navigate around

Adaptability – Easy to change according to use needs

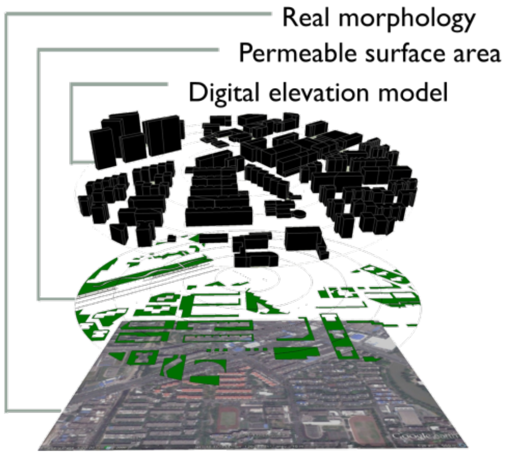
Diversity – Variety and choices

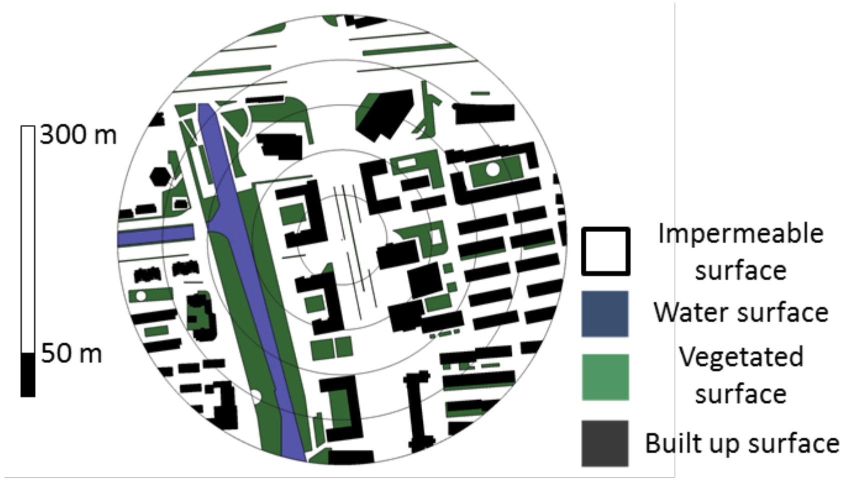
Resilient to climate change and extreme events

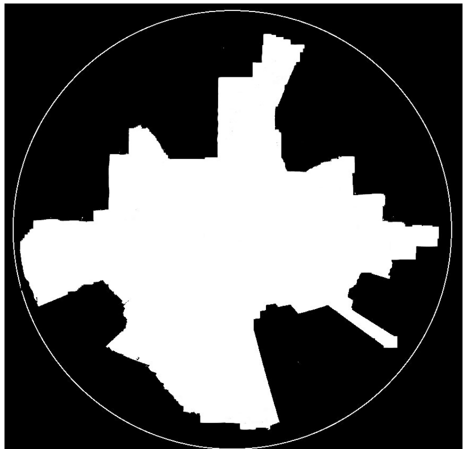
Promoting air quality, thermal comfort and energy savings

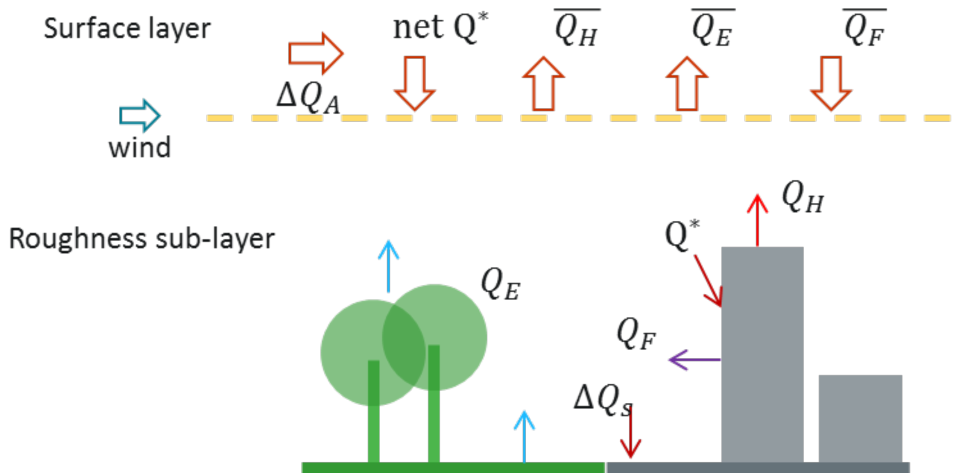
Adapted from CABE “Commission for Architecture and the Built Environment

Urban design – Microclimate





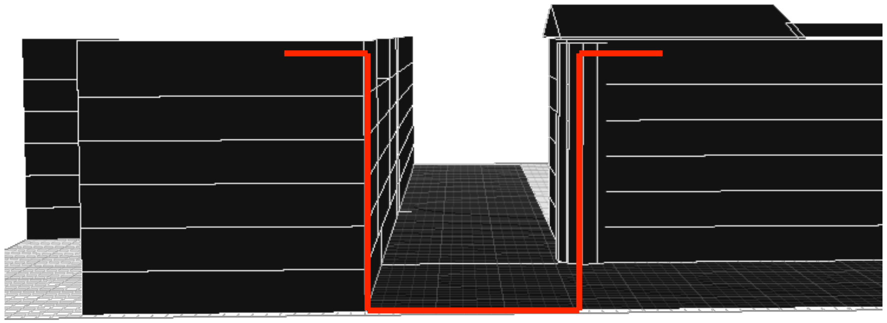




Adapted from CABE “Commission for Architecture and the Built Environment

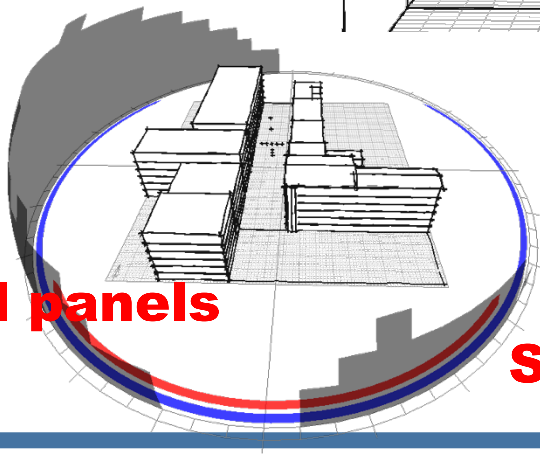
Urban design – Building layout

Optimum AR = ?



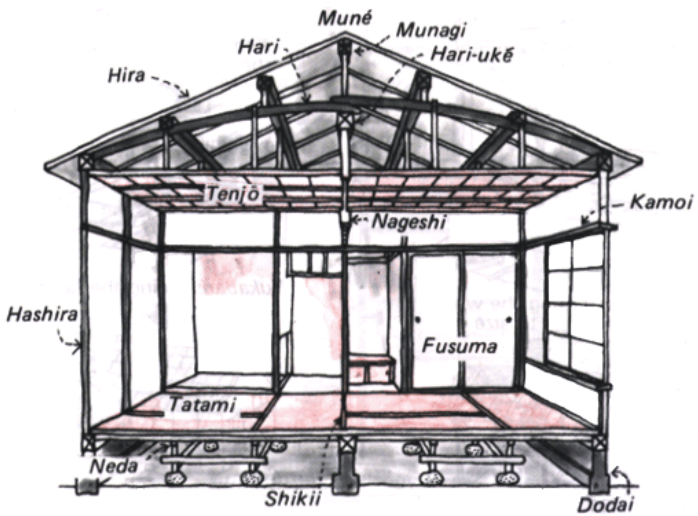
Height Restrictions ?

Consider ....
Daylight levels
Air quality
Pedestrian comfort
Integrated PV and solar thermal panels



SVF = 0.93

Urban design – Building layout



Construction of a small wooden house in the traditional style

Lessons taught from **traditional architecture**

Openings to South (solar gains)

Cold air recession – secondary use spaces to North

Daylight access

Change in the use of space

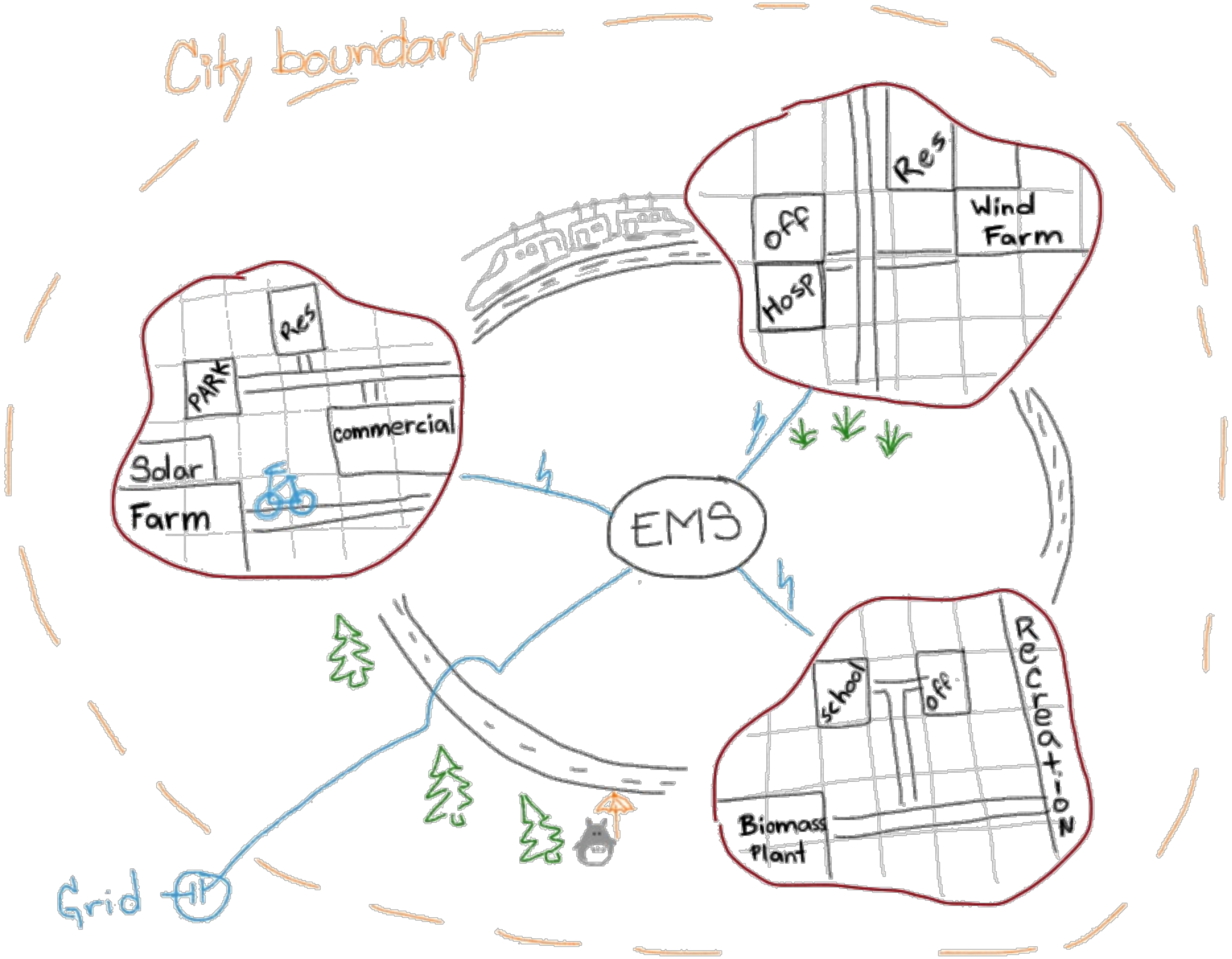
Cross ventilation

Urban design – Building layout

Regional – responsive to climate design

Use of local materials and recycling at the end of life – Life Cycle Assessment

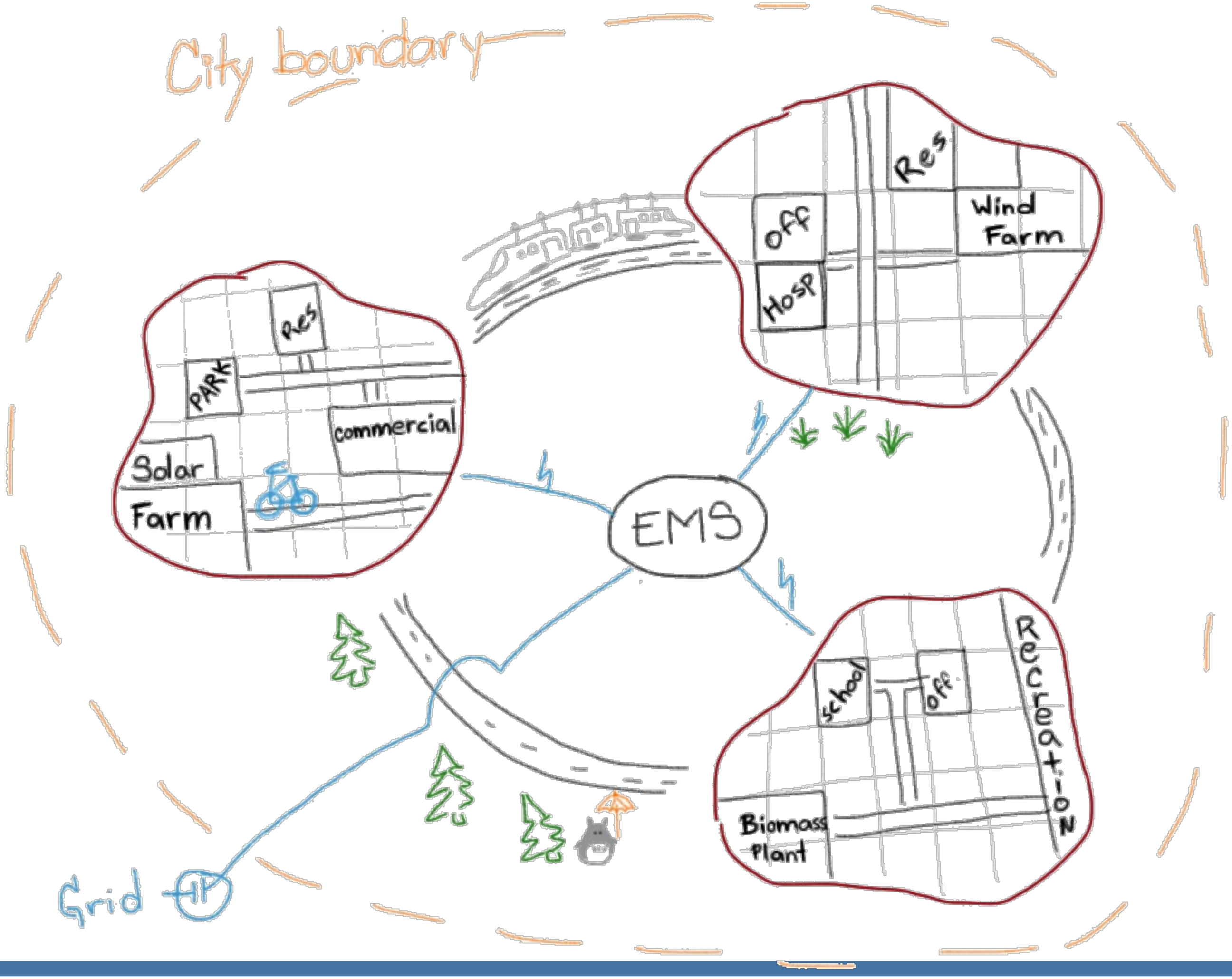
Energy – Management



Annual Total Electricity demand: 594 GWh

Energy management system for Fukuhampton

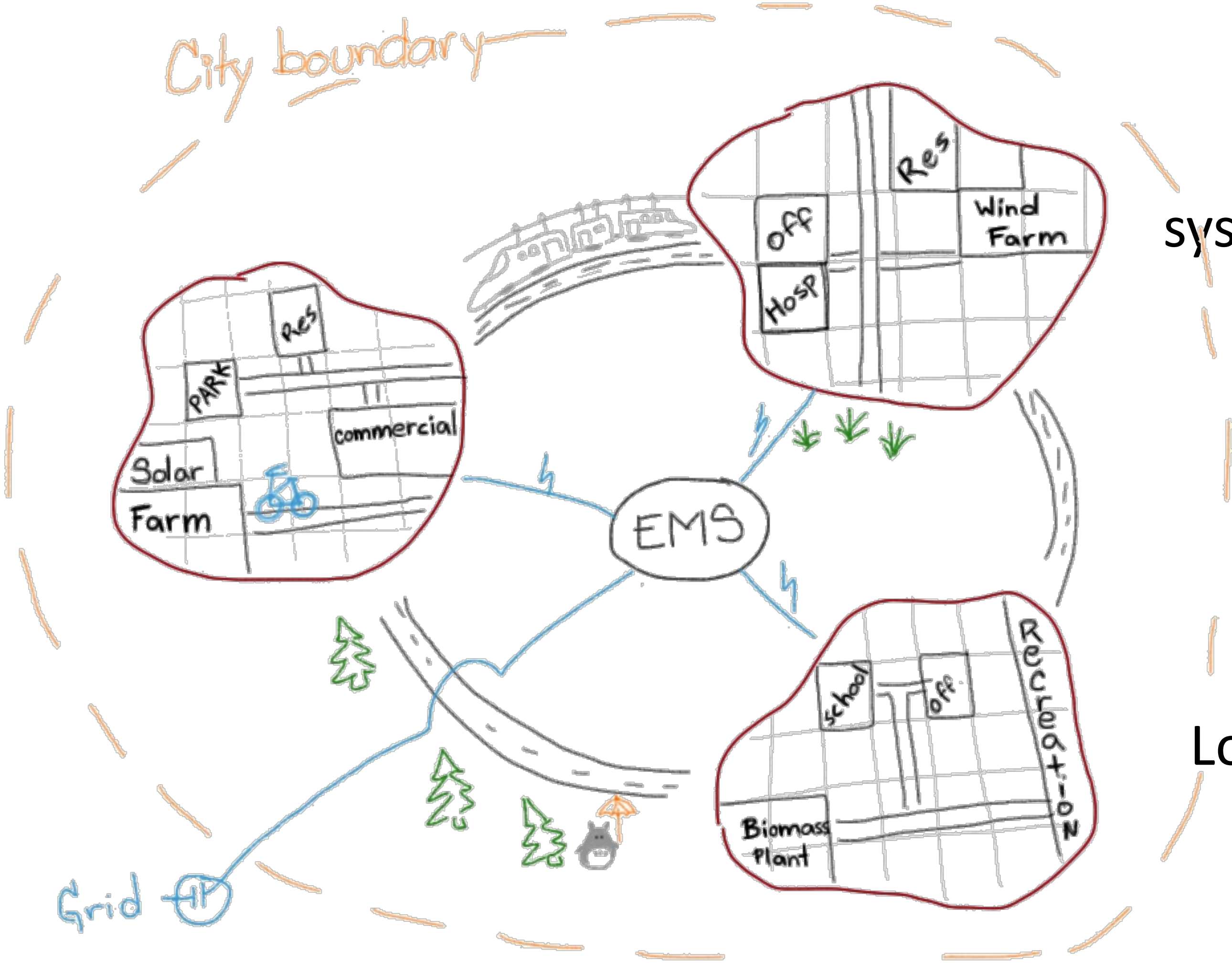
Energy – Hybrid approach



Annual Total Electricity demand: 742.5 GWh

Target: 125% net cover of energy demand

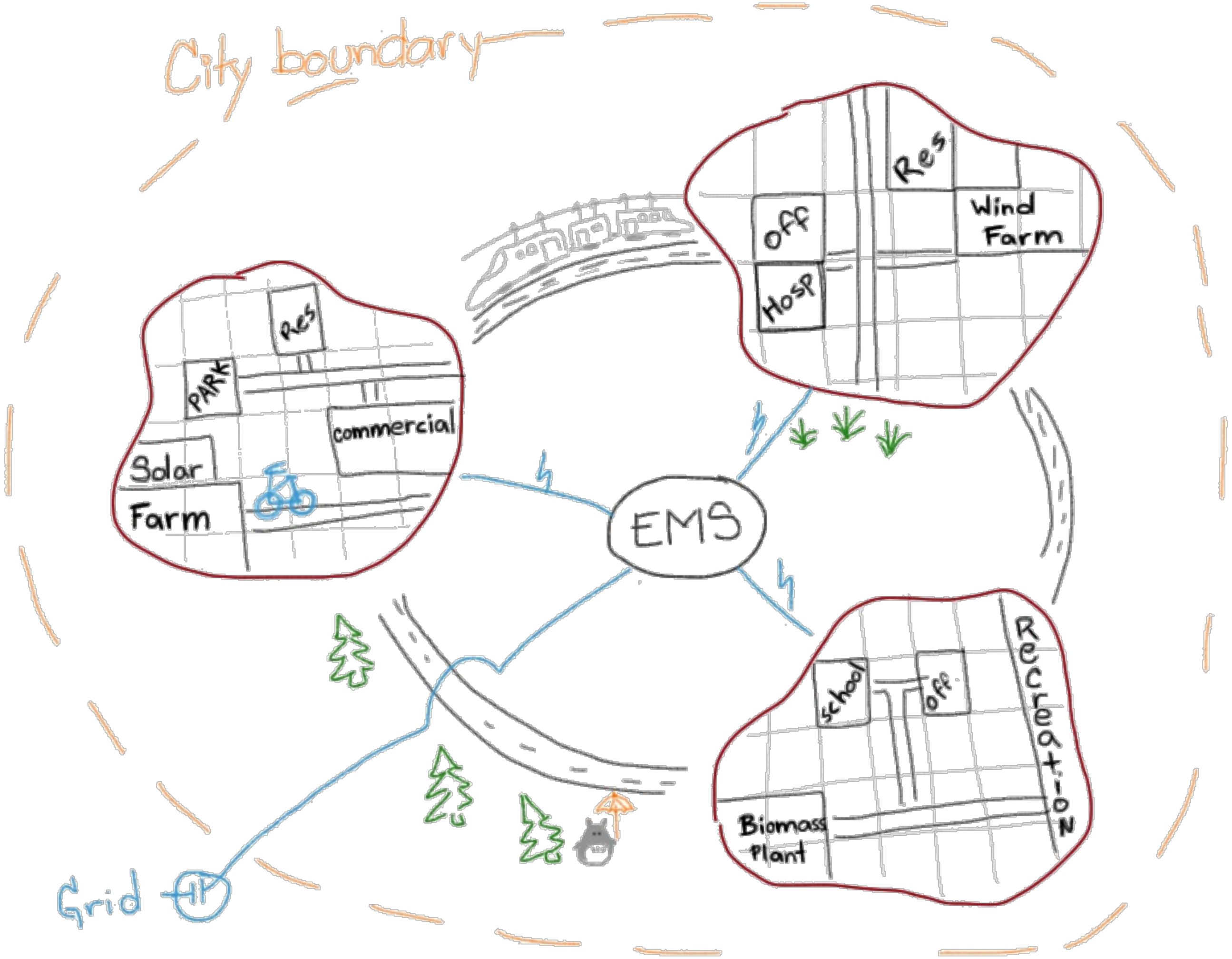
Energy – Management



Community owned energy management system controls the local power distribution between the districts

Local decentralised grid is connected to the national grid

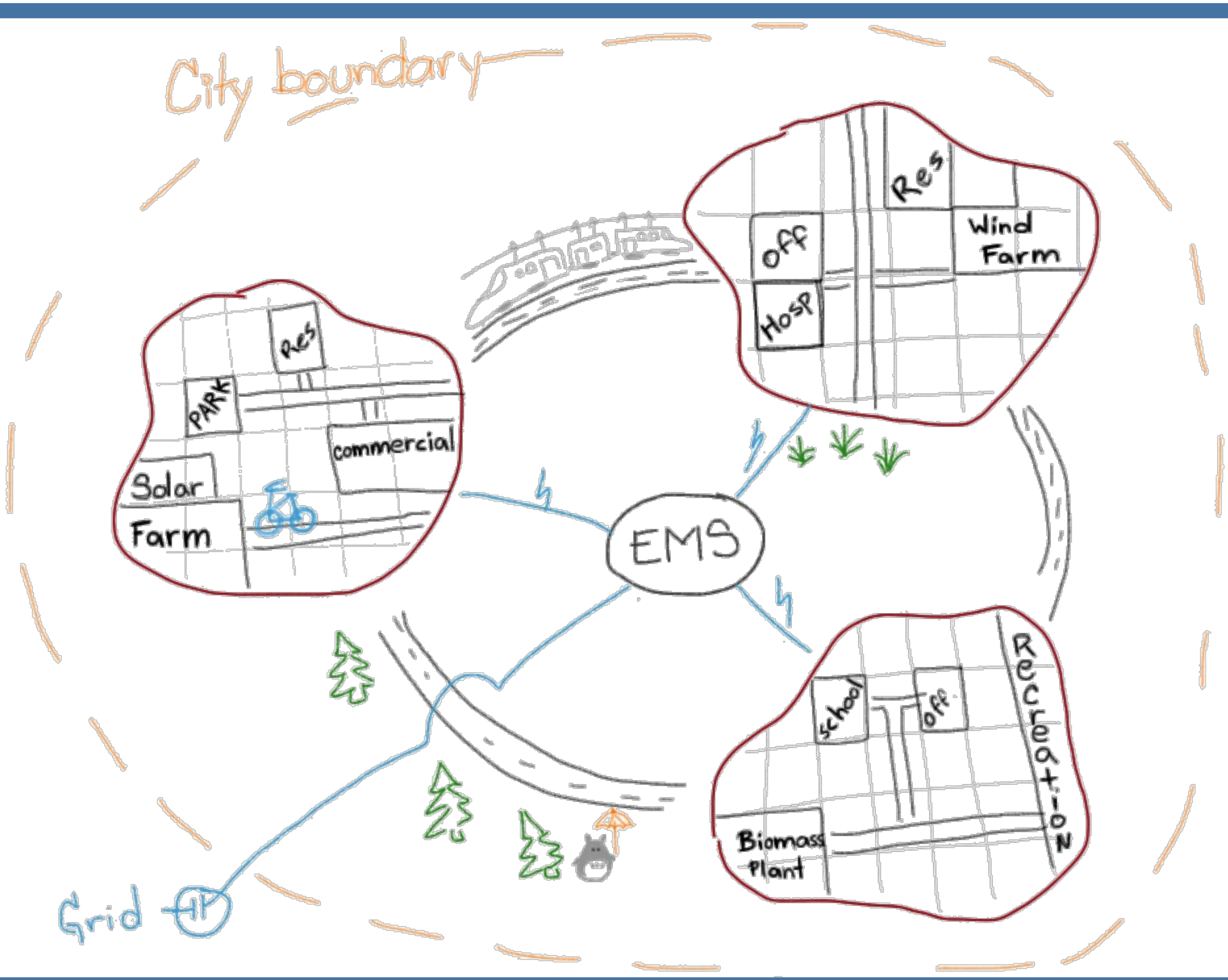
Energy – Hybrid approach



Surplus is exported to the grid.
Carbon offset for the CO_2 emitted by private vehicles and conventional energy generation.

At mature stage of the development average per capita demand does not exceed 2,200 kWh

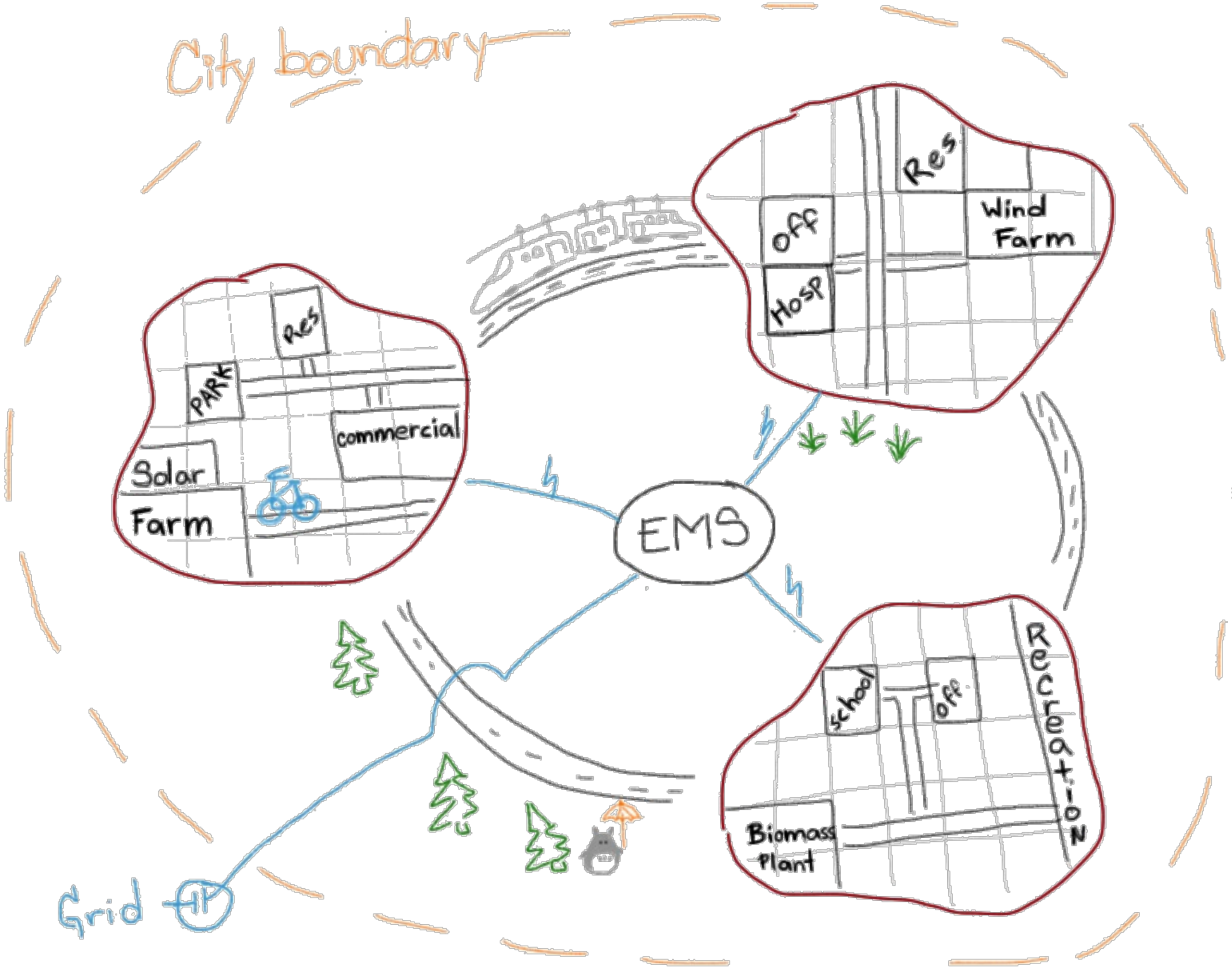
Energy – Hybrid approach



Solar PV potential...

Total A=400 10^6 m^2

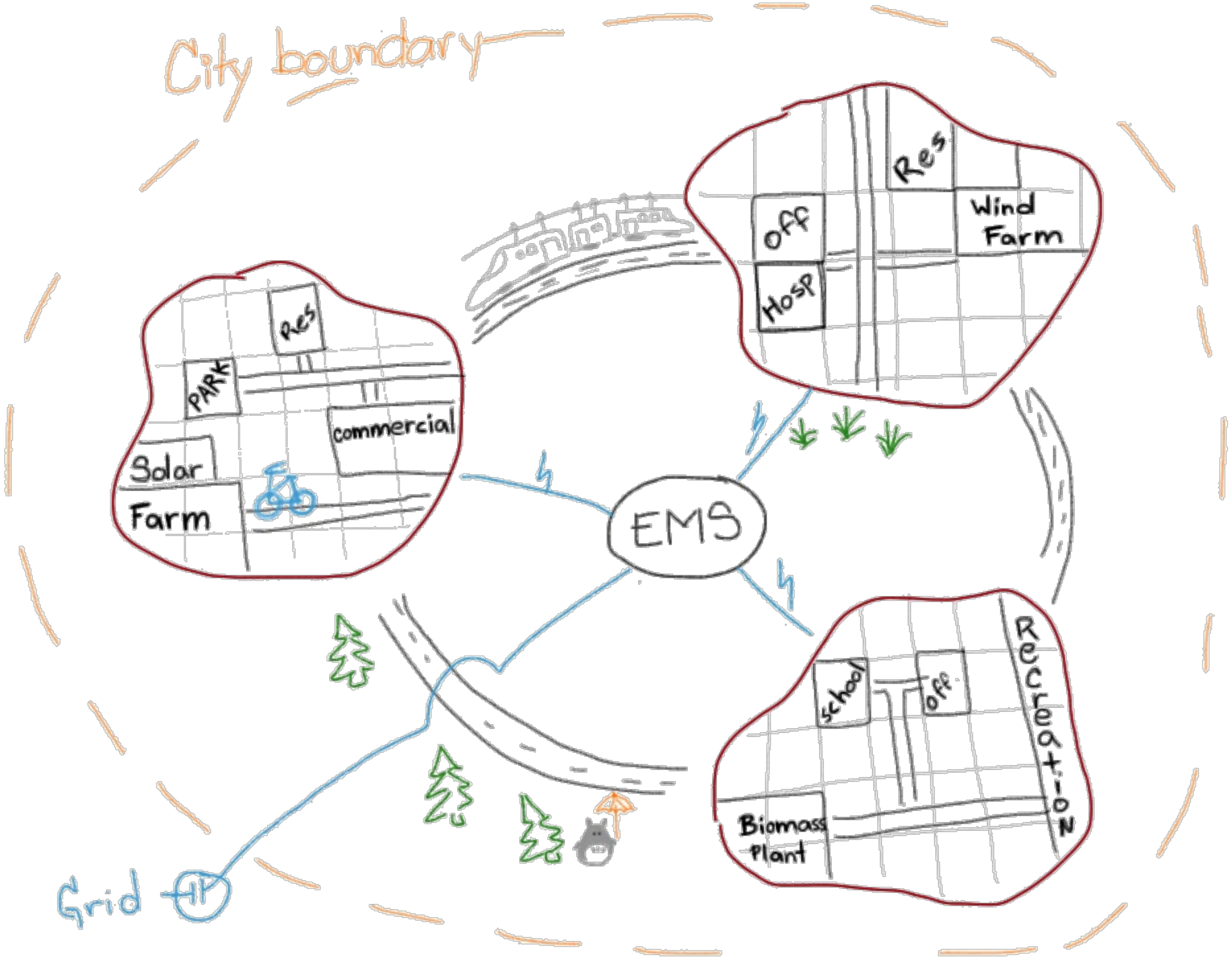
Energy – Hybrid approach



Annual Total Electricity demand: 742.5 GWh

50% Built x 400 10^6 m^2 x 5% suitable roofs x 800 kWh / kWp x 0.1 kWp/m^2 = 800 GWh!

Energy – Hybrid approach

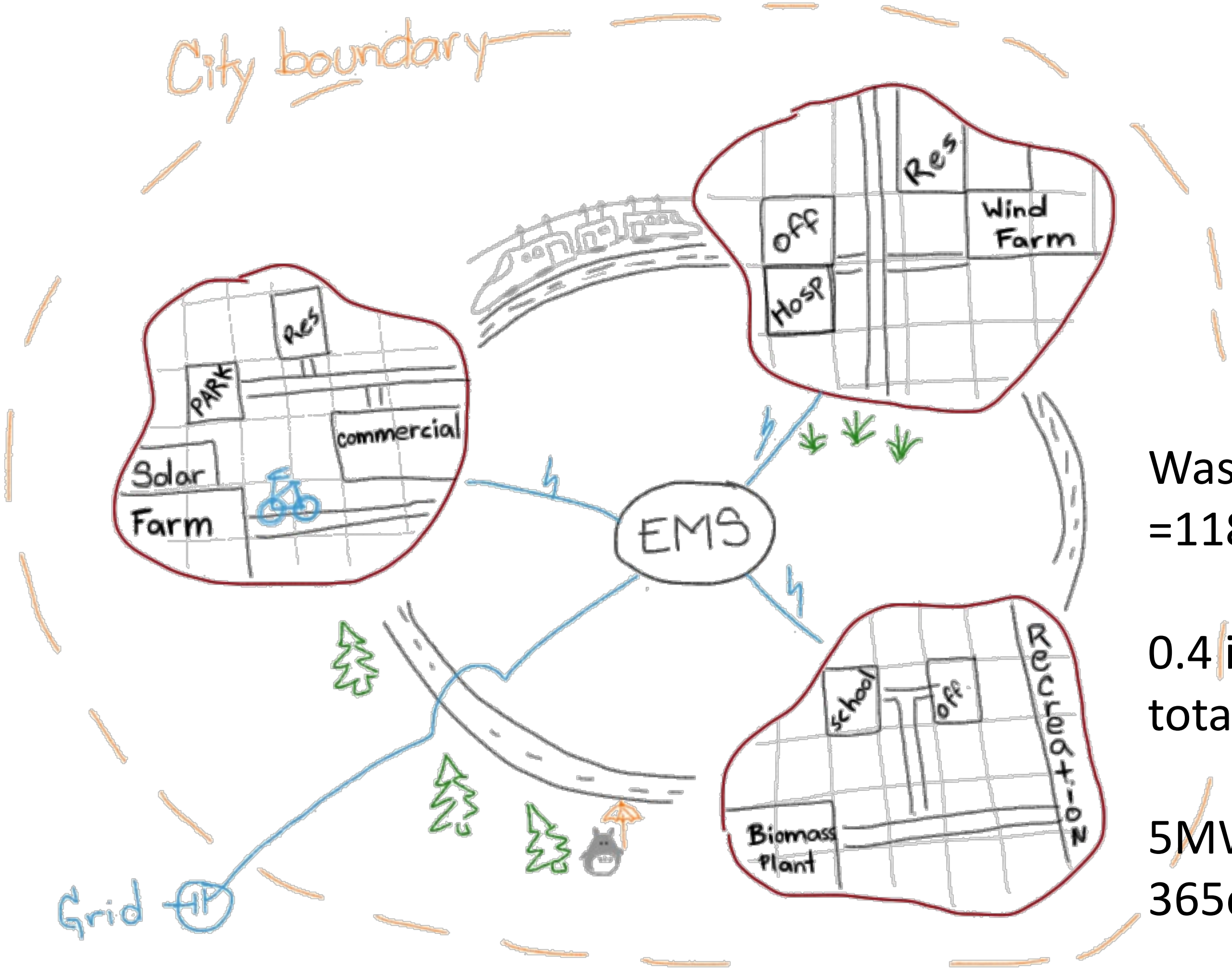


Annual Total Electricity demand: 742.5 GWh

Wind 10 MW onshore -> 15 GWh*

* World View. Wind Energy opportunities in Japan. www.worldview.co.nz

Energy – Hybrid approach



Annual Total Electricity demand: 742.5 GWh

Waste 1.2 kg /person/daily =118,000 tons annually

0.4 incinerated in 5MW e^- total plants.

5MW x 0.2 effic. x 12hr/day x 365days = 22 GWh

Energy – Hybrid approach

FUKUHAMPTON	Energy	Cost
Biomass - waste incineration - CHP	0	0
Geothermal	627GWh/year	0.1070MM$
Hydropower - large-scale	0	0
Hydropower - small-scale	0	0
Solar photovoltaics - Large scale	0	0
Solar photovoltaics - Buildings	0	0
Marine	0	0
Wind onshore	0	0
Wind offshore	0	0

FUKUHAMPTON	Energy	Cost
Biomass - waste incineration - CHP	0	0
Geothermal	97.2	0.0166
Hydropower - large-scale	0	0
Hydropower - small-scale	0	0
Solar photovoltaics - Large scale	0	0
Solar photovoltaics - Buildings	0	0
Marine	0	0
Wind onshore	530.65	0.2423
Wind offshore	0	0

Energy– risks and limitations

- Low community engagement - Not in my back yard syndrome
- Cost and initial capital stock
- Natural disasters
- Unpredicted climate conditions
- Finite primary energy resources
- Low rate of technological learning

Sustainable infrastructure

- Water management infrastructure

Drinking water supply(save water usage)

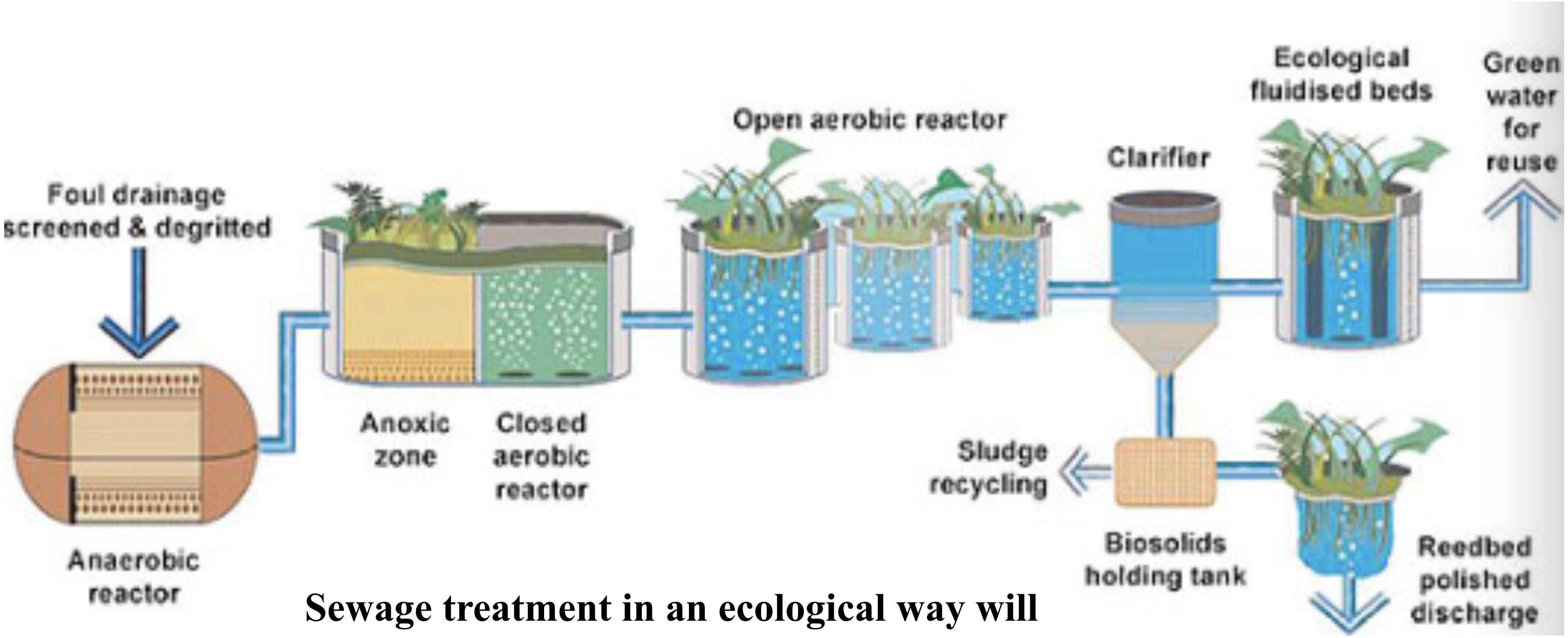
Sewage treatment-Ecological treatment

- Solid waste management

Solid waste gasification facilities

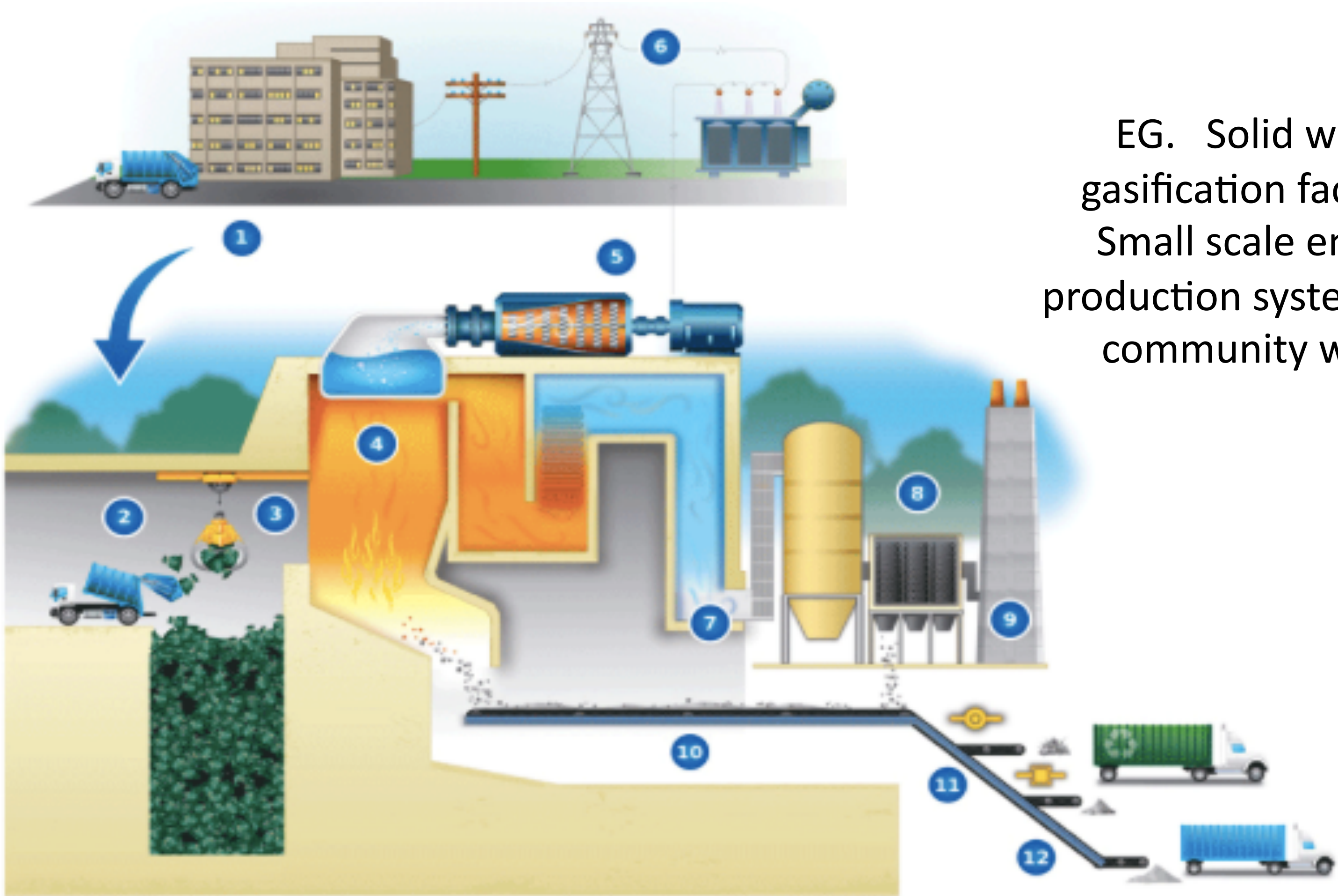
- Green infrastructure

Water management (water-energy nexus)



Sewage treatment in an ecological way will save energy compared to traditional treatment methods.

Solid waste management (energy production from waste)



EG. Solid waste gasification facilities
Small scale energy production system using community waste

Green infrastructure

Green belt in the city: early drainage of rainwater the rainwater, and at the same time, can be used to facilitate CO_2 sequestration

Green roof: if there is some roof top space left, green roof can be used to save energy by increasing the insulation of the buildings.

Conclusion

- Energy demand reduction through behaviour shift and efficient city design.
- Emissions from Gas/Biomass CHP and grid carbon intensity are offset by energy export to the grid.
- Community cooperation networks have shares on the energy generation plants.
- Fukuhampton can set as a global example for community based generation according to regional resources.

Thank you very much

Q&A