Synergy Zones

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Working at the building scale of development

- During the last decades most effort related to high-performance design, development and assessment has been focused on single buildings;
- A limitation of this approach, especially in performance assessment, has been the focus on single buildings of a particular type, e.g. single office or residential or public buildings;
- In reality, many contemporary projects tend to be individual buildings that contain multiple occupancies, or projects with multiple buildings of various types, or both;

Making buildings more efficient

- The current goal for energy performance is now zero (ZEB) or nearly-zero (NZEB) energy operating consumption;
- But it is very difficult to achieve the last ten percent at the scale of single buildings;
- Within iiSBE, we are currently focusing more on the potential role of very small urban areas in improving the aggregate performance of buildings;
- A concept model is presented that builds on these ideas, in the form of synergistic performance in energy consumption, emissions and water consumption and other less critical issues.
- We call the concept Synergy Zones.

Working at the scale of groups or clusters of buildings offers better possibilities

Building scale of development

The figure shows the fit between generic building type and various system types. It indicates that, in many cases, buildings with deficits in energy, water, or even parking spaces, could be supplied by other buildings with surpluses.

Figure 1: Overview of relationship between selected generic building types.

Issue / System	Residential	Office w. interior zone	School
Space to install PV or thermal solar collectors (orientation issue not considered)	In low-rise, space for large arrays on roofs.	Roof or ground installation is problematic, and spandrel panel types are expensive.	Space for large arrays on roofs.
Space heating (heating season)	Energy deficit for space heating	Thermal surplus from interior zones	Variable, depending on student density
Domestic hot water	High constant demand	Low demand	Low and intermittent demand
Rainwater collection for use as greywater (if there is storage and more than 500 mm/yr. rain)	Good possibilities in low-rise family projects with open landscaped areas and flat roofs	Could have surplus in low-rise projects, but deficit in high-rise.	Surplus is likely due to large collection area on roof and grounds.
Vehicle parking	Night-time peak demand	Day-time peak demand	Day-time peak demand

Moving from Buildings to Building Clusters

- Most architects and engineers are aware of the performance synergies that can be achieved within multi-use buildings, such as different schedules within each occupancy for peak electrical or space heating or cooling demand;
- The principle of inter-system synergies can be applied if the scope of analysis is extended from building to a scale of small urban clusters of buildings;
- We define the area of a cluster to be small enough to allow economical active thermal transfer between buildings and to allow direct use of DC power to buildings in the cluster;

Moving from Buildings to Building Clusters

- Buildings within the cluster should be different in primary occupancies, heights and footprints;
- The cluster will include a small number of buildings (10 to 50), with aggregate areas probably ranging from 50,000 to 200,000 m2;
- The area should have a high diversity index;
- None of these potentials can be realized unless there is a well-developed form of formal cooperation between property owners to establish a sharing of costs, benefits and risks.

Reported efficiency gains in Smart Grids

Potential Reductions in US Electricity and CO_2 Emissions in 2030 attributable to smart grid technologies, assuming 100% penetration (adapted from Pratt et al. 2010)

Mechanism	Reductions in Electricity Sector CO_2 Emissions Direct (%)	Reductions in Electricity Sector CO_2 Emissions Indirect (%)
Conservation Effect of Consumer Information and Feedback Systems	3	-
Joint Marketing of Energy Efficiency and Demand Response Programs	-	0
Deployment of Diagnostics in Residential and Small/Medium Commercial Buildings	3	-
Measurement & Verification for Energy Efficiency Programs	1	0.5
Shifting Load to More Efficient Generation	<0.1	-
Support Additional Electric Vehicles and Plug-In Electric Vehicles	3	-
Conservation Voltage Reduction and Advanced Voltage Control	2	-
Support Penetration of Renewable Wind and Solar Generation	<0.1	5
Total Reduction	**12**	**6**

Synergy zones

- This proposed model is focused on potentials at the Cluster scale:
- It has been developed from the work on small urban area assessment and a consideration of smart grid work for electrical distribution, storage and optimization;
- Some of the cluster-scale (zone) systems that could benefit from optimization of supply and demand include buildings with:
  - a deficit or surplus of thermal energy;
  - a deficit or surplus of domestic hot water;
  - a deficit or surplus of grey water;
  - a deficit or surplus of DC power;
- Each of these local sub-systems could benefit from appropriate storage systems, controls and algorithms for optimization of supply and demand, and distribution networks.
- Optimising supply and demand of parking spaces, and the provision of local public transport systems are separate but related issues.

System overview in new areas – passive design

1. The starting point in a *new* development is to maximize the passive solar performance potential of the buildings in the Zone, through optimal orientation, prevention of solar shading etc.

   These arguments obviously do not apply to existing zones.

System overview – thermal generation and use

2. Optimization of thermal supply, demand and storage would be logical in the context of some buildings producing a heat surplus (captured through heat-recovery ventilation systems), while others could benefit from heat supplied by the zone system.

   On the **cooling** side, it may be more economical to draw on a chilled thermal source supplied from the zone than to have cooling systems in the building.

   We therefore see a need for **thermal mid-term storage** of thermal generation sources and a **low-temperature heating distribution system** for buildings in the zone that have thermal deficits. **Optimization controls and software** are essential to optimize such systems.

System overview – domestic hot water

3. **Domestic hot water** systems are also candidates for optimisation of supply and demand;

   Some occupancies (residential, hotels, restaurants) have high demand;

   Commercial or public occupancies have little demand, but offer the possibility of DHW production for other buildings in the zone through waste heat produced in combined heat and power (CHP) systems or (for DHW pre-heating) recapture of thermal energy from HRVs.

System overview – grey water

4. Many modern buildings make provision for **rainwater capture** and grey water use, but some (e.g. highrise) have relatively minimal opportunities for rainwater capture, while low-rise buildings can produce large amounts.

   There is logic in exploring a zone-wide **greywater supply, storage and redistribution system** for all buildings in the zone. Such a system would filter and treat grey and black-water within the zone before storage.

   Again, optimization controls and software are essential to optimize such a system.

System overview – solid waste

5. A similar case can be made for a zone-wide system for **solid waste capture and storage** for all buildings in the zone, such as provided by central vacuum systems. Such a system could be linked to a local zone **bio-generation plant.**

System overview – DC generation and storage

6. In Smart Grids, DC power is usually discussed in relation to power contributions by *regional* renewable energy sources and with respect to plug-in electric vehicles;

   In the restricted area of a Synergy Zone, the source of DC power may include that produced from CHP, PV, wind power, bio-mass or other renewable source in the zone. Power can also be produced on buildings in the zone that have orientations or configurations suited for solar;

   The **storage of DC power** will be an important feature of a Synergy Zone approach, to store power generated in the zone as well as off-peak power from outside sources.

System overview – DC distribution

7. We also propose to explore the installation of **DC power distribution systems in commercial buildings** in the zone, operating in parallel with conventional AC systems to directly provide power to low-voltage DC equipment. This reflects the increasing prevalence of DC-powered systems in buildings, such as electronic light ballasts and computer equipment. Such an approach would greatly reduce AC-DC conversion losses.

   Parallel AC-DC systems would represent a major shift in systems thinking, and would also require that new lines of electronic equipment be developed.

   As in Smart Grid systems, DC power should be provided for **vehicle re-charging** in the zone.

System overview - management

8. The issue of **jurisdiction and management** is of critical importance in cases where a zone is not under single ownership.

   Coordinated system implementation and operation within a zone under multiple ownership could easily fail at the beginning unless there are contracts and agreements in place that allow a common management body to build, operate and charge for the required systems.

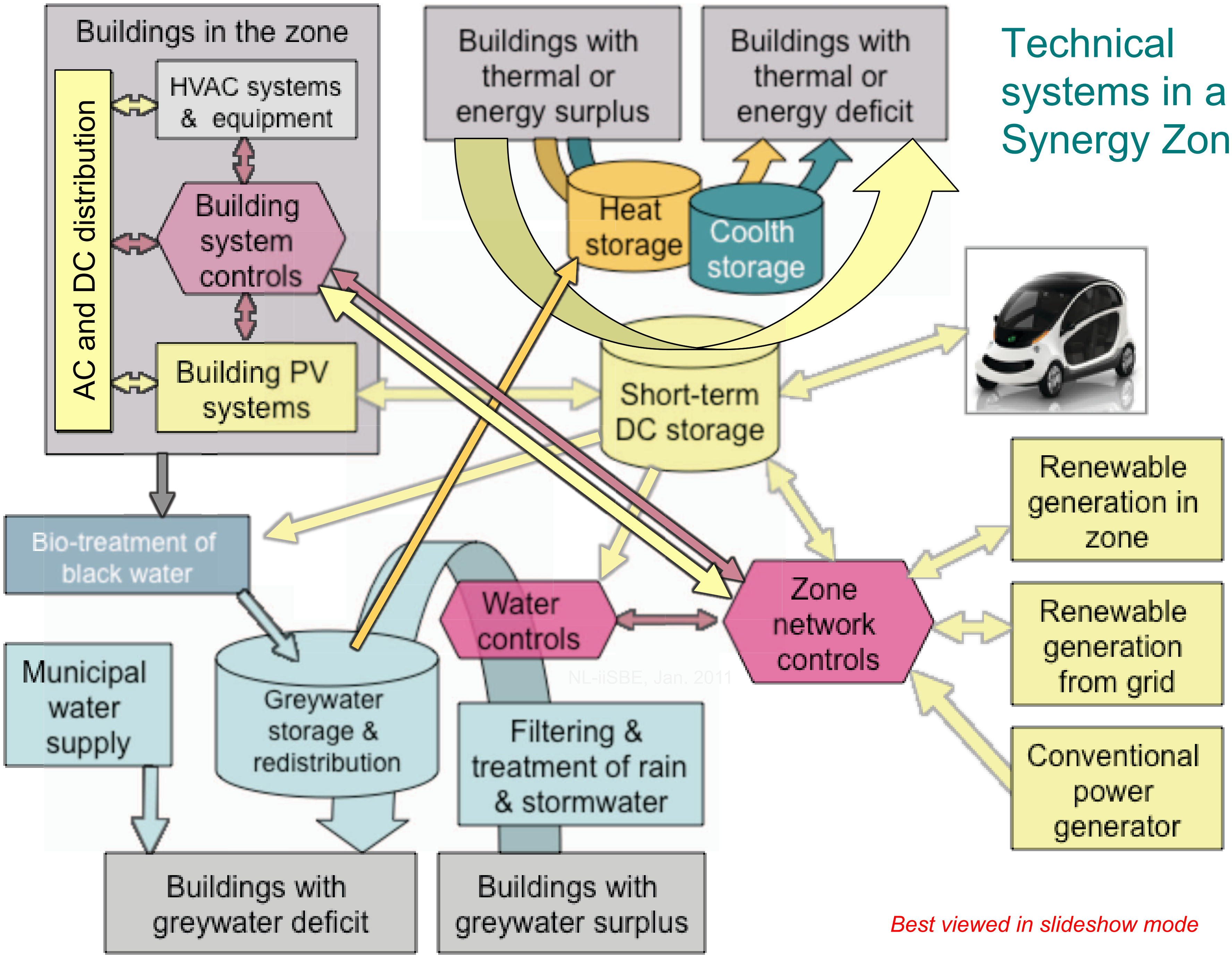
   In such cases, the physical implementation of systems, their operation and the revenue and cost sharing will require a new form of **cooperative zone management** to be successful.

A different but related issue

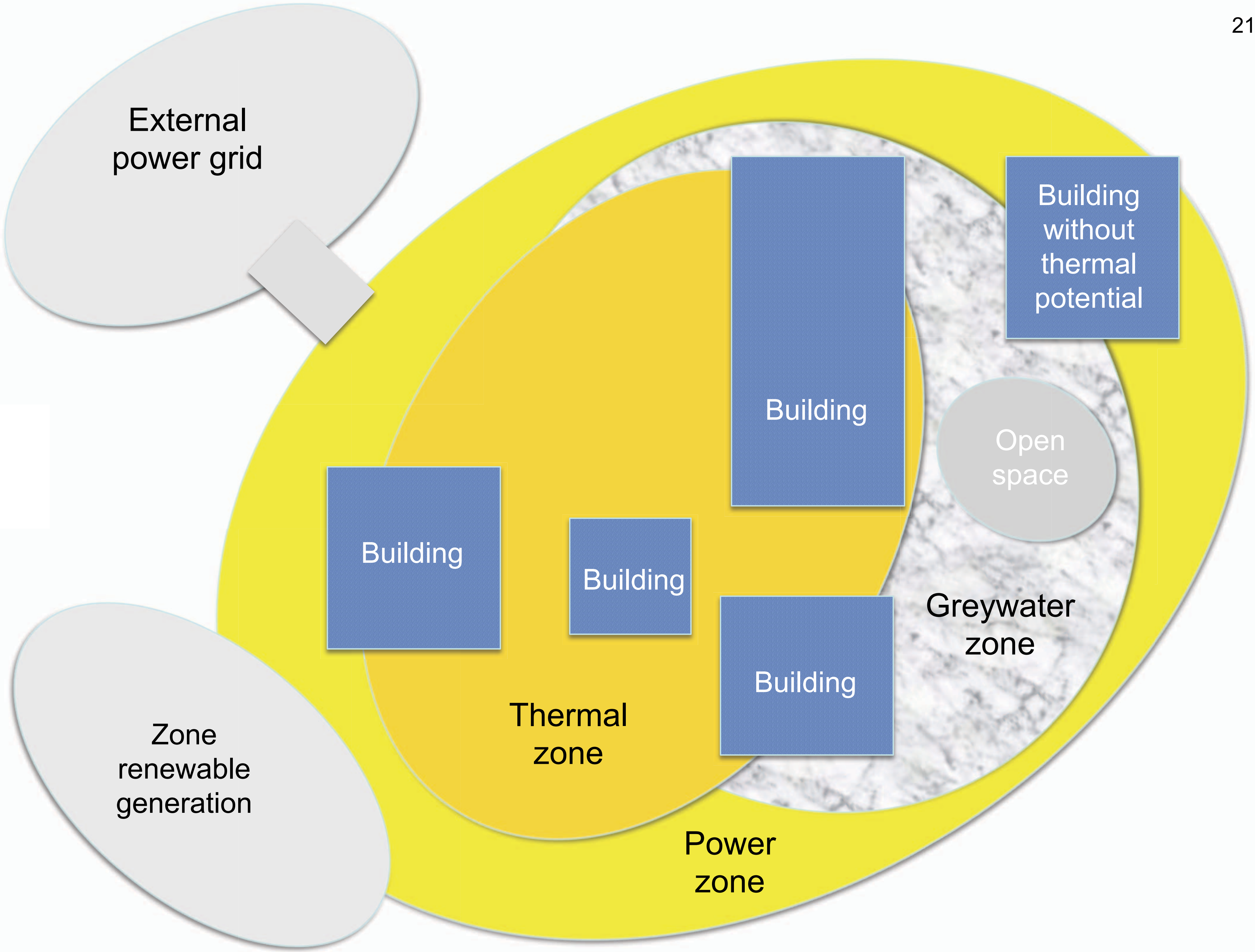
The use of common **vehicle parking facilities** by different occupancies is usual in major public or single-owner developments, and it is frequently observed that efficiencies can be made by taking advantage of the different peak demand times for various occupancies. Further efficiencies can be made by designing pricing algorithms that reflect the pattern of optimal use.

We can integrate all these elements in a Synergy Zone

Technical systems in a Synergy Zone



Best viewed in slideshow mode

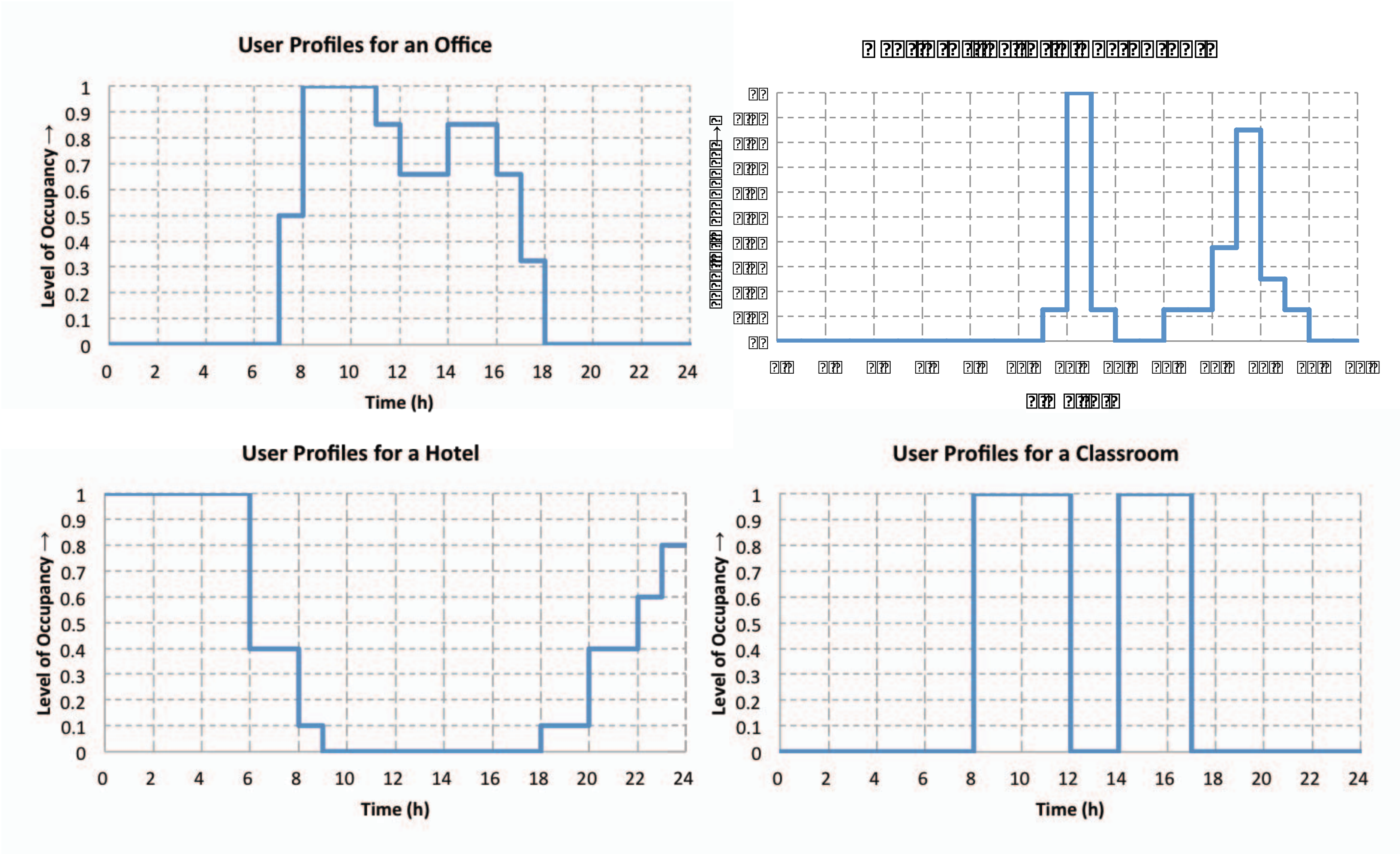

External
power grid
Building
Building
without
thermal
potential
Open
space
Building
Building
Greywater
zone
Building
Zone
renewable
generation
Thermal
zone
Power
zone

Scenarios for performance

The total performance gains are likely to vary with the type of zone;

- Heterogeneity of building configurations is one factor – a combination of some low-rise (big roofs) and medium to high rise (more demand, less roof) - these two conditions are likely to affect solar renewable capacities and rainwater collection;
- A mix of uses will also affect the benefits - residential and food service uses have heavy demand for DHW and space heating, while commercial uses typically generate excess internal heat gains;
- Open space uses (green areas, playgrounds, parking lots) will be good collectors of rain and storm water;
- In many cases, older urban neighborhoods may have the best conditions, while areas from 1950 to 1990 may be too homogeneous to be good prospects
- A related factor is that older zones may face more intractable management issues.

Diverse occupancy profiles provide opportunities



Source: Meli Stylianou, CANMET, NRCan, originally from BS EN 15232:2012: Energy Performance of buildings - Impact of building automation, controls and building management.

A poor candidate for system synergies

Very low densities and a lack of variation in occupancy types reduces possibilities for system synergies.

From Wikipedia Commons

A better candidate...

- Building orientations, footprints, heights and open space determine capabilities for gathering rainwater;
- Building occupancy type and area determine the demand for space heating, consumption of potable and greywater, leading to surpluses or deficits.

Summary of system types and interactions

The following matrix outlines potential system types in a Synergy Zone related to their interactions.

Summary of system types and performance issues

	Synergy Zones in new areas	Storage & Controls	Comments
Passive Design	Location for wind, solar and occupancy co-benefit issues, orientation to optimise solar gain, fenestration distribution and amount.	N.A.	In existing zones, location and orientation are fixed, but building envelope can be modified.
DC generation	PV arrays on building roofs or in open areas, also wind turbines, CHP, Biomass.	DC storage is needed for power generated in the zone and from off-site off-peak power.	Feed-in to power grid would only occurr after zonal needs are satisfied.
DC distribution	Include DC distribution in parallel w. AC systems for lighting and computer systems and for DC vehicle recharging.		

Summary of system types and performance issues

	Synergy Zones in new areas	Storage & Controls	Comments
Thermal energy	Low-temp heat distribution system to connect sources of surplus thermal energy with others that have deficit, through HRV and storage systems. Solar thermal systems are an additional source.	Thermal mid-term storage, separate coolth storage depending on climate, optimization controls	The feasibility of installing thermal energy exchange systems will be affected by the design, layout and technical systems in existing buildings.
Domestic hot water	Important for residential, hotel and restaurant occupancies. Thermal energy from Solar Thermal or HRV pre-heating.		

Summary of system types and performance issues

	Synergy Zones in new areas	Storage & Controls	Comments
Rain and Grey water	Buildings with large sites and roof areas are good generation sources; high-rise with small site areas have little potential. End use of greywater is landscaping and toilets. Distribution is to high-demand occupancies	Central storage for greywater with optimisation controls.	Treat black- and grey-water before storage. Heat exchangers can provide thermal tnput to thermal storage.
Solid waste	A central vacuum-powered system can deliver solid wastes to a central point for sorting and feeding into a bio-gen. plant.	Needs a central sorting plant.	Not a realistic solution for existing areas. Efficiency of vacuum system is an issue.
Other	Multi-occuoancy parking areas can make more efficient use of space because of different peak hours.	A control system could issue access based on peaks.	Difficult to do in existing areas unless large public spaces are available.

Further development required

1. Identify case studies that approximate at least some of the concepts being studied, and study aspects that were successful and others that were not;
2. Identify potential urban zones for the implementation of pilot projects ;
3. Identify special issues that are related to new v. existing zones;
4. Identify special implementation issues in existing zones, specifically regarding the linkage of technical systems to existing buildings;
5. Develop approaches to deal with management structure, occupant input needed for operations and likely occupant behaviour;

Further development required

6. Prepare estimates of energy, emissions, water and cost performance gains that can be made in a synergy zone relative to a building- by-building and occupancy-by-occupancy approach;
7. Project operating cost and income, and develop generalised models;
8. Identify costs and benefits v. scale of implementation for PV, solar thermal, thermal storage, DC storage;
9. Identify technical issues that exist in the operation of parallel AC-DC distribution systems;
10. Develop control and allocation strategies for potable, grey, storm and black water;
11. Identify regulatory issues related to DC power and greywater use;

Conclusions and questions

- What are the performance gains possible from a greater integration at a neighborhood scale?
- The Synergy Zone concept should be able to improve on the reduction in CO_2 emissions that has been possible from the implementation of REAP and Smart Grid initiatives;
- There should also be considerable gains in the resilience of the zone during conditions of power outages or other extreme events;
- But further work and pilot projects are needed to better understand and to prove the actual level of possible functional, energy, environmental and economic gains;

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