Performance Synergies in Small Urban Zones

Hong Kong SB13, September 2013

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the International Initiative for a Sustainable Built Environment

iiSBE at a glance

- An international non-profit organization;
- Focus on guiding the international construction industry towards sustainable building practices;
- Emphasis is on research and policy, with a special emphasis on information dissemination, building performance and its assessment;
- 400 members, 23 Board members from 20 countries;
- Office is in Ottawa and in Maastricht;
- Local chapters exist in Czech Republic, Israel, Italy, Portugal, Spain, Taiwan and Korea, with others being organized in Brazil and Malta;
- There is a strong iiSBE team in Canada, which has prepared assessments of case studies for over 10 years;
- Luis Bragança (Portugal) is President, Nils Larsson is XD.
- No paid staff, very active network.
- see www.iisbe.org and http://iisbecanada.ca

iiSBE –activities

- Active networking support;
- In partnership with CIB, UNEP and FIDIC, sponsorship of international *SB conferences*;
- Leadership of the international *Sustainable Building Challenge* process and development of Key Performance Indicators (KPI);
- A Forum for university or research institute departments with a special interest in SB;
- Aa partnership of universities to deliver an international Masters and Doctorate in SB;
- Development and training in performance assessment (SBTool) and Integrated Design Process (IDP);

Confirmed SB conferences for 2013-14

SB13 Munich	Munich, Germany	April 2013
SB13 Oulu	Oulu, Finland	May 2013
SB13 Vancouver	Vancouver, Canada	June 2013
SB 13 Colombo	Colombo, Sri Lanka	June 2013
BESS - SB13 California	Pomona CA, USA	June 2013
SB13 Prague (CESB 13)	Prague, Czech Republic	June 2013
SB13 Coventry	Coventry, United Kingdom	July 2013
SB13 Seoul	Seoul, Korea	July 2013
SB13 Singapore	Singapore	September 2013
SB13 Hong Kong	Hong Kong	September 2013
SB13 Graz	Graz, Austria	September 2013
SB13 Cape Town	Cape Town, South Africa	October 2013
SB13 Guimar! es (Portugal SB13)	Guimar! es, Portugal	October 2013
SB13 Cairo	Cairo, Egypt	November 2013
SB 13 SE Asia, Manila	Metro Manila, Philippines	November 2013
SB13 Dubai	Dubai, UAE	December 2013
World SB14 Barcelona	Barcelona, Spain	October 2014

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FIDIC

UNEP Sustainable Buildings and Climate Initiative
Promoting Policies and Practices for Sustainability

SB Challenge

- This is a display of performance case studies prepared for each global SB conference, managed by iSBE;
- Not a competition, but emphasis on high performance, including results of performance assessments and KPIs;
- For 2014, the emphasis will be on comparing **predicted** performance at the design stage with **actual** performance during operation;
- Please contact us if you have an interest in receiving an invitation package.

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 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 buldings that contain multiple occupancies, or projects with multiple buildings of various types, or both;

Building scale of development

The figure shows, in a very generalized way, 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, sometimes concurrently or at different times.

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 scales from from Building to Urban Zones

- 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, or for elevator use, extending to peak demand for vehicle parking;
- The principle of inter-system synergies can be increased if the scope of analysis is extended from building to a scale of small urban zones;
- Urban zones for purposes of this analysis can be defined as groups or clusters of buildings large enough to contain several diverse building types, but small enough to support inter-building thermal transfers;
- Buildings within the zone should have different in primary occupancies, different heights and footprints;

Moving from Building to Urban Zone Scale

- Such a scale of development and analysis may offer synergies between buildings such as:
  - exchange of thermal (heating or cooling) surplus or deficits;
  - exchange of domestic hot water surplus or deficits;
  - exchange of rainwater and greywater surplus or deficits;
  - exchange of PV or solar thermal renewable energy surplus or deficits;
- Urban zones may also offer synergies between other systems that provide zonal or inter-building services, such as:
  - Wastewater filtration and purification;
  - Zone renewable energy systems: PV, solar thermal or bio-generation;
  - Natural or landscaped open space;
  - Vehicle parking facilities;
  - Streets or lanes used for access to buildings.

Moving from Building to Urban Zone Scale

- None of these potentials can be realized unless there is some form of formal cooperation between property owners to establish a sharing of costs and benefits.

Related initiatives

Recent work carried out in Rotterdam, Amsterdam and other Dutch locations, has shown the considerable potential for reductions in energy, water and material consumption. The initiatives are based on three separately developed methods: *Energy Potential Mapping*, the *New Stepped Strategy* and the *Rotterdam Energy Approach & Planning*.

The *Energy Potential Mapping* method was developed to integrate knowledge of potential energy sources within an area, in horizontal sub-surface layers. The method can produce maps that show the potential for renewable fuels, power generation and thermal potentials.

This work has been primarily developed by the City of Rotterdam and Andy van der Dobbelsteen. The focus is on energy and materials and is known as the REAP method.

Related initiatives - REAP

Tillie et al. (Tillie et al. 2009b) apply the REAP method to a whole district, by optimizing 4 clusters (neighborhood scale);

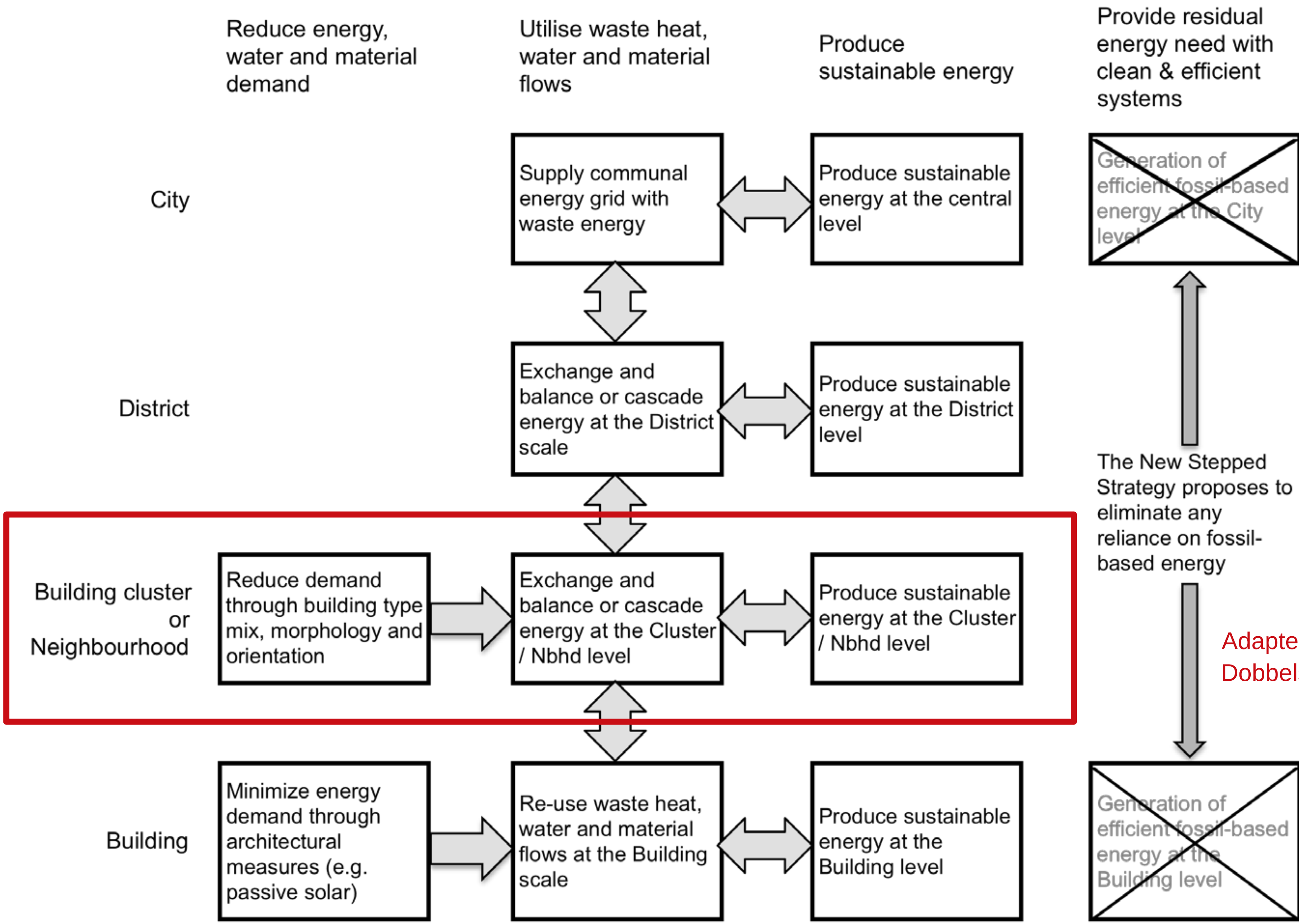
Tillie et al's detailed case study shows that significant reductions (up to 44%) could be achieved just by an appropriate mix of buildings, heating/cooling requirements, and heat/cold storage facilities at the neighborhood scale.

Further investigations have to be made to analyze the dynamic of such heat transfers, and the possibilities of heat and cold storage, to confirm the potentialities of such an approach.

In applying the Dutch experience to other regions, care must be taken to consider the probable supporting role of the temperate Dutch climate in achieving the positive results reported.

Urban Zone Scale (from REAP)

Figure 2 shows the relationships



Adapted from Dobbelsteen

Another related initiative: Smart Grids

- The smart grid can collect information necessary for customers, distributors and generators to change their human and equipment behavior in a way that reduces system demands and costs, increases energy efficiency, optimally allocates and matches demand and resources to meet that demand, and increases the reliability of the grid;
- The social benefits of a smart grid are reduced emissions, lower costs, increased reliability, greater security and flexibility to accommodate new energy technologies, including renewable, intermittent and distributed sources;
- Smart Grid work focuses on electric power systems on a regional scale.

Source: Wikipedia

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**

Applying Smart Grid ideas to Synergy Zones

- The possibilities for inter-building synergies require not only buildings of various types to be located in close proximity, but also the establishment of thermal, energy and greywater storage and control systems;
- How do we approach an urban zone to maximize synergistic possibilities?

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, individually and collectively.

   At the level of individual buildings, this means that the orientation and configuration of each building should maximize its passive performance.

   Even a zone containing buildings that are sub-optimal in terms of passive solar potential may have a high level of passive performance as a whole if inter-building spaces are tight enough to maintain a high level of density and if they are strategically oriented.

   These arguments obviously do not apply to existing zones.

System overview – thermal generation and use

2. Most Smart Grid proposals are silent on the topic of **space heating or cooling, thermal generation** (GSHP, CHP or bio-mass), **or thermal storage**. 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, some building operators may find it 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, given that some occupancies (residential, hotels, restaurants) have high demand, while commercial or public occupancies have little demand, but offer the possibility of DHW production 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, which would ensure diversity of supply.

   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, for redistribution to other buildings in the zone with a DC deficit.

System overview – DC distribution

7. We also propose to explore the installation of **DC power 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 greater availability of DC power sources and also 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

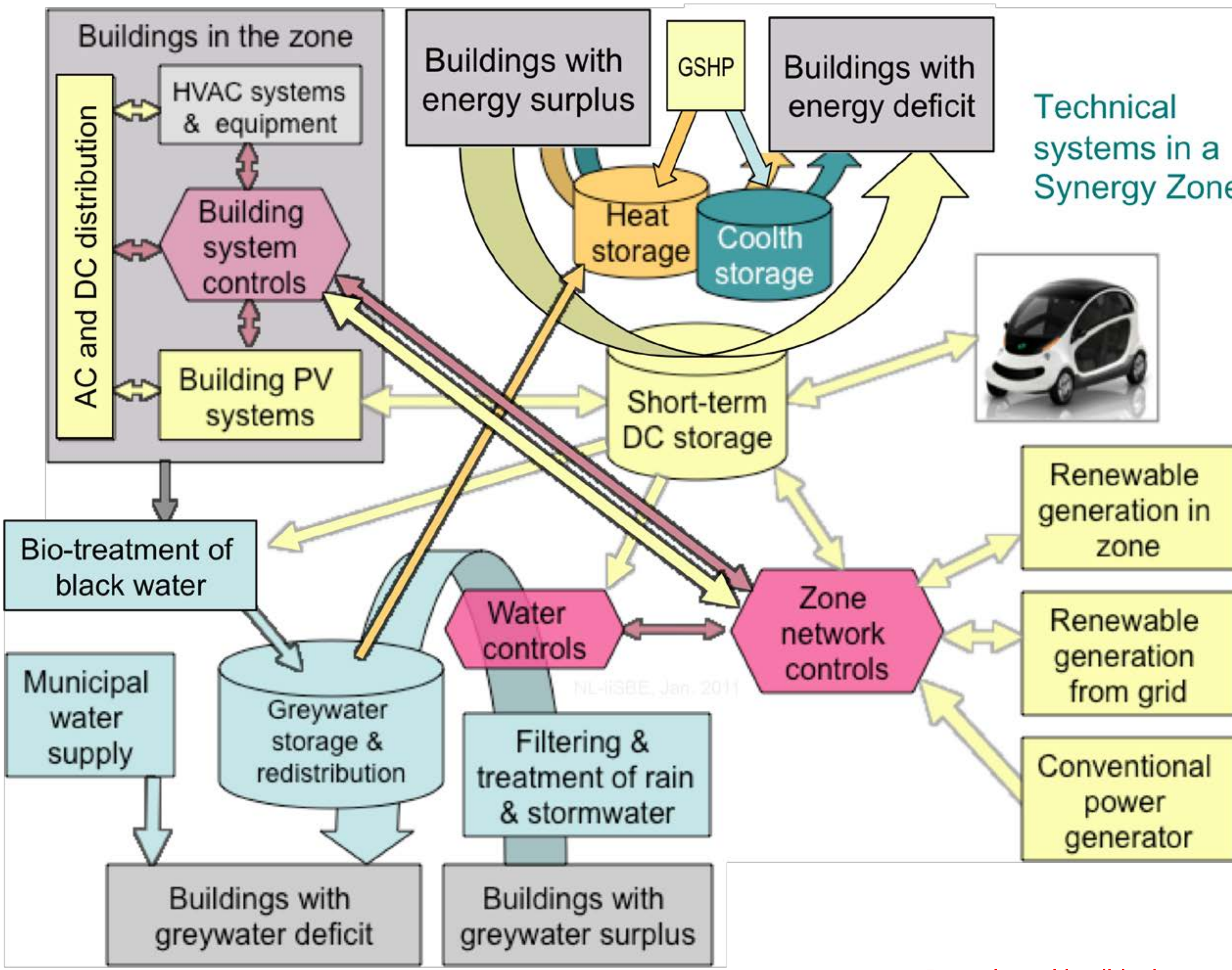
8. The issue of **jurisdiction and management** is of critical importance in cases where a zone is not under single ownership.

   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.



Best viewed in slideshow mode

Scenarios for performance

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

❑Heterogeneity of building configurations is likely to be 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;

❑Residential and non-residential occupancies will be another, since residential has 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.

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

Another poor candidate...

Although high density is genrally a good thing, Hong Kong has very high densities and relatively little variation in building occupancies and configuration. That makes most Hong Kong neighborurhoods poor candidates as synergy zones.

Micahel Wolf, Amusing Planet

But some areas in Hong Kong have a good mix

An even better candidate for system synergies, although less glamourous

From Wikipedia Commons: Millersburg Ohio

A better candidate...

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

Further technical 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 technical 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. Obtain data on 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;

Conclusions and questions

- We assume that the level of performance gains will be related to specific scenarios of neighborhood types, building types in the zone and ownership patterns;
- We also expect that the ownership and management issues in multi-owner zones will present the largest challenge;
- Nevertheless, we believe that the Synergy Zone concept has the potential to become a powerful instrument in striving for sustainable urban development;

Contacts & Info

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