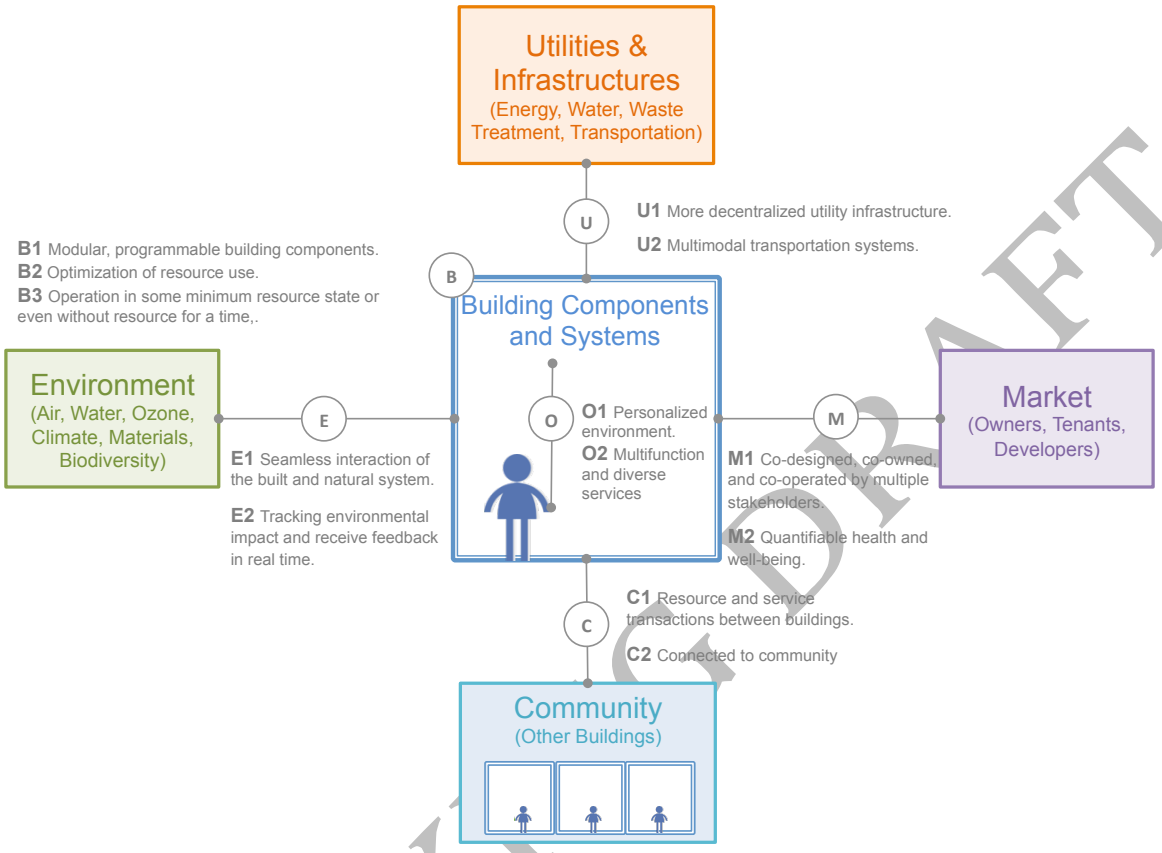
13 Future Building Characteristics

Instruction: *The following building characteristics will be discussed at the workshop on Friday, July 31.*
See Page 3 for descriptions of each characteristic.



E1 Seamless interaction of the built and natural system

E2 Tracking environmental impact and receive feedback in real time

U1 More decentralized utility infrastructure

U2 Multimodal transportation systems

M1 Co-designed, co-owned, and co-operated by multiple stakeholders

M2 Quantifiable health and well-being

C1 Resource and service transactions between buildings

C2 Connected to community

O1 Personalized environment

O2 Multifunction and diverse services

B1 Modular, programmable building components

B2 Optimization of resource use

B3 Operation in some minimum resource state or even without source for a time

4 Future Scenarios

Instruction: *The building characteristics will be discussed under the following scenarios. The scenarios are intended to pose a central design challenge or set up a general context. Some scenarios are not mutually exclusive. They are not polar opposites, nor all potential futures. The common context under all scenarios includes changing demography, demand for affordable housing and livable environments, and continuing pursue of health and wellbeing.*

S1. Climate Change Under Control

The developing and developed countries have managed to aggressively limit carbon emissions resulting in climate change impacts at the low end of current estimates, without major change to existing resources and conditions, e.g. water, agriculture, climate, etc. Fossil fuel is either depleted or restricted. Clean and efficient energy is supplied by either more efficient electric power grid or affordable local renewable generation and storage. Climate change is not a major concern, although some of its impacts (such as climate zone shift, rising sea level) have occurred and will continue.

S2. Climate Change Out of Control

Greenhouse gas emissions continue to grow globally (although possibly slowed down), resulting in significant warming over the latter part of the century, with large sea level rises that displace significant coastal populations, major regional climate changes impacting agriculture (decreased precipitation in dry regions, reduced renewable surface water and ground water resources) and more variable and severe weather patterns conditions (higher frequency and longer duration of heat wave, occasional cold winter), across the country.

S3. Resource Scarcity

Lack of proactive solutions to depleting natural resources and slow improvement of city infrastructure lead to resource crisis in the next century. Buildings have limited, unsustainable supply of fresh water and construction materials. Landfill has reached its capacity. More buildings need major retrofits (including preservations of historical features). Energy supply is also limited due to the depletion of fossil fuel or high cost of clean energy generation.

S4. Resource Abundance

Investment in innovation has significantly improved the infrastructure (buildings, transportation, agriculture, medicine). Discovery or invention of new sustainable materials and development of a closed-loop eco-system have provided more flexibility for building development. There is less concern about energy, water, waste, and materials supply.

No.	Characteristics	Full Descriptions
Environment		
E1	**Seamless interaction of the built and natural system**	Buildings can provide ecological functions on site that improve the local and regional ecosystem (such as water purification, CO_2 capture, biodiversity support). Design solutions are developed based on natural systems strategies and functionalities (biomimicry). Buildings will be tied to the broader cycle of the region, including water cycles, the nutrient load, and the factors that affect our health. The built system promotes a close connection between humans and nature to promote health and wellness (biophilic design). Adaptable topologies are defined for specific geographic regions, urban/rural settings, and climates.
E2	**Tracking environmental impact and receive feedback in real time**	The long-term impact that a building's footprint and usage may have in the local and regional environment can be measured and tracked. Buildings constantly sense and control their impact by measuring outfluxes and monitoring their contribution to the aggregate impact on microenvironment. The local zoning codes will take the environmental impact into consideration such as the impact of building height/density on urban heat island. Buildings will receive feedback from their microenvironment (i.e. the tolerant local environment to building systems). Buildings can monitor and manage their water and airflows. The built environment will integrate with natural airflows to block wind or utilize natural ventilation.
Utilities & Infrastructures		
U1	**More decentralized utility infrastructure**	Future buildings will not rely on a totally centralized utility infrastructure (power, water, waste), but a more decentralized network for generation, distribution, storage, and treatment. Decentralized networks will improve the overall flexibility, efficiency, and resilience of the infrastructure system.
U2	**Multimodal transportation systems**	Buildings are connected by a multimodal transportation network including public transportation, car-sharing (autonomous vehicles on demand), bike-sharing, walking, and other new means of urban transportation. Land use for parking and driveways will be significantly reduced; therefore, more space is available for pedestrians and green space that can perform onsite ecological functions. The real estate value of a building's location is correlated to its integration with the multimodal transportation network. As more activities can be conducted virtually and remotely, today's business centers may diminish or be replaced with new functions.
Market		
M1	**Co-designed, co-owned, and co-operated by multiple stakeholders**	Fewer owner-occupied buildings due to sharing economy and increased population mobility. Buildings and their services can be owned by multiple parties. Building layout needs to be very flexible to meet ever-changing tenant needs. Additional actors (e.g., district system operators) have the ability to take part in distributed marketplace/sharing economy, where decision-making power is shifted to a larger group of stakeholders.
M2	**Quantifiable health and well-being**	Buildings are seen as a mechanism that helps generate a healthy life. Building occupants will experience increased health, productivity, and wellbeing from the enhanced indoor environmental quality and other value-added building services. The results are measurable and tracked on a real-time basis. People can "see" how well designed buildings benefit them. Ownership and tenant decisions are based on the wellness, economic, and environmental values of a building and its services. These values are reflected in the buildings' holistic performance, which is measured, tracked, and recognized at all scales.
Community		
C1	**Resource and service transactions between buildings**	Buildings are connected to their neighbors to share or trade building services and utility resources including energy generation and storage, demand flexibility, waste heat recovery, water purification, onsite waste treatment, localized air-cleaning, etc. Ubiquitous personal devices and crowdsourcing allow scalable solutions to improve efficiency, resilience, and intelligence of a building community. When a building or a district has effective means to produce and share a service, the limits to scalability become internal motivation or need, which is different from the market barriers today (e.g. high upfront cost).
C2	**Connected to community**	A building's place in its community (e.g., physical land use patterns, public realm) and its impacts and contributions are evaluated (during design and planning) and measured (during operation). Buildings are able to foster stronger community, where human resilience is an important component of building resilience. Where there is strong community, the survival rates and ability to recover after disasters is higher. Each community forms a self-sustaining eco-district, which is valuated by multi-dimensional performance metrics.

Occupants		
O1	**Personalized environment**	Future building designs reflect the adaptation range of the human body, designing not for a single optimized point but for a range that is generally free of discomfort. Future buildings are unlikely to achieve 100% satisfaction with the thermal environment if only relying on centralized systems – the designs must turn to more personalized thermal comfort provision through portable/wearable devices (e.g. clothes providing extra heat) that reduce the need for energy consumption. Wearable devices can provide more flexibility for granular control of personal spaces. Wearable/personal devices will have embedded sensors to automate overall system operation and optimization given local-level data. Central systems and decentralized systems can deliver personalized levels of service to each occupant. Occupants have some control over the optimization goals but the majority of the operational information collection, synthesis, and optimization can be automated and invisible to the user. Information is distilled down in complexity before interfacing with occupants for feedback. Buildings learn occupant behavior and expectations from experience in order to proactively tailor building energy and resource consumption to actual needs while avoiding idling.
O2	**Multifunction and diverse services**	Distinct building use types (e.g. today's office, retail) will diminish and more buildings are mixed-use and multifunctional. There will be a significant reduction in the amount of work done in a centralized workspace and an increase in the work that is done from remote locations. Workspaces will become more diverse to accommodate different natures of work. Workspaces will be denser and their configurations will vary in space and time. Gathering points will be created to meet social and collaboration needs. Business travel may be reduced due to the increasing virtual connections. Building designers can shift expectations by the types of building environments they develop for occupants. Expectations may go beyond thermal comfort, to the provision of services towards work/family balance (i.e. babysitting, food services). Future buildings can accommodate the needs of changing demography, such as an older population at work and home.
Building Components and Systems		
B1	**Modular, programmable building components**	Considering the relatively long service life of buildings and the fast change in technologies and life styles, buildings will be easy to reconfigure and upgrade to accommodate various needs and adapt to function or condition changes over time. Future systems can support easy interconnection, modularity, and extensibility. This will make it possible for buildings to use smaller systems or modular components and incur lower first cost. Technologies will be more adaptable, rather than being disposed when obsolete. More recyclable building materials and flexible structures allow some buildings to reduce their service life without increasing embodied energy, generating extra waste, and consuming precious natural resources. Buildings will contain more integrated and distributed systems (such as combined lighting, security, HVAC control system with modular components). Open and interoperable systems can deploy, self discover, self diagnose faults, and act accordingly. Devices from manufacturers will have base functions and be personalized later based on user preferences enabled by machining learning. Future building components will be produced more as manufactured systems, with integrated functionality like automobiles today. Building envelopes will provide more complex functions, such as adjusting indoor temperature, controlling air quality, collecting and purifying water, or generating energy. Space heating and conditioning will relies less on the conventional HVAC systems today as building envelopes become more organic and intelligent with biomimetic strategies, nanotechnology, thermochromic technology, etc.
B2	**Optimization of resource use**	By harnessing forecasts of future weather conditions, market signals, and occupant needs, buildings can anticipate and prepare for how to make better use of resources (predictive control, performance diagnostics, smart maintenance) and create better conditions for stakeholders. Buildings can respond to their external surroundings and occupants in near-real time to reduce energy and water use, achieve net-zero, and contribute to the local or central utilities. Buildings are operated to achieve a holistic set of objectives (energy use, comfort, productivity, indoor environmental quality, etc.). Building systems will be more proactive, self-learning, adapting to changes over time. Building-wide or city-wide intelligent applications will collaborate and exchange data to provide optimized outcomes. Technology integrates inputs from sensors and network signals to optimize real time performance. Buildings can monitor their own performance, detect problems, and predict maintenance needs.
B3	**Operation in some minimum resource state or even without source for a time**	Buildings are able to run without energy or water supply for limited periods of time (during extreme conditions). A certain percentage of buildings in a district can be operated without direct generation or a grid-connection for a certain period of time. Adaptive built developments anticipate extremes and employ low-tech and distributed solutions relying on local resources.