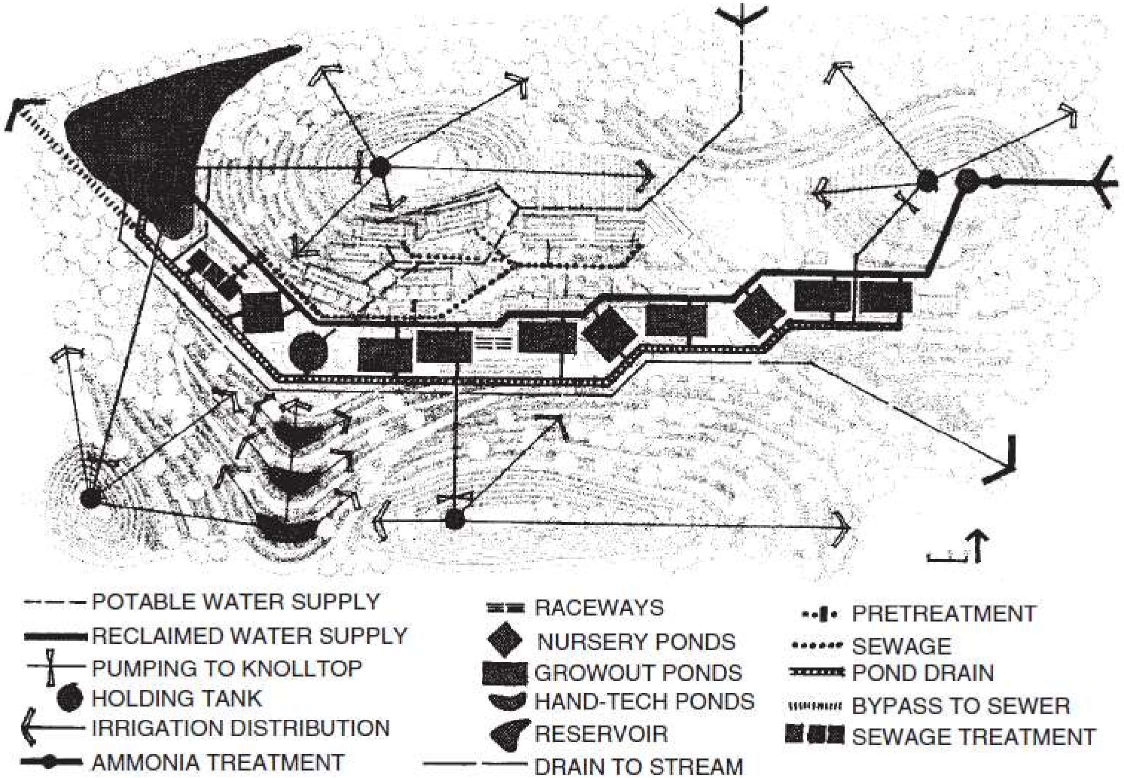
Influences on the design process: (k) Regenerative design strategies

- Regenerative design strategies
  - Energy efficiency: use less energy (reduce 'net' negative energy impacts)
  - Green: maximize the positive effects while minimizing the negative ones (reduce 'net' negative environmental impacts) with respect to energy, water and materials
  - Sustainability: solve today's problems while reserving adequate resources (no 'net' negative environmental impacts)
  - Regenerative design: it goes beyond sustainability. produce a 'net' positive environmental impacts (energy, water, materials) → Example: Fig. 1.14 Site remediation and water reclamation

(*a*)

(*b*)



(*c*)

Fig. 1.14 *(a) The Center for Regenerative Studies (CRS), California Polytechnic State University–Pomona. (b) Plants provide water treatment and generate biomass in an aquacultural pond at the Center for Regenerative Studies, Cal Poly–Pomona. (c) Site plan for the CRS. It's not easy being regenerative—the highlighted elements relate only to the water reclamation aspects of the project. (Photos © Terri Meyer Boake; used with permission; drawing from John Tillman Lyle. 1994.* Regenerative Design for Sustainable Development*. Hoboken, NJ: John Wiley & Sons.)*

Campus metabolism

- http://cm.asu.edu/
- What is missing?

(I) Extreme events: (1) Resilience

- Relative to infrastructure, resilience has been described as "the ability to reduce the magnitude and/or duration of disruptive events".
- There is no formal definition of resilient building or list of characteristics that would identify such a building.
- Storm surge, hurricane (windows not blown out), flood, COVID
- The Resilient Design Institute: https://www.resilientdesign.org/category/news-blogs/alex-wilson/

(I) Extreme events: (2) Passive Survivability

- Different from resiliency.
- The fundamental precept of passive survivability is that habitable conditions can be maintained in a building (or portion of a building) during an extreme event.
- What can be done to allow occupants to stay in place, without risking their health, in the event of failure of normal utilities (electricity, natural gas, water, sewer)?

(I) Extreme events: (3) adaptability

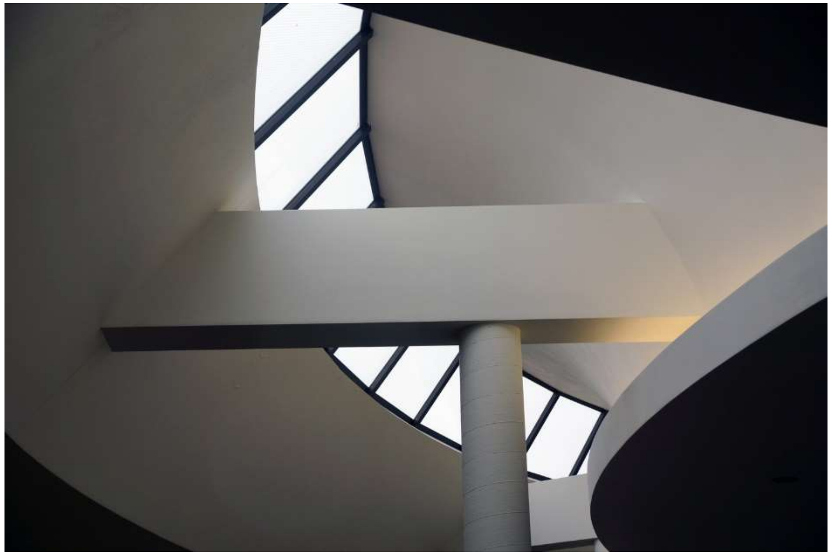
- Adaptability refers to the ability of a building to perform reasonably well under changing (but not extreme) conditions.
- One example is the design of a building that can perform well without radical renovations under changing climate conditions.
- Ex.: to allow space for future installation of systems or system modules, e.g. preparing for a rooftop PV system in anticipation of a lower-cost system in the future.

Design tips and strategies

John Lyle's approach in his book (Regenerative design for sustainable development)

- (a) Let the nature do the work (Fig. 1.15)
  - Passive systems first, active systems next

Fig. 1.15 Letting nature do the work—via daylighting. Mt. Angel Abbey Library, St. Benedict (Mt. Angel), Oregon, designed by Alvar Aalto. (© Tyler Mavichien; used with permission.)





(b) Consider nature as both model and context: a living machine (=nature) to process building wastes as opposed to a conventional sewage treatment plant (Fig. 1.14)

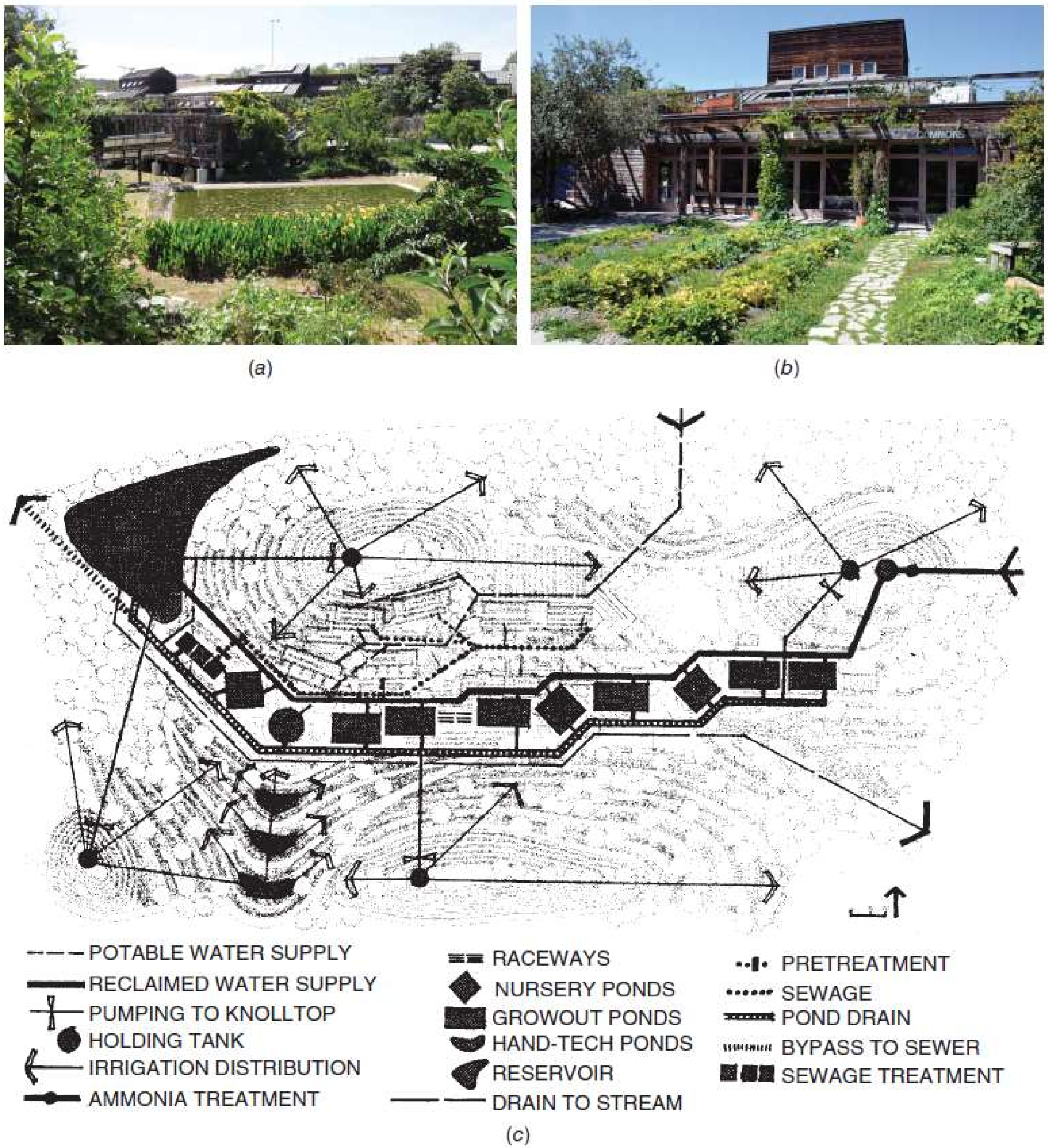


Fig. 1.14 *(a) The Center for Regenerative Studies (CRS), California Polytechnic State University–Pomona. (b) Plants provide water treatment and generate biomass in an aquacultural pond at the Center for Regenerative Studies, Cal Poly–Pomona. (c) Site plan for the CRS. It's not easy being regenerative—the highlighted elements relate only to the water reclamation aspects of the project. (Photos © Terri Meyer Boake; used with permission; drawing from John Tillman Lyle. 1994.* Regenerative Design for Sustainable Development*. Hoboken, NJ: John Wiley & Sons.)*

(c) Aggregate rather than isolate

- The components of a system should be highly integrated (solar heating performance of a direct heat gain: Fig.1.16)
- See the forest through the trees

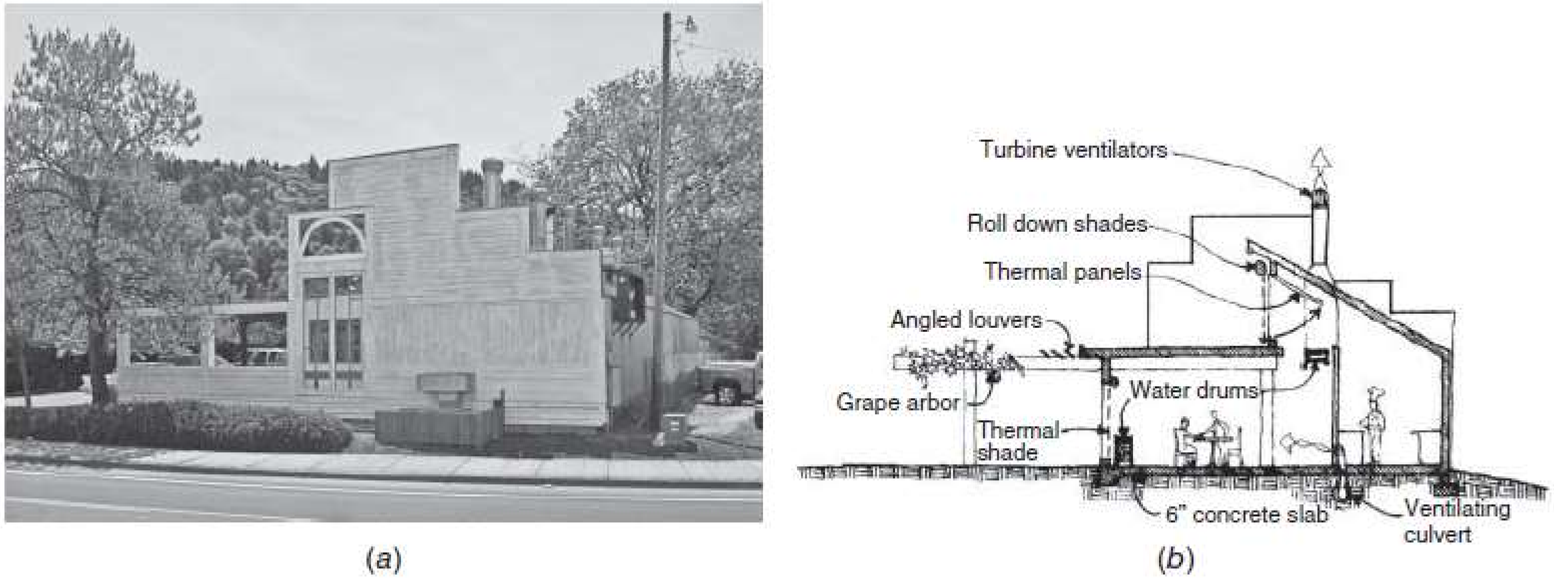


Fig. 1.16 Aggregating, not isolating. (a) The former Cottage Restaurant, Cottage Grove, Oregon, operated successfully with passive strategies for thirty years. (b) This section through the restaurant illustrates the substantial integration and coordination (aggregation) of elements typical of passive design solutions. (Photo by Lisa Leal; drawing by Michael Cockram; © by John S. Reynolds; all rights reserved.)

(d) Matching technology to the need

- Do not use high-grade resources for low-grade tasks

Fig. 1.17 Match technology to the need. Sometimes it's the simple things that count. Keeping cool with a solar-powered fan cap.

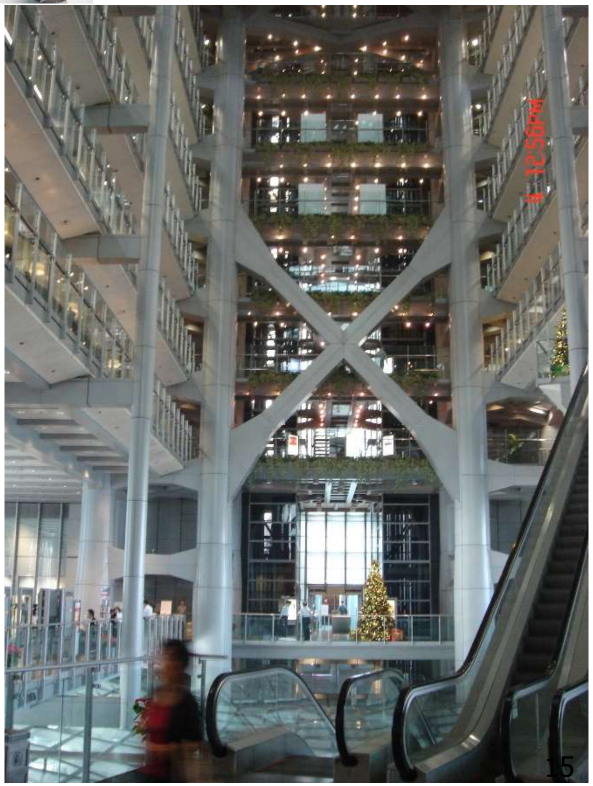
(e) Seek common solutions to disparate problems

- Systems to be multifunctional and multidisciplinary
- Fig. 1.18: mechanical, electrical, architectural tasks
- Think out of the box

Fig. 1.18 Seek common solutions. The "atrium" of the Hood River County Library, Hood River, Oregon, provides a central hub for the library, daylighting, views (spectacular), and stack ventilation. (© Alison Kwok; all rights reserved.)

HSBC's Hong Kong head office

- Architect: Norman Foster
- Built from 1979 to 1986
- The Hong Kong and Shanghai Banking Corporation
- Atrium → multifunctional and multidisciplinary (architectural, structural, environmental tasks)



- (f) Shape the form to guide the flow (solar, wind, ventilation) (Fig.1.19)

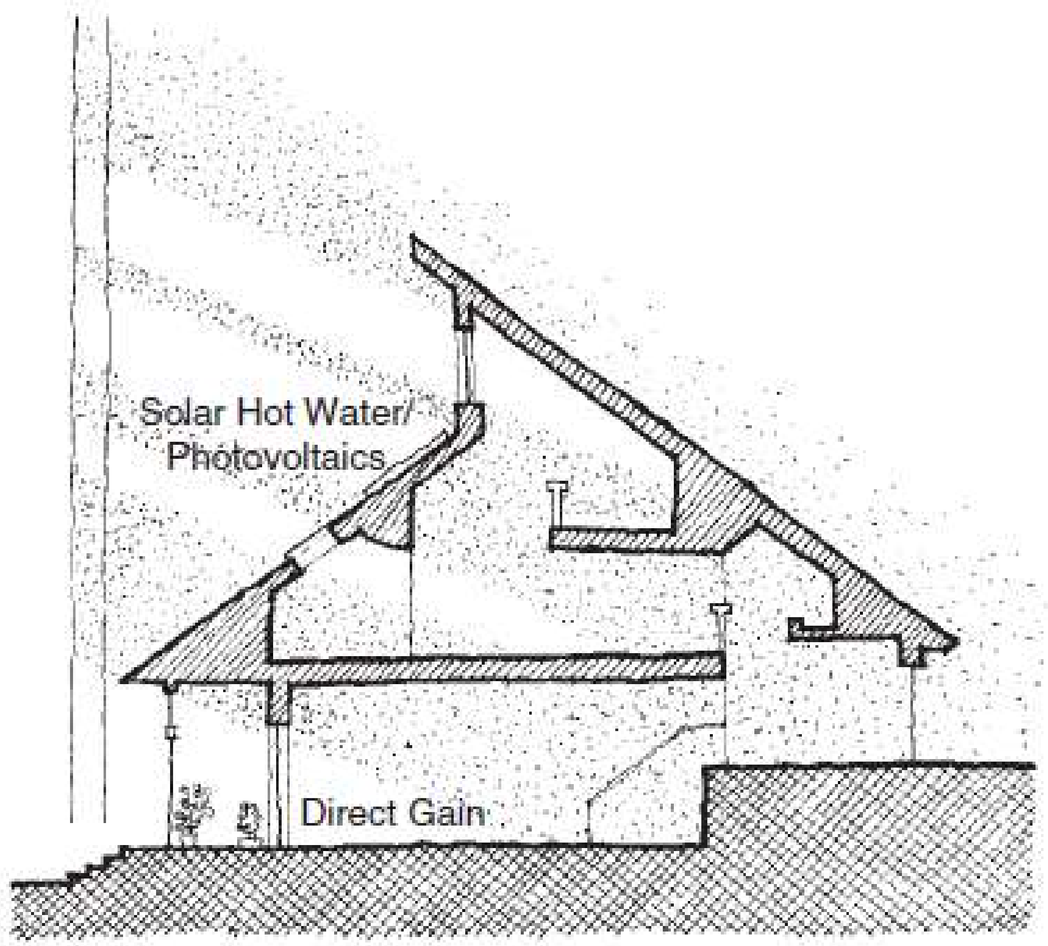


Fig. 1.19 Shaping the form to the flow. Using a "band of sun" analysis as a solar form giver (see Chapter 3 for further details). (Redrawn by Jonathan Meendering.)

- (g) Shape the form to manifest the process: Let a building teach occupants (Fig. 1.20)

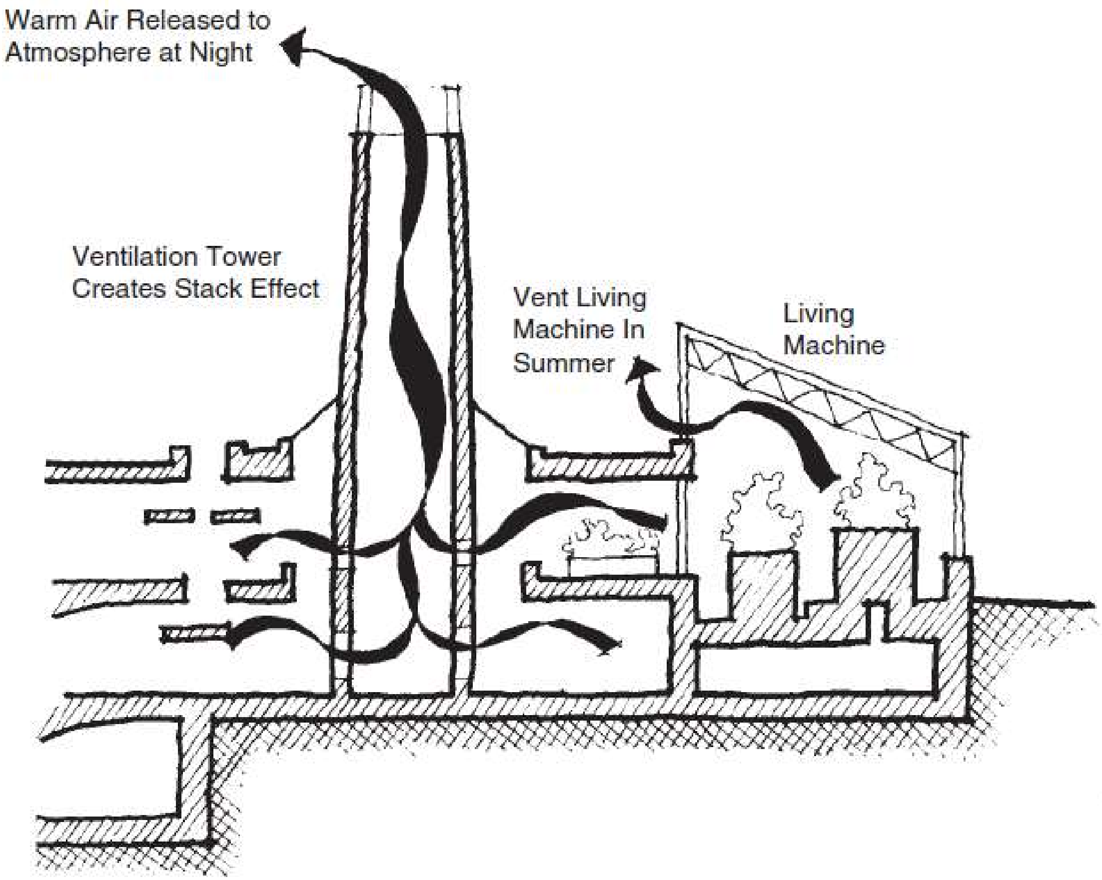


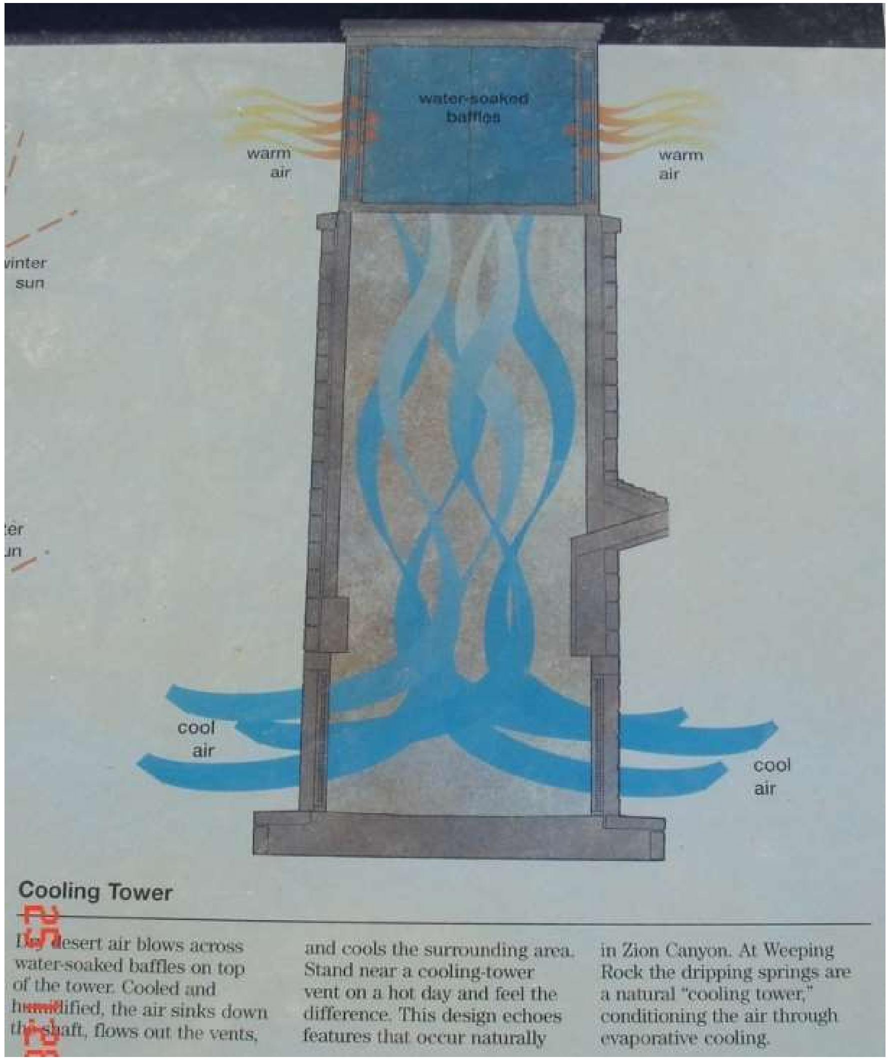
Fig. 1.20 *Shaping the form to the process. Stack effect ventilation is augmented by the building form in this proposal for the EPICente project, Bozeman, Montana. (Courtesy of Place Architecture LLC, Bozeman, Montana, and Berkebile Nelson Immenschuh McDowell Architects, Kansas City, Missouri. Redrawn by Jonathan Meendering.)*

Zion canyon visitor center

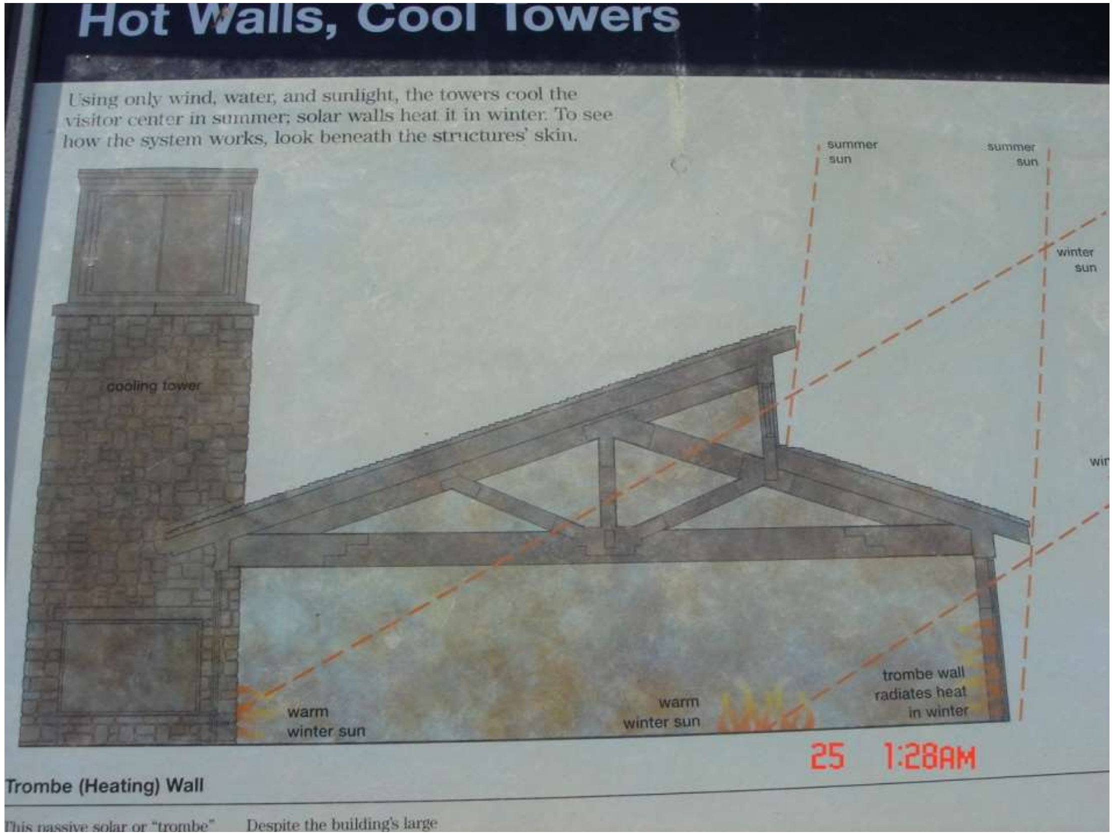
- Trombe (heating) wall
- Cooling tower

Zion canyon visitor center

- Cool towers, hot walls



Zion canyon visitor center



Indirect Gain or Trombe Wall

- In contrast, indirect gain means that while massive exterior surfaces such as brick and concrete absorb solar heat effectively, solar energy retention is improved significantly by the addition of an external glass layer a short distance from the mass, creating an indirect-gain system. (Fig.11.14)

- Glazed walls, also known as *Trombe walls* after the French engineer who pioneered their development in the 1960s, are usually vertical, making them best suited to sunny winter climates with low sun angles; because of this, they feature prominently on the sun-facing facades of their buildings. (Fig.11.15)

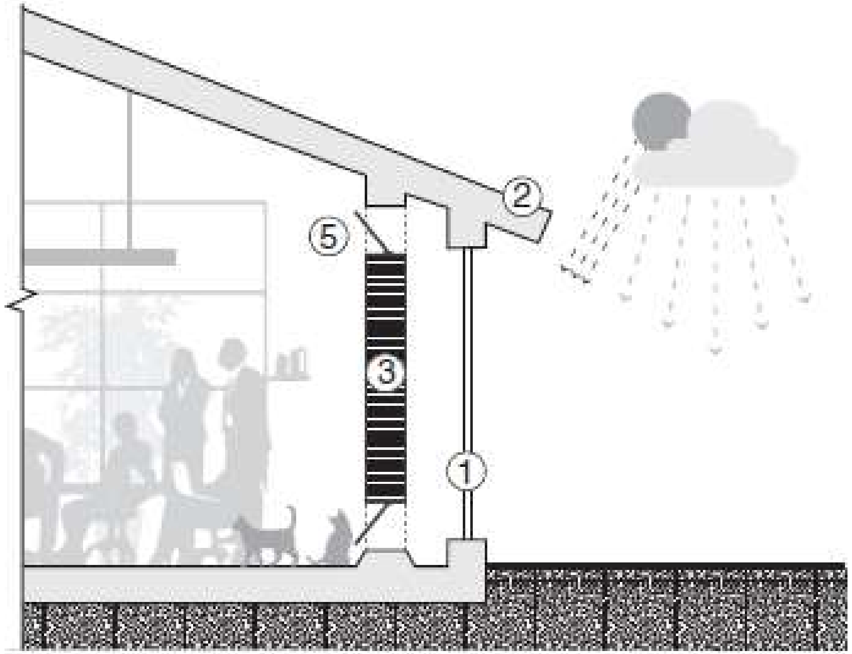


Fig. 11.14 *Indirect-gain configuration, showing solar energy collection through vertical glazing (1), which may be selectively coated to increase solar absorption; upper portions often remain clear to provide daylight. Overhangs (2) provide shade from high sun angles; movable insulation is uncommon. When sun angles are low, solar energy is partly absorbed by wall mass (3), and warm air may be vented to the interior if desired (5). Element (4), separation of floor mass from the ground seen in other system diagrams, is not critical to this system configuration. (Drawing by Alexa Thornton. © Walter Grondzik; all rights reserved.)*

Difference between direct and indirect gains

- Direct-gain systems admit solar energy directly to living space through windows and/or skylights. (Figs.11.9, 11.10)

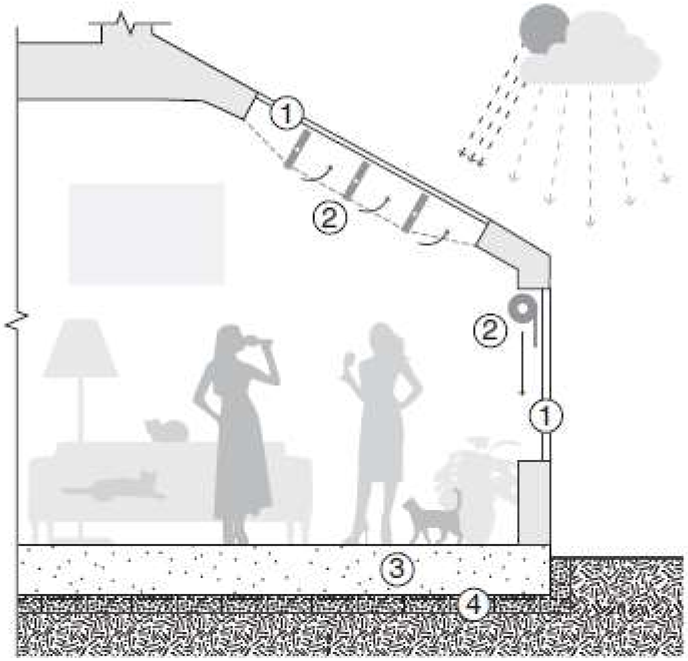


Fig. 11.9 *Direct gain configuration, showing solar energy collection in living space through tilted and, optionally, vertical glazing (1) equipped with movable insulation and shading (2); thermal storage is provided by floor mass (3) that is thermally separated from the ground (4). (Drawing by Alexa Thornton. © Walter Grondzik; all rights reserved.)*

Fig. 11.10 *Direct-gain atrium in the Federal Center South Building, Seattle, WA. (Image courtesy of ZGF Architects.)*

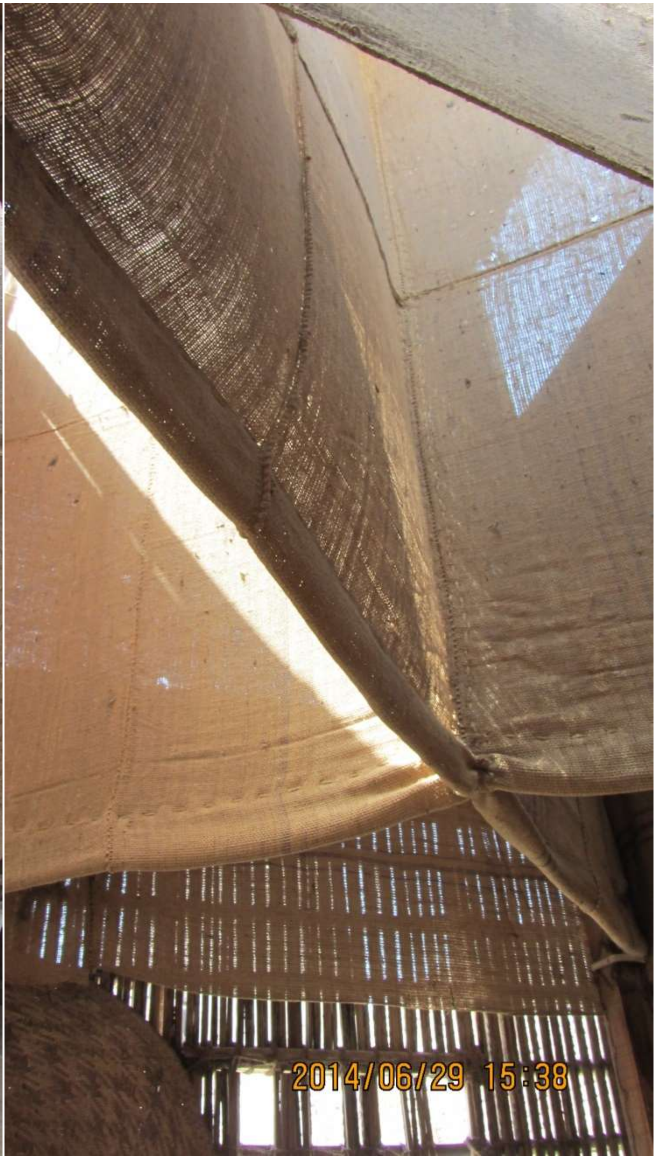
(a) (b)

Fig. 11.15 *Exterior (a) and interior (b) of the Trombe wall at the Zion National Park Visitor Center, Springdale, UT, designed by architects of the National Park Service in collaboration with scientists and engineers at the National Renewable Energy Laboratory. (Photos by Robb Williamson, NREL image 09256 and NREL image 09237.)*

Fig. 11.18 *A Trombe wall design for the Burger Residence in Lakeside, Oregon, completed in 2008, uses circular openings to preserve lake views. (Photos courtesy of D. Holmes Chamberlin Jr., Architect LLC.)*

Traditional house in Dubai


الرجاء عدم الجلوس على
السرير
Please Do Not Sit On
the Bed
2014/06/29 15:38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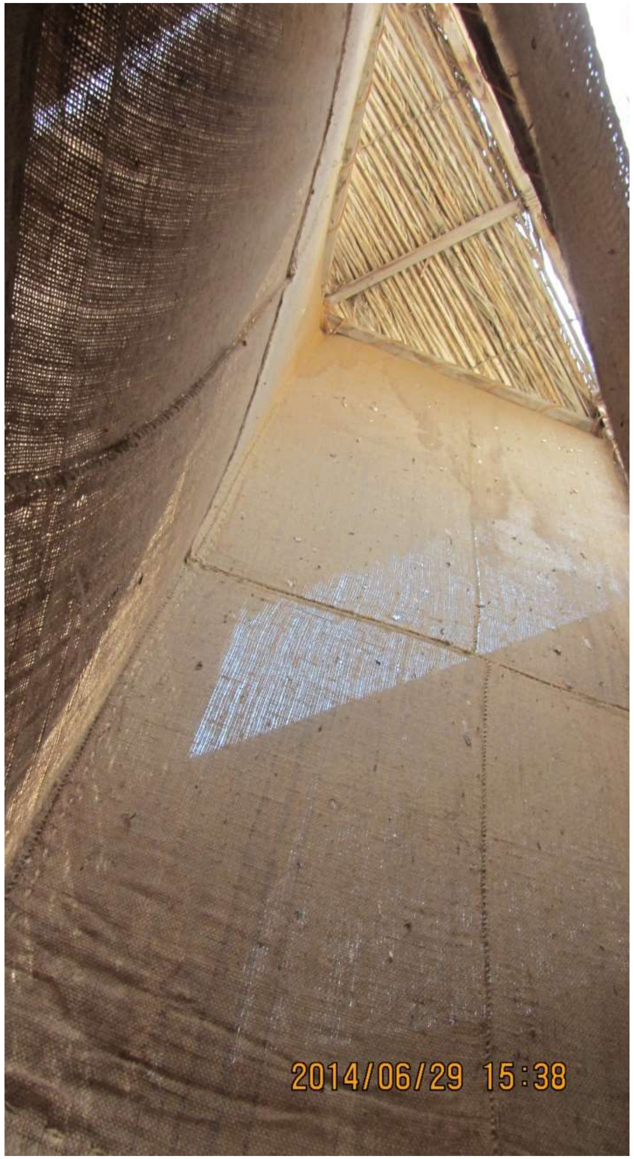
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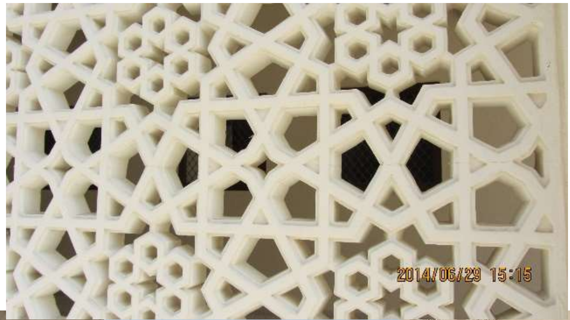
DUBAI CREEK
HISTORIC AL FAHEIDI
MOSQUE
Assembly Point
AL DEWAN R/A
2014/06/29 15:09


2014/06/29 15:15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(h) Use information to replace power

- Reliance on a building's user is not so much a direct energy saver → BEMS & machine learning

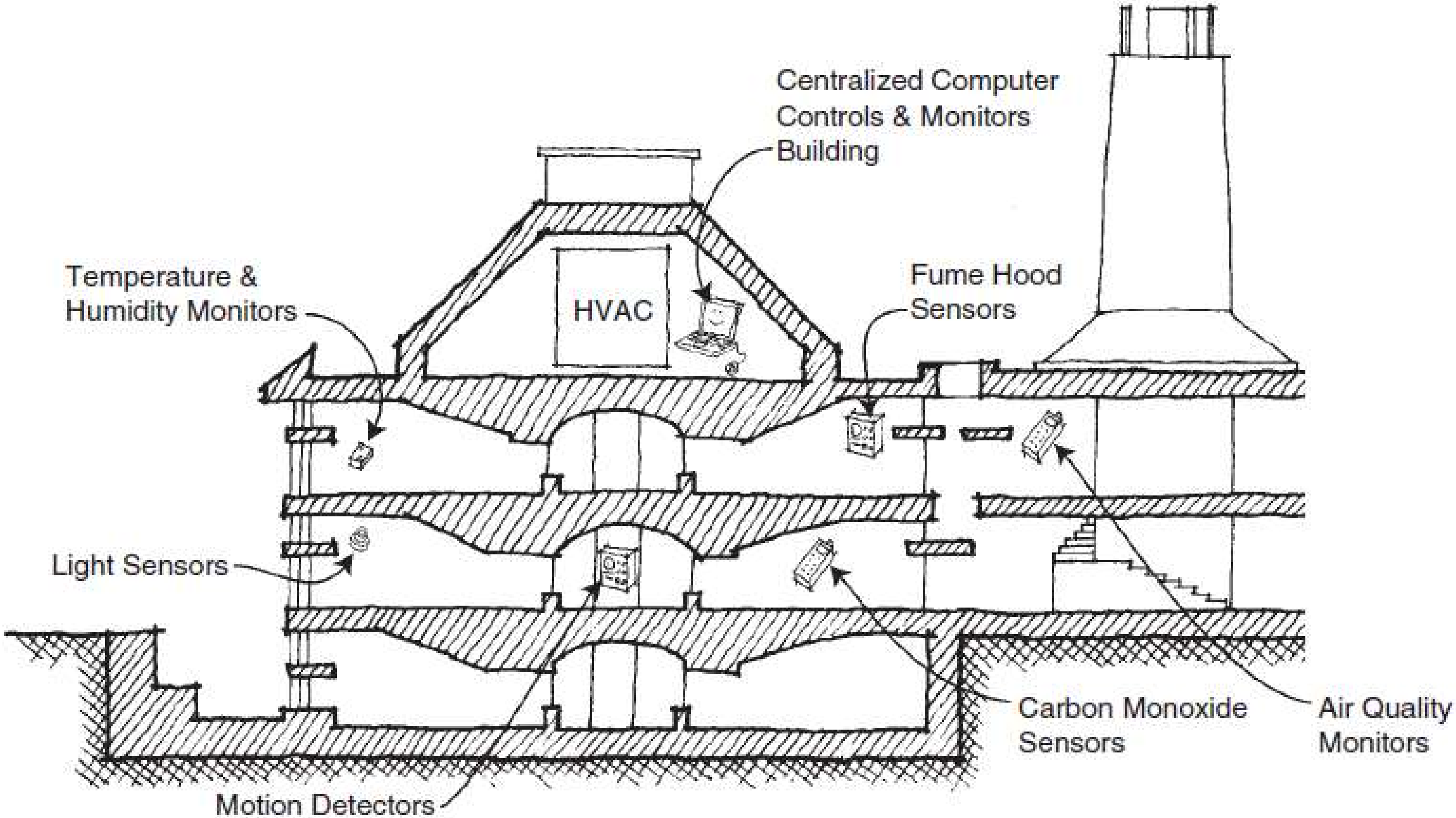
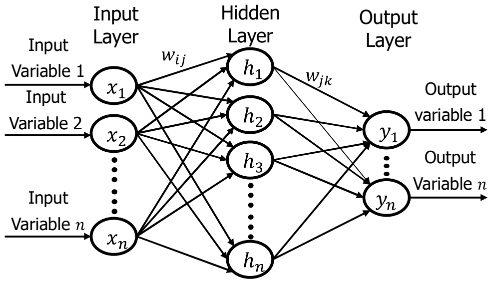
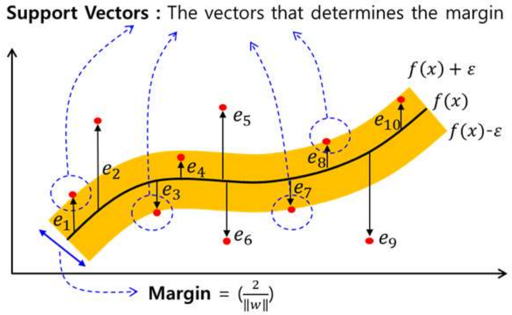


Fig. 1.21 *Use information to replace power. Section showing intelligent control system components for the proposed EPICenter project, Bozeman, Montana. (Courtesy of Place Architecture LLC, Bozeman, Montana, and Berkebile Nelson Immenschuh McDowell Architects, Kansas City, Missouri. Redrawn by Jonathan Meendering.)*

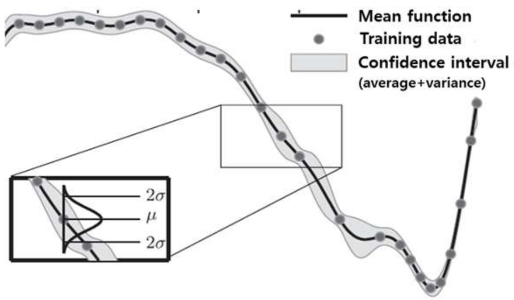
Five machine learning algorithms



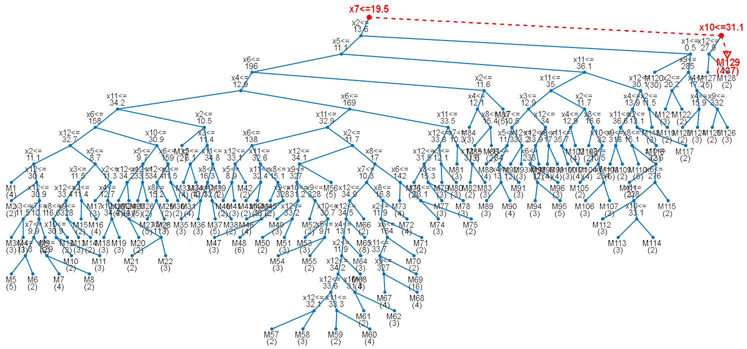
Artificial Neural Network [ANN]



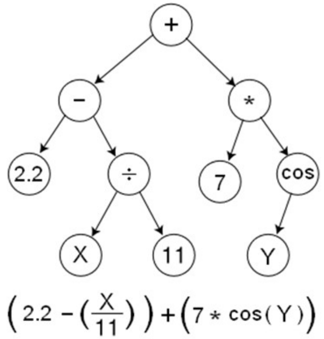
Support Vector Machine [SVM]



Gaussian Process Emulator [GPE]

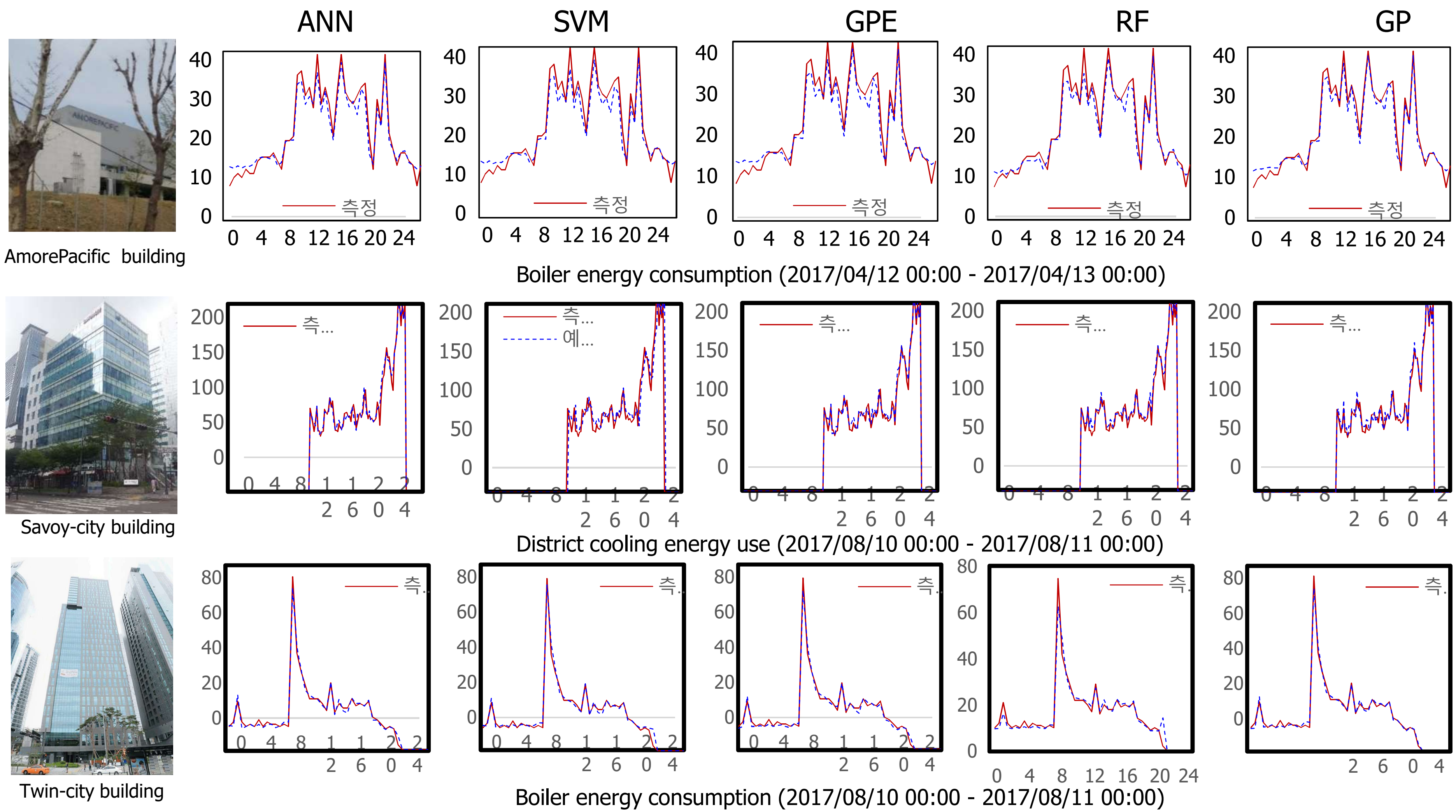


Random Forest [RF]*



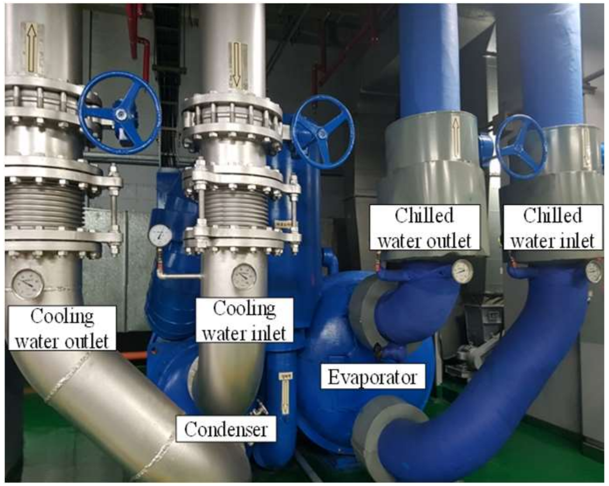
Genetic Programming [GP]

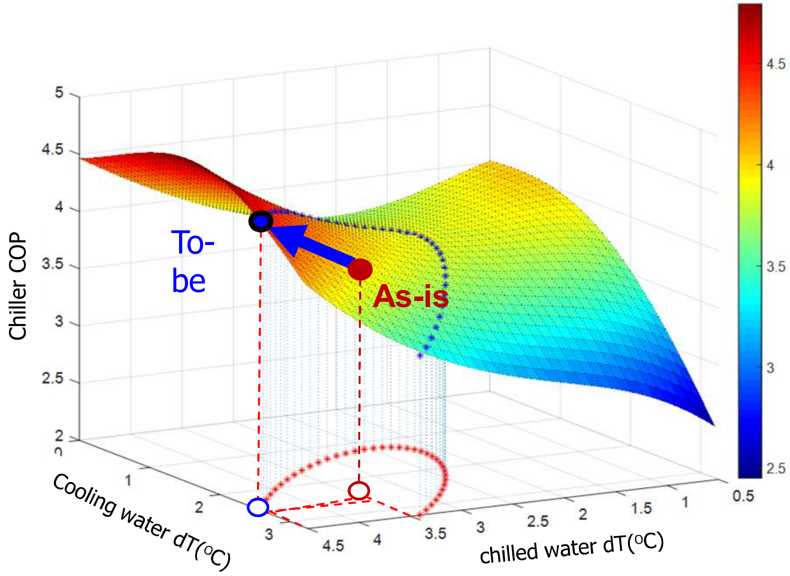
(*) Shin, H.S., and **Park, C.S.** (2017), Comparison of three random forest models of a chiller, Proceedings of the 15th IBPSA conference (International Building Performance Simulation Association), August 7-9, San Francisco, California, USA., pp.1881-1886


ANN
SVM
GPE
RF
GP
AmorePacific building
측정
Boiler energy consumption (2017/04/12 00:00 - 2017/04/13 00:00)
Savoy-city building
측...
예...
District cooling energy use (2017/08/10 00:00 - 2017/08/11 00:00)
Twin-city building
Boiler energy consumption (2017/08/10 00:00 - 2017/08/11 00:00)

Optimal control of a compression chiller

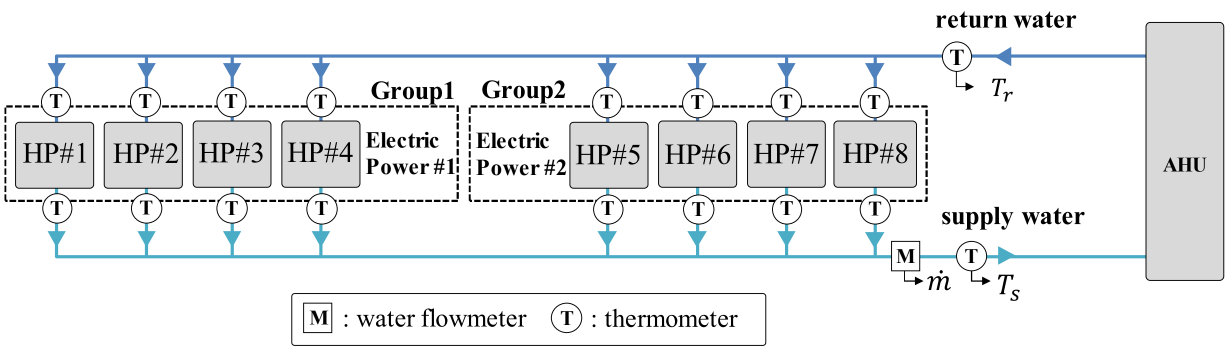
SK Namsan building





- ANN chiller model
- As-is: COP 3.96 (chilled water dT: 3.5°C, cooling water dT: 2.5°C) ← the median from the measured data
- To-be: COP 4.52 (chilled water dT: 4.5°C, cooling water dT: 2.6°C)
- Energy savings: 14%

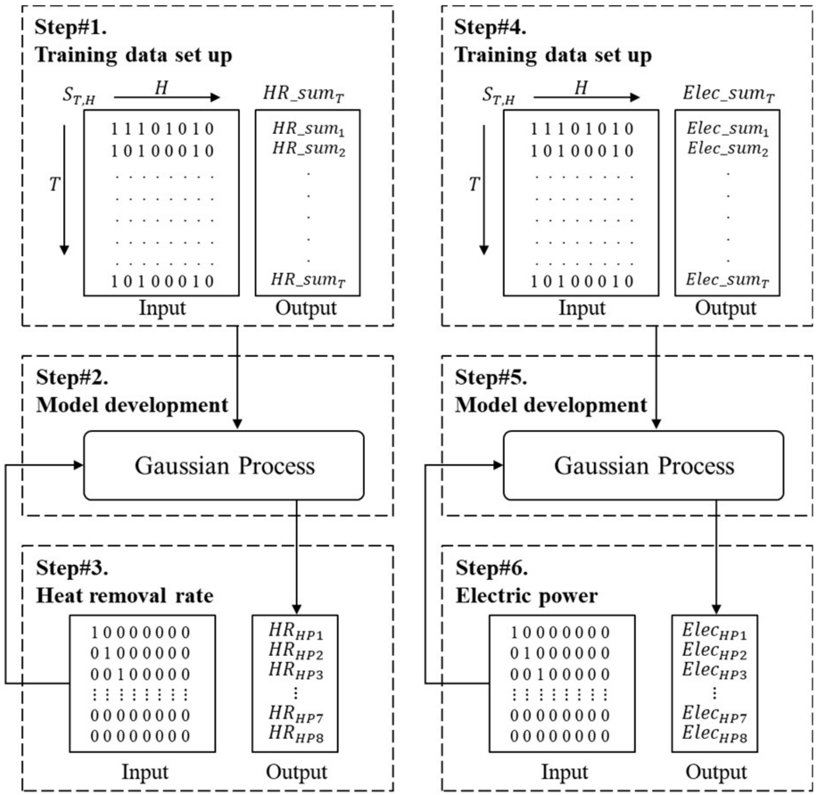
COP based control strategies

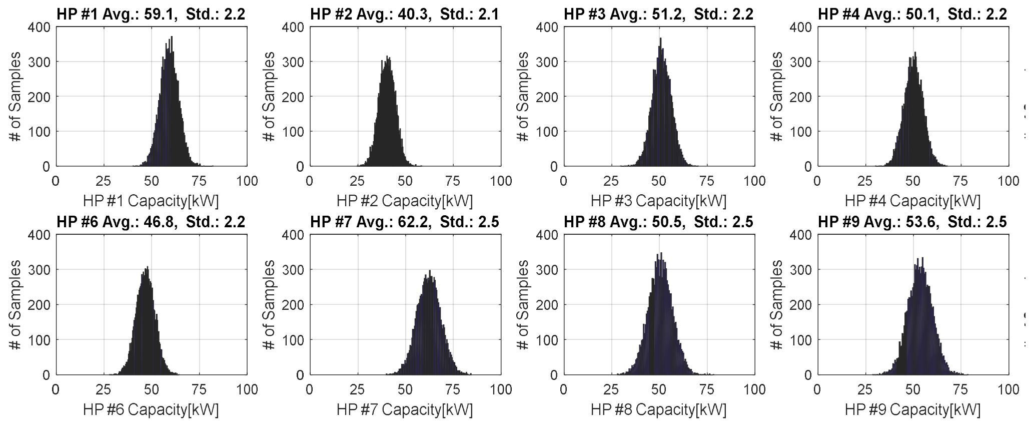


- Hospital building (Total floor area: 22,440m^2)
- Nominal cooling capacity of each heat pump: 51.2kW
- Existing control: return water temperature based control
- Heat removal rate and COP of each heat pump.

Stochastic nature!!

Gaussian process model





In the order of highest to lowest COP: energy savings by 20%

(i) Provide multiple pathways

- This celebrates functional redundancy as a virtue: fire escapes, backup heating and cooling systems, multiple water reservoirs and piping pathways for fire sprinklers.

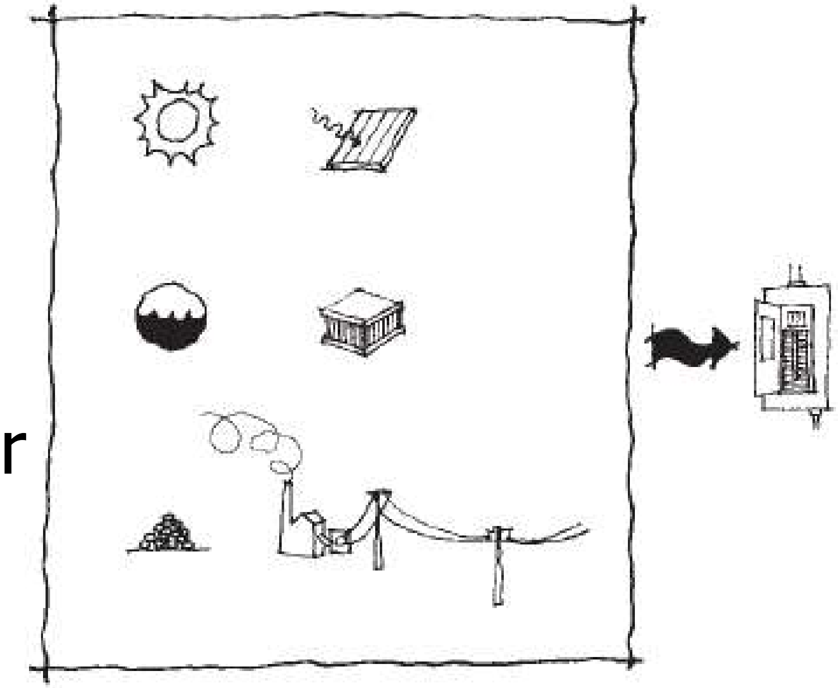


Fig. 1.22 Providing multiple pathways. Three distinct sources of electricity are projected in this conceptual diagram for the proposed EPICenter project, Bozeman, Montana. (Courtesy of Place Architecture LLC, Bozeman, Montana, and Berkebile Nelson Immenschuh McDowell Architects, Kansas City, Missouri. Redrawn by Jonathan Meendering.)

(j) Manage storage

- Storage is used to help balance needs and resources across time
  - Rainwater cisterns, wind-generated electricity, heat storage (floor, wall)

Fig. 1.23 *Manage storage. The 2007 MIT Solar Decathlon house features a Trombe wall made of translucent tiles to capture and store heat. (© Alison Kwok; all rights reserved.)*