ARUP's Environmental Strategies

Engineering + Sustainability + Architecture

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based on a lecture by
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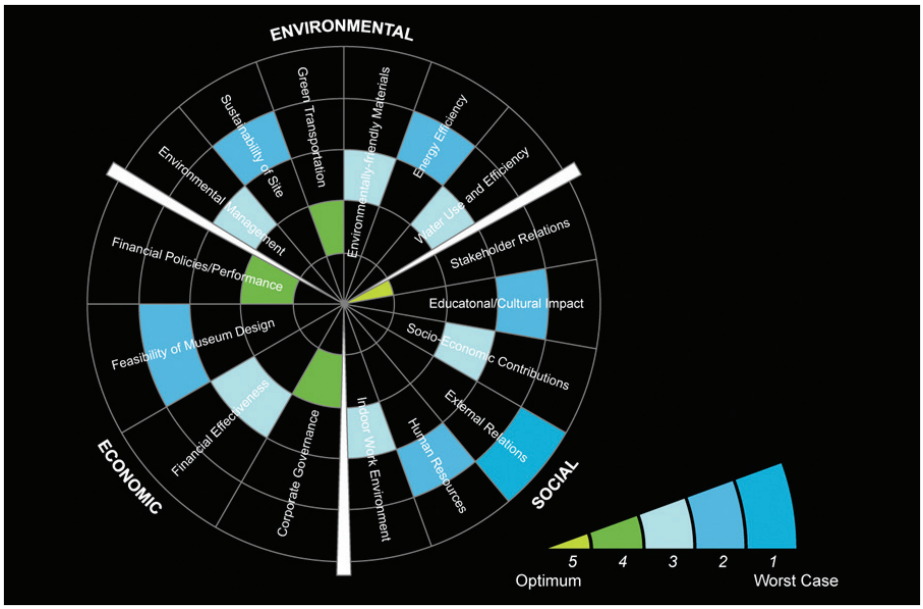

Fig. 01 ARUP's SPeAR Diagram

ARUP Overview

Arup was founded 63 years ago by Sir Ove Arup, and his ideals and principles are still the driving forces within the firm. One of his primary design attitudes is called 'total architecture', or the integration of the design and construction processes and the interdependence of all the professions involved in order to create the best designs. Currently, ARUP employs about 10,000 designers, planners, management consultants and economists in 90 networked offices located in 37 countries. Due to the large staff and multidisciplinary approach, Arup is able to provide a broad range of services in a variety of project types for clients worldwide.[1]

As Arup's body of work over the past twenty years has begun to include a focus on energy strategies and providing environmental consulting services as well as traditional engineering and project management, the firm has developed particular strategies stemming from Ove Arup's integrated approach to universally assess and tailor their sustainable strategies for specific projects. The Sustainability Project Appraisal Routine (or SPeAR) software was developed to allow companies to demonstrate and improve on the sustainability of a product, project, or their organization's performance and to visually display a 'score'. As Arup's marketing material states, "The overriding aim of SPeAR is continual improvement in project performance in delivering sustainable development objectives. Arup is using SPeAR successfully on many diverse projects, providing feedback to owners, designers and users."[2] Projects are evaluated based on environmental, societal, economic, and natural factors related to sustainable development and the SPeAR scores are taken throughout a project's conception and development, to appraise the

sustainable strategies at play and their interrelated impacts, allowing both clients and designers to understand the holistic implications of their choices.

Arup provides a wide range of services for various scales of projects worldwide. Three of the firm's most innovative projects with regard to sustainable strategies will be discussed in depth as case studies of interesting environmental and energy strategies.

San Francisco Federal Building

The 652,000 square-foot San Francisco Federal Building, designed by Morphosis Architects, was conceived to integrate the local climate into the design and take advantage of wind-driven cross-ventilation. The form of the building, with its narrow tower profile, is designed to use natural ventilation techniques for most of its occupants' working areas rather than traditional air conditioning systems. As a result of the architectural vision and the integration of sustainable strategies applied across the structural, mechanical, and electrical systems, over 70 percent of the working area is naturally ventilated and 90 percent of the building's 1,500 federal employees enjoy natural light and operable windows near their workstations.[3]

The 18-story building facade was designed with a 'living skin' that breathes to cool the interior, while building systems monitor the interior temperature and pressure and trigger automatically operable floor-level vents to maintain a comfortable environment inside the building. At night when the outside temperature is cool, the automated building system opens the metal facade and allows the warm air collected during the workday to escape, bringing in fresh air and utilizing the thermal mass of the building's uniquely wave-shaped concrete slabs to keep the interior cool throughout the next work day. With the high-performance techniques employed at the San Francisco Federal Building, the GSA has enjoyed a 50 percent energy savings over a traditional building of the same size.[4]

Fig. 02 San Francisco Federal Building

In line with Arup's goal of attempting to perform well in all categories of the SPeAR system, the San Francisco Federal Building focused not only on the environmental and economic components to sustainability, but on the social one as well. Situated at the south end of the San Francisco Civic Center, the building is part of a process of urban renewal in a transitional neighborhood. The new federal presence has become a dominant force that has helped to bring much needed attention to the neighborhood landscape of run-down buildings, struggling local businesses, and criminal activity. Streets and sidewalks were repaved and private developers have begun building new projects in the area. The public has benefited from a large, protected, sun-filled plaza paved with a permeable, decomposed granite surface that allows rainwater to percolate back into the earth after rainfall. This prevents city sewers from being overloaded with surface-generated runoff pollutants that would otherwise drain into the San Francisco Bay.[5]

Within the building, elevators only stop on every third floor, promoting employee interaction and health, as well as a comprehensive awareness of demand-side energy reduction measures. Employees also enjoy informal gathering spaces throughout the building, such as the three-story open-air sky garden on the

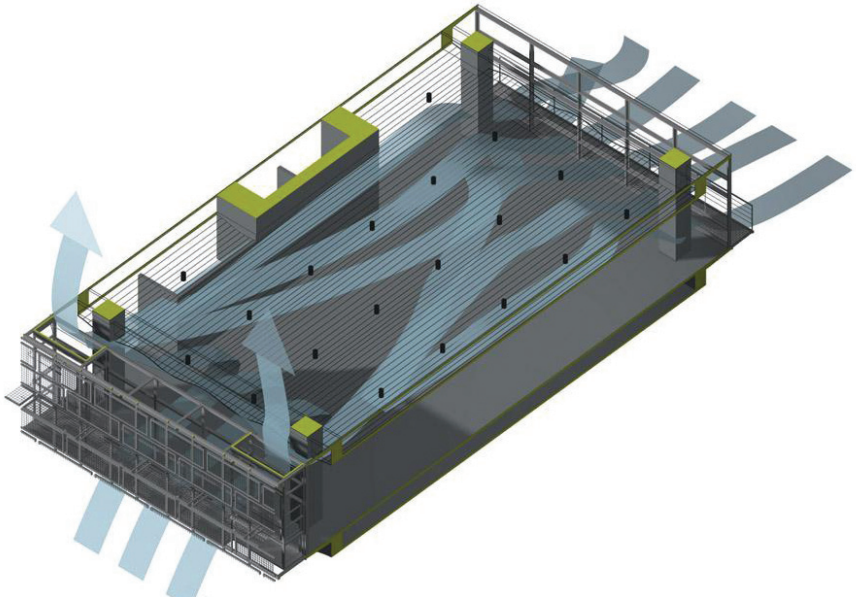

Fig. 03 Air Circulation Diagram

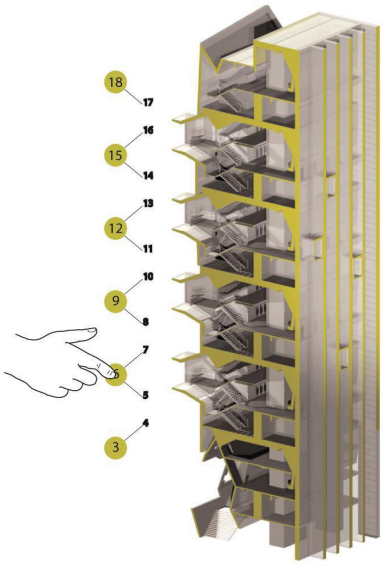

Fig. 04 Skip-stop Elevator Diagram + Wave-Ceiling Form

11th floor, which allows for social interaction and the ability to enjoy breaks outside without leaving and reentering the regulated security of a federal building.[6]

The San Francisco Federal Building is a good example of Arup's integrated approach to sustainability, wherein the structural, environmental, and mechanical engineering all worked in tandem with the architectural design to create a unique, spatially-interesting, and energy-efficient place. Although lauded in architectural and environmental circles, some occupant-based criticism of the building has come out over the past two years since the building was opened. As published in the San Francisco Chronicle, workers have complained about the lack of operable internal climate controls. Instead of having the ability to modify their thermal environment, they must react to the automated building system's whims. When its sensors automatically open the facade to let in fresh air, papers are sent flying due to the unexpected draft. It was also reported that employees have resorted to using umbrellas to shade their workspaces when the automated perforated metal shading screen is not aligned to the sun's position.[7]

While these criticisms are certainly valid from an experiential point of view, it is certain that they have more to do with the building system's careful tuning and typical employee discontent than wholesale problems with the energy strategies and innovative design of the building. Overall, the Federal Building is successful in its commitment to employing natural flows for ventilation, and serves as an environmentally, socially and climatologically situated example of a new type of office tower for the United States.

California Academy of Sciences

Also located in San Francisco, the 410,000 square-foot California Academy of Sciences building, designed by Renzo Piano Building Workshop and which opened in late 2008, is a pedagogical and physical representation of environmental conservation and as such entailed an innovative, integrated sustainable design approach over a seven year period. Conceived as a physical materialization of the Academy's mission to study, store, and exhibit the wonders of natural science,[8] the project is the largest public LEED Platinum building in the world.

The main architectural statement of the building, the undulating living roof, plays a critical role in the building's performance, reducing stormwater runoff by 98 percent, providing thermal insulation, and creating a 2.5 acre habitat for 1.7 million Californian plants, insects, and birds. The circular skylight

Fig. 05 Aerial View of California Academy of Sciences

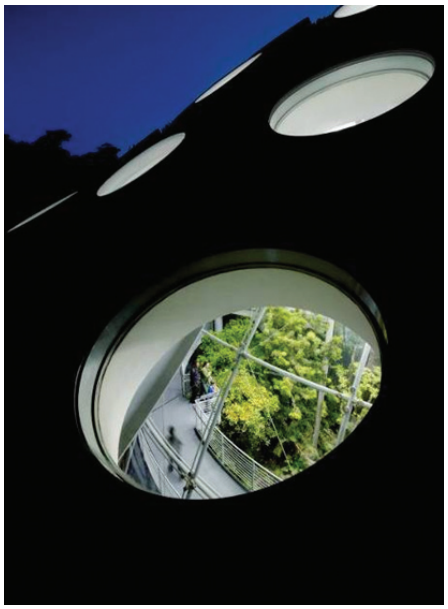

Fig. 06 View through a roof portal into the Rainforest

penetrations in the 'hills' of the greenroof are controlled by an automated system which opens and closes them to naturally ventilate the exhibition spaces underneath. A solar canopy wrapping around the perimeter of the building contains more than 55,000 photovoltaic cells that can generate over 200,000 kilowatt hours of power each year. The building consumes 30 to 35 percent less energy than required by California's already strict building code.[9] The public program of the Academy is quite complicated and includes an aquarium, a planetarium, a natural history museum, and a four-story rainforest within the building. It also houses over 70,000 live animals in its many exhibits that showcase ecosystems from around the globe, including the largest artificial coral reef in the world. In addition to its public program, the Academy also supports the efforts of 46 world-class scientists and hundreds of researchers in eleven fields of study.[10]

In addition to the coordinated innovative environmental techniques employed by Arup at the Academy, the building takes advantage of a variety of basic sustainable building strategies, including recycling 90 percent of the demolition waste, employing a heat-recovery system to capture and reuse heat generated by the HVAC system, using radiant heated floors, focusing on daylighting the interior spaces, and reducing the need for potable water by using low-flow fixtures and reclaimed water by the City of San Francisco. Total potable water usage is 22 percent less than code requirements.[11]

Arup's scope of work on the California Academy of Sciences included structural and building services engineering, fire engineering, acoustics consulting, LEED consulting, lighting design, and sustainability advice and life cycle analysis. Arup's careful tweaking of the free and natural resources available enabled most of the building's spaces to be naturally lit and ventilated, which is a key aspect to the Academy's sustainable strategies. Due to the climatic conditions of San Francisco, both the rainforest and coral reef required supplemental electric lighting to complement the daylight that permeates throughout the exhibit space.

Computational fluid dynamics (CFD) were used to develop air-circulation models for each of the spaces independently, and to maintain temperature and air speeds within comfortable ranges. The main exhibit hall is one of the largest naturally ventilated exhibit spaces in North America, and is controlled with dynamic sensors and a radiant floor. During project development, extensive CFD studies provided an assessment of the natural ventilation schemes to maintain temperatures and air speeds within a comfortable range. The natural ventilation strategies at work in the main exhibit

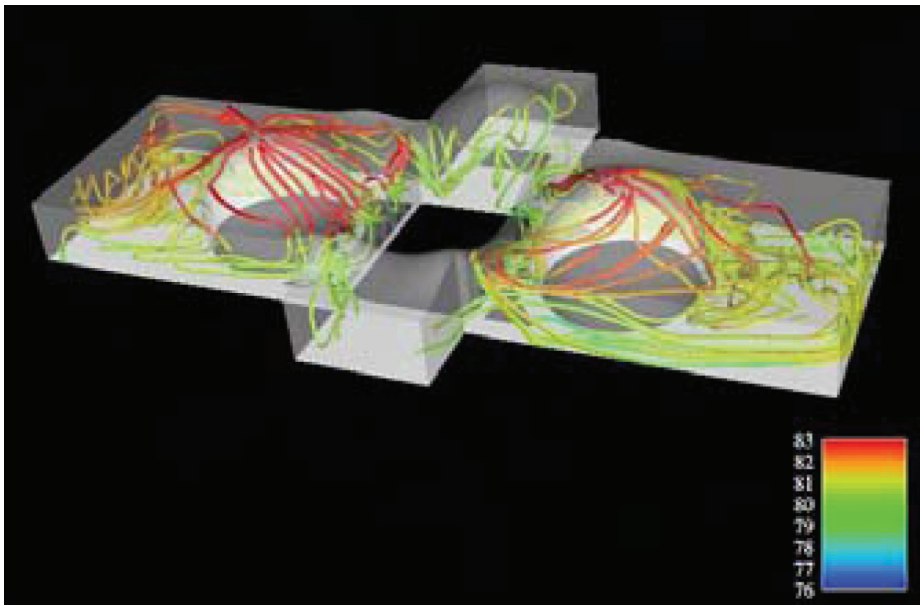

Fig. 07 CFD Model of the California Academy of Sciences

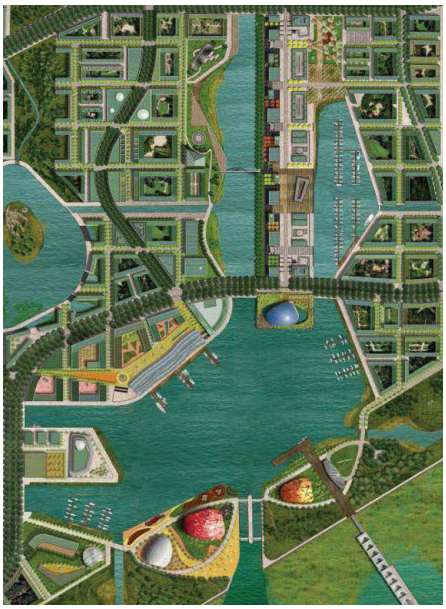

Fig. 08 Dongtan Eco-City Plan

hall will maintain temperatures at comfort levels for both peak summer and winter conditions, and will provide a ventilation effectiveness higher than 0.9.[12]

The California Academy of Sciences is a state-of-the-art pedagogical and representational example of integrated sustainable design. The building employs a variety of low-impact and effective techniques that address the environmental component of Arup's SPeAR tool, but the mission and position of the Academy as well as its ability to influence visitors' opinions about the ecosystem also affects the social component as well. While Arup has effectively proven that it can work holistically with a design team on pushing the envelope of environmental design with regard to a single building, its urban-scale projects provide new opportunities for full-energy-cycle planning and production.

Dongtan Eco-City

Due to its rapidly growing population, China is founding new cities at an unprecedented rate. Arup is at the forefront of a reconceived type of city making, merging high-performance energy production with advanced sustainable design techniques implemented simultaneously at the infrastructure, urban, and building levels.

Dongtan city is located on the southeast side of Chongming Island, which will soon be connected to the Shanghai metropolis with a new bridge and tunnel. The Dongtan city site is 8,600 hectares, which is roughly 3/4 the size of Manhattan. The city is planning to be able to accommodate 500,000 people on 3,000 hectares by 2050. The comprehensive urban development plan includes only building out 40% of the land, preserving the rest for wetlands, energy production, and agricultural area. Within the comprehensive plan of the island, Dongtan will be transformed into a green city that will have as little negative impact on its surrounding environment as possible.

Arup has conceived Dongtan city to be truly sustainable, addressing all components of the SPeAR diagram - environmental, economic, and social. All of Dongtan's housing will be within a 7-minute walk of public transportation and will have easy access to public resources such as hospitals and schools. By employing a combination of traditional and innovative techniques, the energy demand for the building stock will be reduced by about 66% compared to conventional new buildings in China, and will save 350,000 tons of CO_2 per year. The planned Dongtan city buildings will be naturally ventilated to reduce energy demand, will employ planted green roofs to improve insulation and water filtration, and will provide potential storage for irrigation.

Fig. 09 Lake View Of Dongtan Eco-City

Through sustainable design, planning, and construction techniques, the city hopes to be entirely self-sufficient, generating all its needed energy from on-site renewable resources, growing all its required food on-site and recycling all its waste.[12] Dongtan's energy supply will be via a localized grid and electricity and heat will by produced using a combination of renewable resources, including a combined heat and power (CHP) plant which will run on biomass from rice husks and other agricultural waste, an extensive wind farm, anaerobic digesters generating energy from bio-gas, sewage, and food waste, and on a micro-level using building-integrated photovoltaics.

A part of the electricity generated on-site will be used to recharge electric vehicles or produce hydrogen for fuel cells. One key tactic of energy management in Dongtan city will be providing direct feedback to its inhabitants including smart metering for its housing stock and financial incentives to encourage energy saving measures. The planned visitor's center, which will be located close to the energy production center, will display and illustrate how cities can achieve sustainability from an energy-management point of view. The design team of Dongtan city has set a goal of reusing 90 percent of the city's collected waste. Because of the energy production techniques that will be employed at Dongtan, waste is considered a resource, and will be used as fuel. There are no planned landfills for the city, as even human sewage will be processed for energy recovery, irrigation, and composting.[13]

According to Arup's models, the energy demand in Dongtan will be substantially lower than comparable conventional new cities. At the building level, this will be achieved by specifying high thermal performance and using energy efficient mechanical equipment to encourage users to save energy. Transportation energy demand will be low due to walkable communities as well as the ban on vehicles using internal combustion-engines.

The site for Dongtan city is adjacent to a wetland site of international importance for wildlife and migrating birds. The delicate nature of the Dongtan wetlands has been one of the driving factors of the city's ecologically-sensitive design. An important part of Arup's conception of the project is to protect and enhance the existing wetlands by returning agricultural land to a wetland state and creating a 3.5 kilometer buffer-zone between the city and the mudflats, intending to protect the wetlands from any pollution (light, sound, emissions, and water discharge) from the urban development area.[14]

Through a series of policy incentives and the implementation of a zero-

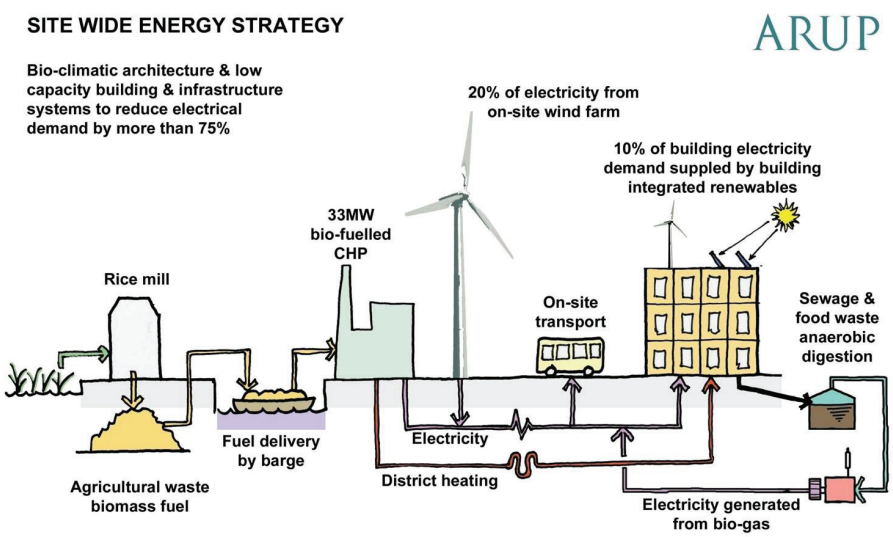

Fig. 10 Dongtan Energy Strategy

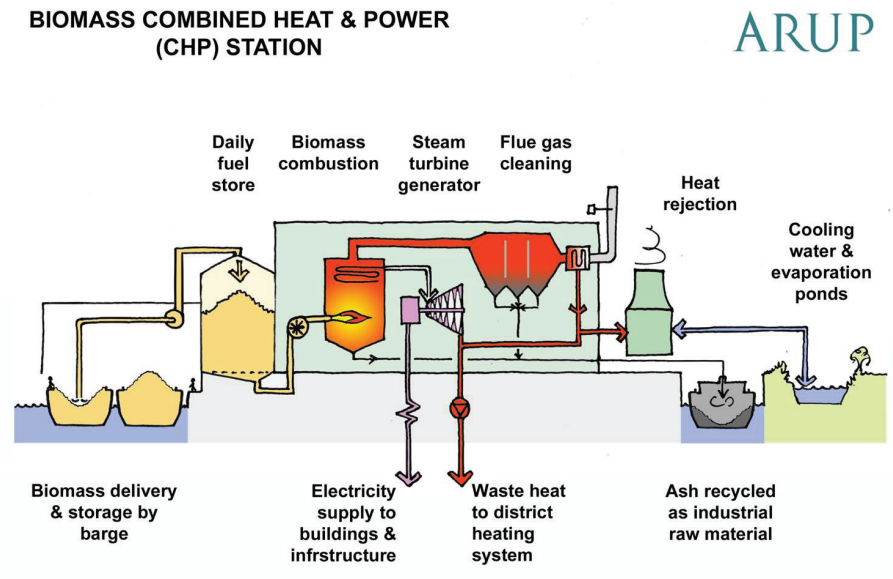

Fig. 11 Dongtan CHP System

emission transport zone, Dongtan will enforce strict environmental policies on a social as well as an environmental level. Only battery or fuel-celled vehicles will be allowed within the city zone, preventing a significant amount of transportation-related emissions. All farmland within Dongtan will employ organic farming methods to grow food for the city's inhabitants.

Dongtan city will be compact, made up of only three villages, reducing infrastructure costs as well as improving the impact and efficiency of amenities and public transportation systems. The city will be linked by a combination of bicycle paths, pedestrian routes, and varied modes of public transit, including water taxis and hydrogen fuel-cell powered busses. Visitors to the city will park their cars outside and use public transit to access their destinations within Dongtan.

Although some of Dongtan city's inhabitants may choose to commute to Shanghai for work, the aim is to create employment for the majority of Dongtan residents across all social and economic demographics. This is a goal that intends to address all components on Arup's SPeAR diagram, increasing the synergies of the project for everyone's benefit. A key initiative is the intent to found the Dongtan Institute for Sustainability. It is hoped that the Institute will become one of the world's centers for "examining the connection between the environment and economic performance on the one hand, and the technological solutions to sustainability challenges on the other."[15] Arup intends the Institute to be a key attractor of businesses associated with sustainability as well as residents to Dongtan city.

The construction process of building Dongtan city will be as sustainable as the completed city itself. Labor and materials will be sourced locally to reduce transportation and embodied energy associated with construction.

Although still not yet under construction, despite a 2010 first-

phase completion goal, Dongtan city is still remarkable in its aspirations. Due to significant and unprovable claims regarding Dongtan, Arup has come under harsh criticism for publicly promoting its as-yet-unbuilt project, earning the Ethical Corporation's "Greenwasher of the Year" award for 2007.[16]

In a 2008 interview, Arup's Director for Global Foresight and Innovation, Chris Luebkeman, said, "It's not a matter of this or that project compensating for all future change – every little bit has to help. What we are trying to do with projects like Dongtan, and eco-city projects elsewhere, is to continually raise the bar."[17] Treehugger.org wrote a critical yet revealing post about the project at the beginning of 2009, concluding that perhaps Dongtan serves enough of a purpose in its conception, regardless of its construction. They conclude, "Dongtan's plan and concepts have in fact raised the bar in the theoretical discourse about eco-city planning, and have influenced plans for other new eco-developments that are currently being built. Just by existing in its paper form, Dongtan has a lot to teach the world about the art and science of planning green cities."

Conclusion

While Arup is involved in a significant amount of cutting-edge sustainable design, engineering, and planning work which deserves praise, the reality of the portfolio of such a large firm is that much of their workload does not include sustainability as a goal. While one of their services is advising clients about sustainable corporate responsibility, perhaps they should also turn that lens inward and assess how much of their portfolio is truly integrated in an ecologically-oriented manner.

The SPeAR system appears to be a fine tool, provided that at least there is some accountability and transparency of how projects, portfolios, or industrial processes are scored. This legibility is not apparent from simply seeing the diagrams, and it seems it may suffer from a similar criticism as LEED, a ranking system where point values are somewhat arbitrary and based on changing current market conditions. While addressing the social component of sustainability within the SPeAR tool is laudable and a key portion of the Brundtland definition of sustainability, it is unclear how these values are ranked and what points of view are accounted for.

While Michael Sweeney, as a representative of Arup and attempting to whittle down his presentation to the firm's "most sustainable" projects, carefully chose which projects to show UTSoA, it is curious that he would include Dongtan without addressing any of the criticism or explaining an updated timeline. It appears as if he may not have been aware of these issues related to the project, and while that speaks to how large a firm Arup is, it is also telling about how little many of its own employees may know about the firm's own practices.

Notes

1. "Introduction to ARUP" brochure, provided by ARUP Los Angeles.

2. "SPeAR for Projects" brochure, provided by ARUP Los Angeles, originally published and presented at Greenbuild 2003.

3. from Michael Sweeney's presentation to UTSoA on 2 November 2009.

4. Morphosis project website, Morphopedia: http://www.morphopedia.com/projects/san-francisco-federal-building

5. GSA website SF Federal Building overview: http://www.govexec.com/pdfs/green/080108gsa.pdf

6. Morphosis project website, Morphopedia: http://www.morphopedia.com/projects/san-francisco-federal-building

7. "San Francisco's Green Building Nightmare," San Francisco Chronical (3 March 2008): http://www.beyondchron.org/articles/San_Francisco_s_Green_Building_Nightmare_5428.html

8. California Academy of Sciences Website, http://www.calacademy.org/academy/about

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11. "California Academy of Sciences" brochure, provided by ARUP Los Angeles.

12. "Ultimate eco-city", World Architecture News Websites (09 Apr 2008), http://www.worldarchitecturenews.com/news_images/Dongtan.pdf

13. from Michael Sweeney's presentation to UTSoA on 2 November 2009.

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16. "Arup and Dongtan, Worthy Winner of Greenwasher of the Year," Ethical Corporation Newsletter (December 2007): http://www.ethicalcorp.com/content.asp?ContentID=5552

17. "Dongtan, China's Flagship Ecocity Project, R.I.P.," Treehugger.org (5 January 2009): http://www.treehugger.com/files/2009/01/dongtan-ecocity-modern-shangri-la.php

18. "Dongtan, China's Flagship Ecocity Project, R.I.P.," Treehugger.org (5 January 2009): http://www.treehugger.com/files/2009/01/dongtan-ecocity-modern-shangri-la.php

Figures

Cover Figure: Dongtan City Perspective, provided by ARUP Los Angeles

Figure 01: from Michael Sweeney's presentation to UTSoA on 2 November 2009

Figure 02: provided by ARUP Los Angeles, (c) Cody Andresen

Figure 03: from Morphosis project website, Morphopedia: http://www.morphopedia.com/projects/san-francisco-federal-building

Figure 04: from Morphosis project website, Morphopedia: http://www.morphopedia.com/projects/san-francisco-federal-building

Figure 05: provided by ARUP Los Angeles

Figure 06: provided by ARUP Los Angeles

Figure 07: from Michael Sweeney's presentation to UTSoA on 2 November 2009

Figure 08: provided by ARUP Los Angeles

Figure 09: provided by ARUP Los Angeles

Figure 10: from Michael Sweeney's presentation to UTSoA on 2 November 2009

Figure 11: from Michael Sweeney's presentation to UTSoA on 2 November 2009