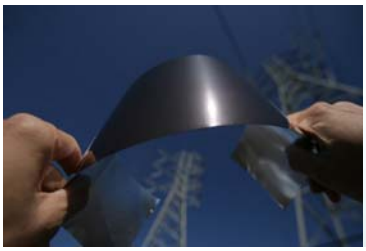
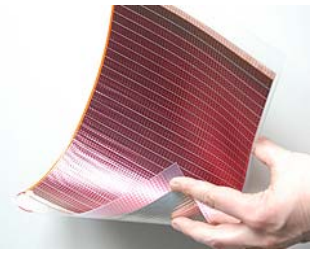
ONSITE & RENEWABLE POWER

Onsite and renewable electricity generation opportunities have been organized into 2 categories: building scale installation and demonstration scale installation. Building scale consists of technologies that will educate, but are supplying significant portions of the building energy requirements. Demonstration scale refers to technologies that are either new and experimental or are not appropriate for our site. Many generation technologies are highly site specific.

BUILDING SCALE INSTALLATION

Thin Film BIPV at Roof Screen





Annual electricity generation is generally maximized for surfaces at a tilt of latitude, plus or minus 10 degrees. As such, the greatest opportunity for the use photovoltaic technology is to integrate it into the roof screen. The current design includes a pliable construction, likely using a EFTE product. With this design, a flexible thin film technology is the most appropriate PV technology to apply.

Some of the issues that should be considered include:

- Thin film has a lower efficiency than rigid mono and poly crystalline options (5%-7%).
- Though integrating into the building fabric can reduce cost, all PV products are still expensive ($8-$10 per watt).
- PV should only be located where no shading occurs and should be primarily at flat or southernly tilted surfaces.
- PV is a solid state technology and is not expected to increase maintenance.
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
    - 30% federal tax credit; no limit - Business Energy Tax Credit
    - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
    - $4/kW per installation with a maximum of $100,000 – Solar Energy System Incentives Program
    - Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

There are many thin film PV options available; the following are the most appropriate for this application.

	Type	Efficiency	Notes
SolarNext	Thin Film	5%	Designed specifically for ETFE products
Nanosolar	CGCI	14%	Next Generation Organic

PV at Solid Roof

Another excellent opportunity for the use of PV is to apply it to any solid horizontal or southernly tilted opaque surfaces; particularly the roofs over the atrium and shafts for daylight and natural ventilation. The current design is showing potential solid roofs above the atrium, administration, gallery, and entertainment suites. There are no unique requirements for these PV panels, so any PV technology will suffice. These locations provide an opportunity to utilize the highest efficiency units in order to maximize the total generation or utilize the most cost effective units ($/kWh generated) to optimize the financial performance.

Some of the issues that should be considered include:

- PV can be building integrated (roof tiles) or traditionally building mounted units.
- Venting the backside of the PV should be considered to increase PV efficiency.
- All PV products are expensive ($8-$10 per watt).
- PV should only be located where no shading occurs with optimum tilt at 15-30°.
- PV is a solid state technology and is not expected to increase maintenance.
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
    - 30% federal tax credit; no limit - Business Energy Tax Credit
    - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
    - $4/kW per installation with a maximum of $100,000 – Solar Energy System Incentives Program

- Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

All PV technologies are sufficient for this application; the following is a short list of the many PV options available.

	Type	Efficiency	Notes
Sunpower	Mono	18%	Best efficiency on market
GE	Poly	14%	
BP Solar	Poly	13%	
Nanosolar	CGCI	14%	Nest Generation Organic

PV at Southwest Wall

Due to the extensive and purposeful building shade, the southwest façade is the only remaining significant location where there is a potential for applying PV technology. A vertical installation would reduce the production by more than half. As a result, an array of PV could be to mounted, each at a tilt, insuring minimal shading from one to the next. With the exception of the entertainment suite at Level 4, this façade borders mechanical rooms.

Some of the issues that should be considered include:

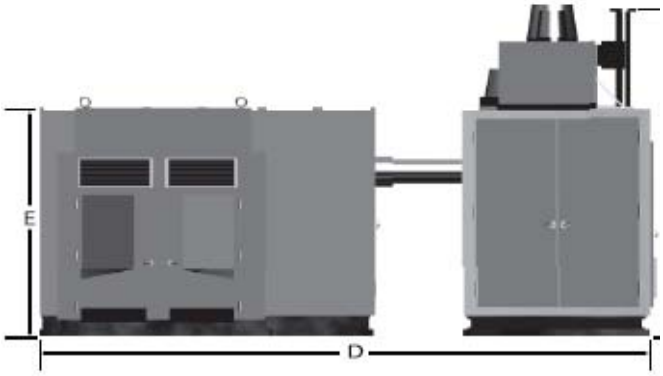
- PV should be carefully located to insure minimal shading from one panel to the next; the optimum tilt is between 15-30°.
- Transparent thin film PV could be used which would allow roughly 10% of the light to pass through onto the wall or window surface.
- All PV products are expensive ($8-$10 per watt).
- PV is a solid state technology and is not expected to increase maintenance.
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
  - 30% federal tax credit; no limit - Business Energy Tax Credit
  - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
  - $4/kW per installation with a maximum of $100,000 – Solar Energy System Incentives Program

- Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

All PV technologies are sufficient for this application; the following is a short list of the many PV options available.

	Type	Efficiency	Notes
Sunpower	Mono	18%	Best efficiency on market
GE	Poly	14%	
BP Solar	Poly	13%	
Schott	Thin film	5%	Transparent; 10% VLT
Nanosolar	CGCI	14%	Nest Generation Organic

Fuel Cell with Absorption Chiller & Desiccant Regeneration



Combined Heat and Power (CHP) generally refers to cogeneration where waste heat from the electrical production process is used for building heat. An augmentation to this strategy is often referred to as trigeneration and uses an absorption chiller to also provide cooling from the waste heat.

The proposed fuel cell based CHP trigeneration system generates electricity at a roughly 50% higher efficiency than the local power plants, utilizes the majority of waste heat to produce chilled water, regenerates the desiccant dehumidification systems, and provides domestic hot water. In addition, the fuel cell is virtually pollution free and is quieter than a vacuum cleaner. Overall, this system significantly reduces the environmental footprint of the project.

The configuration would include a natural gas served fuel cell in the 200-400kW range combined with a double effect absorption chiller in the 100 ton range.

Some of the issues that should be considered include:

- Per 100 kW of installed fuel cell capacity, 750,000 pounds of CO_2 and over 8000 pounds of NO_x and SO_x are eliminated.
- Fuel cells are still a very expensive option ($3500-$4500 per kW).
- Fuel cells and absorption chillers are not expected to increase the amount of maintenance, though these are not industry standards.

- Absorption chillers are more sensitive to varying load changes than electric chillers. This is not an issue with this design. The absorption chillers comprise less than 20% of the total installed chiller capacity and will be baseloaded insuring a consistent load.
- Double effect absorption chillers (400 degree input) have a source energy COP (efficiency) lower than electric chillers; 1.6 compared to 2.0 for electric chiller.
- Natural gas service is required for the desiccant regeneration system
- There is a possibility to eliminate the diesel back up generator by utilizing the fuel cell with on site propane or other storable fuel. The fuel cells are capable of multiple fuel types and have been shown in tests to adequately switch for emergency power. However, this technology is still under development and there are concerns with on site storage of fuel.
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
    - 30% federal tax credit; $3000/kW - Business Energy Tax Credit
    - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
    - 75% of installation and operating costs; maximum of $12,000 – Renewable Energy Technologies Investment Tax Credit
    - Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program
- 3rd party ownership of fuel cell is a typical financial setup and may want to be investigated.

The following is a short list of fuel cell options available.

	Type	Efficiency	Notes
Fuel Cell Energy		47%/80%	Best electrical efficiency
UTC		42%/90%	Optionally Packaged with absorption chiller

DEMONSTRATION SCALE INSTALLATION

Site-Mounted & Building Mounted Wind

The existing wind data, based on the airport weather, and the broad wind classification define our site to have a poor wind resource. This level of wind resource will result in no significant electricity generation. However, the recently installed weather station will provide more site specific data.

Beyond the wind resource, installations of wind turbines are difficult in urban areas due to the inherent turbulence in the air. Wind turbines of all types, though certain designs claim to handle the urban environment better than others, need “clean air.” Thus a proper installation will require a hub height to be a minimum of 10 – 20 meters above the structure, though this value will have to be further investigated.

Due to these concerns, wind turbines are not expected to provide building scale power generation. At a demonstrative level though, wind turbines are a highly visible element and are an important technology for the future energy market. As such there are significant educational benefits to the inclusion of wind turbines.

Some of the issues that should be considered include:

- Wind turbine opportunities are primarily at the roof or site mounted. They must be outside of the “wind shadow” of the building or other structures.
- Wind Turbines generally require annual maintenance similar to an automobile
- Expecting between 750-1000 kWh generated per installed kW.
- Hurricane concerns must be taken into consideration
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
    - 30% federal tax credit; no limit - Business Energy Tax Credit

- $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
- Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

Onsite Generation from Algae Harvested Bio-Diesel

Bio-Diesel harvested from algae is a proven technology; at a large scale. In theory, CHP strategies could be applied using the bio-diesel fuel and a generator or turbine.

The algae harvesting process is highly space intensive, even the newer considerable condensed algae harvesting machines require significant space on our site or within the building. Furthermore, the operations of system are highly unique and would require very specific training and on going maintenance.

Due to these concerns, algae harvesting is not recommended at a building scale. At a demonstrative level though, the process and concepts are extremely engaging; it is an example of “farming energy” and is an opportunity to very clearly and directly connect the environment with energy resources. Like wind, biomass is important technology for the future energy market and there are significant educational benefits to the inclusion of the algae to bio-diesel process.

Some of the issues that should be considered include:

- Area intensive
- Significant operations and maintenance at a building scale
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
  - 10% federal tax credit; no limit - Business Energy Tax Credit
  - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
  - Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

Onsite Generation from Solid Waste Generated Bio-Gas

Bio-Gas generated from solid waste digesters is a proven technology. There are a number of successful applications where these digesters drive a fuel cell or CHP configuration. These applications, however, have almost exclusively been located at waste treatment plants or breweries where the scale of waste treatment was significantly larger.

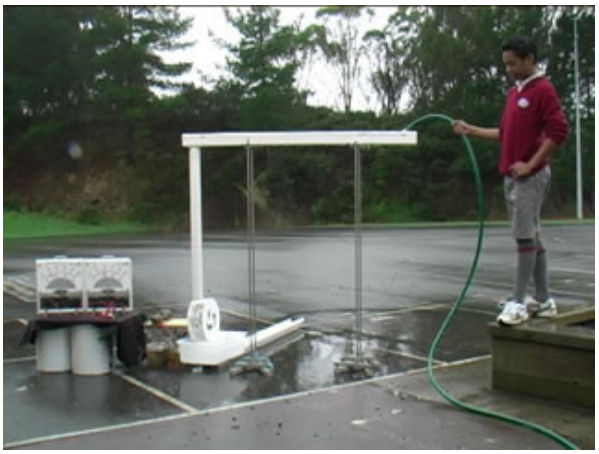
The solid waste digesters need a considerable volume of building area, typically the basement, to breakdown the solid wastes. Furthermore, the operations of system are highly unique and would require very specific training and significant on going maintenance.

Due to these concerns, solid waste digesters are not recommended at a building scale. At a demonstrative level though, the process and concepts are extremely engaging; it is the ultimate example of turning waste into energy and is an opportunity to very clearly and directly express the full circle of consumption. Like wind, biomass is important technology for the future energy market and there are significant educational benefits to the inclusion of the algae to bio-diesel process.

Some of the issues that should be considered include:

- Building area intensive
- Significant operations and maintenance at a building scale
- A brief review of the current federal and state incentives identified the following as potential options. All programs have maximum program expenditures that may restrict claims.
  - 10% federal tax credit; no limit - Business Energy Tax Credit
  - $0.01/kWh per year state tax credit; no limit – Renewable Energy Production Tax Credit
  - Matching Grants per installation; amounts vary ($15,000,000 to spend per year) - Renewable Energy Technologies Grants Program

Rainwater Microturbines

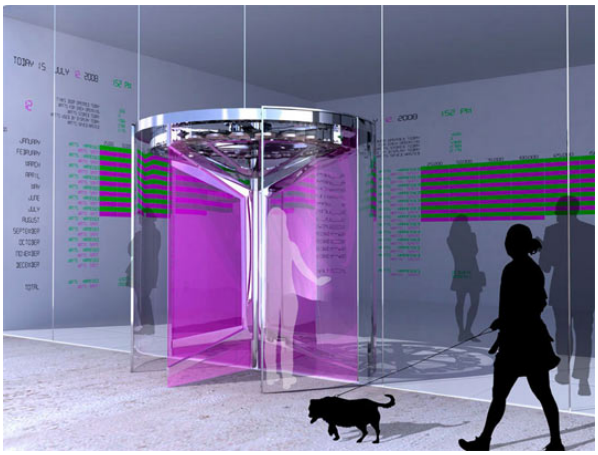


When evaluating what natural resources the local climate offers, rain is a significant resource. Though harvesting the energy form the collection of nearly 4 million gallons of water is relatively insignificant, the demonstration of energy transfer is an engaging element.

Piezoelectric Sidewalks

Piezoelectric materials generate electricity from being deformed. The leading application to use these materials for energy generation is to harvest energy from human activity – walking. This technology is currently under consideration for train stations and airports. It is experimental, but would certainly be an excellent demonstration at the energy playground.

Revolving Doors



Similar to the piezoelectric sidewalks, power generation from revolving doors is attempting to convert energy from day to day human activity into electricity for use. All revolving doors have “brakes” that keep the door from rotating too quickly. The brakes have been replaced with a small generator. The power generation is not significant, but it again is a great demonstration of energy conversion.