# Best Practices for Large Urban Solar Energy Installations

Version 2.0 - January 2012

Technology

Monitoring

Best Practices

SolarCity Partnership

This feasibility study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

## About the SolarCity Partnership

The SolarCity Partnership is a joint initiative of the Toronto Atmospheric Fund, Toronto and Region Conservation Authority and the City of Toronto designed to promote best practices and careful monitoring of large solar installations. SolarCity Partnership is an information-sharing hub for both public and private organizations involved in deploying solar power. Our **SolarCityPartnership.ca** website provides case studies, research, and solar weather data to help with the effective use of zero emissions energy from the sun.

### We want to hear from you!

If you have further best practices recommendations, insights into system design, deployment or maintenance or a project to profile, please get involved with the SolarCity Partnership! Contact us at:

**info@solarcitypartnership.ca**

**289-268-3902**

*Cover photo: A 175 $kW_t$ evacuated tube solar thermal system on Toronto Community Housing seniors residence. Photo by Lyle Jones. Right: 3.2 kW photovoltaic system at Fire Hall 334. Centre: Evacuated tube solar water heating system at 24 Forest Manor Road. Photo by Lucio Mesquita. Far right: 67 $kW_t$ glazed solar pool heating system on Albion Pool and Health Club. Photo by Danielle Murray.*

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*93 $kW_t$ solar pool heating system on Rotary Park outdoor pool. Photo: Lucio Mesquita*

# Getting the most from your large urban solar installation in 10 important steps!

1. **Thinking of installing a solar thermal or photovoltaic generation system?** Do a preliminary feasibility study to assess the initial viability for the project, and whether you have the right site, application and necessary human and financial resources at your disposal.
2. **Your plans looking generally feasible?** Invest some up-front seed money in a full-scale feasibility study to thoroughly review your opportunity and costs and to begin building the funding and technical partnerships you will need.
3. **You have a clear, viable option for your solar installation?** Time to do a careful and detailed purchasing document to secure the best services possible to turn your vision into reality.
4. **Getting down to brass tacks with system design?** Be sure to acknowledge and act on the fact that the solar system will need to be integrated with all the other building and safety systems at the site — take an integrated approach to ensure your plan is implemented with excellence.
5. **Plans ready?** Don’t forget to build a monitoring plan to make sure your investment will be well supported over time — this thing is going to be around for 20 plus years!
6. **Time to call in the cranes?** Before you do, make sure you’ve got all the necessary permits and that someone is assigned to coordinate all the parties to avoid construction delays.
7. **System installed?** Take some photos and have a glass of something special! Now make sure it’s all working properly by having a commissioning inspection and correcting any issues that may be identified in both the generation and monitoring systems.
8. **Up and running!** Of course you want to know just how much energy you are getting from your investment and you also want to make sure that if blips in energy production do occur — and  trust us they will — you can quickly identify and correct problems to avoid loss of income or costly equipment damage. Be sure also to understand and implement any basic maintenance routines, including training the on-site operators so they can incorporate these into their workplans.
9. **Capture your experience** — the good, the bad and the ugly — and share it with solar industry members and other facilities managers because you are a solar leader and you want to help those who follow to maximize their success.
10. **Shout from the rooftop — or pool deck.** Successful renewable energy installations bring many community benefits. Be sure you tell the public about your successful efforts.

## 1. Pre-Feasibility Study

A pre-feasibility study serves as an early screening tool to briefly examine and assess the opportunities and challenges of a proposed solar installation. The results of the pre-feasibility study determine whether or not the proposed installation should be considered in more detail. The pre-feasibility study should include:

- An **estimate of the solar resource** available at the site
- **Preliminary shading analysis** (shade from existing elements and/or from potential future development – check with local planning department regarding local zoning and/or development proposals for adjacent sites)
- An **estimate of solar system size** (unobstructed installation space)
- **RETScreen analysis** or similar feasibility and performance analyses must be undertaken. The analysis must use local insolation and weather data over at least 20 years and include realistic assumptions for array loss factors (such as those recommended by the California Energy Commission). A factor of 16% has been shown in SolarCity assessments of rooftop PV systems to be a conservative estimate of array losses, exclusive of shading.
- **Preliminary heat load analysis** (solar thermal installations)
- **General assessment of roof condition** (type and age of roof, next planned re-roofing)

*87 $kW_t$ solar thermal system at Gihon Spring outdoor pool. Photo by Lucio Mesquita.*

- Review of project **eligibility for government incentive programs**
- **simple financial analysis** – rough estimated costs and revenues over the life of the system.
- Identification **of sources of potential funding/financing**
- Exploration of the **receptivity of the site owners and operators**
- identification of **potential challenges or limitations** (permit requirements, suitable grid interconnection points for photovoltaic install, on-site thermal energy demand for solar thermal installs, planned or potential changes at the site (will the building exist for another 20+ years)
- Copy of **site or building drawings** for proposed site

## 2. Feasibility Study

Should the pre-feasibility study determine that the proposed solar installation has merit, a more detailed feasibility study should be undertaken to explore issues and opportunity in more depth. The feasibility study should include:

- A **detailed feasibility study** using modelling software such as ENERPOOL (for pools), TRNSYS, Polysun, PV-Syst, etc. should be undertaken to provide more detailed shading analysis, different load profiles, and detailed equipment performance models.
- **In-depth shading analysis.** Shading from obstructions such as flag poles, exhaust fans, billboards and other buildings, needs to be accurately identified in order to develop realistic performance models. Especially in urban areas, potential future shading must be considered – check with local Planning Department regarding zoning and planned development for adjacent sites. At this stage, the more sophisticated models are being used, as indicated in the first point. Shading losses (as measured using a device such as a Solar Pathfinder) can and should be included as an array efficiency loss in the modeling software. The quality of financial analysis will be determined by the accuracy of the information used.
- **In-depth roof condition assessment** including visual roof inspection, coring (if applicable to the roof type) and, if needed, thermography to determine roof age and condition.
- **Preliminary structural roof assessment** to determine available dead and live loads (including wind and snow loads).
- For solar thermal installations, a **heat load analysis** needs to be undertaken detailing the amount and type of energy currently being used by the site facility as well as time of energy use and weekly and seasonal load variations. At least one week's worth of hot water consumption measurements should be taken.
- For photovoltaic installations, a **review of grid connection requirements** needs to be undertaken including close review of requirements that may be stipulated in potential electricity sale contracts.
- For solar thermal systems, review of any relevant building code requirements that might affect the cost and feasibility of the projects, such as requirements for mixing and back flow prevention valves that may be required by building codes.
- **Preliminary system design.** Based on the assessment information, prepare preliminary design of the system proposing type of mounting of the panels, panel type, electrical connection, inverter type and size and location of panels, inverter, interconnection, etc. System design must also take into account the energy

*Checking system performance at Exhibition Place. Photo by David Nixon.*

demand of components of the solar system, such as pumps or inverters.

- **Negotiation with partners and funders** to determine level of interest and commitment. For photovoltaic installations under consideration, it may be prudent to initiate a Feed-in-Tariff (FIT) contract application at this time, given the timelines associated with this process.
- **Assessment of administrative costs and assignment of party responsible for administering FIT or other government contracts** associated with the install. This should likely be a representative of the owner of the system. Dedicated resources to this task will be required in order to implement the contracts over time, report on benchmarks, and liaise with contractors to access technical project details. Similarly, dedicated resources will be required for ongoing monitoring and optimization of installed equipment and roles concerning these tasks must be clearly assigned at early project stages.

## 3. Procurement

Should the feasibility study prove to be positive, you may wish to proceed to purchase of service and equipment, taking into consideration the following:

- Providing as much detail as possible in the procurement documents helps to ensure best outcomes.
- Requests for proposals (RFP) for solar installations should give bidders full access to the completed feasibility study and clearly state the system performance expectations.
- When possible, it is desirable to procure the system design, installation, commissioning and ongoing maintenance contracts from the same contractors to allow for seamless process integration. If this is not done, some consideration should be made regarding requirements for regular reporting to a central coordinator.
- The creation of a monitoring plan and installation and commissioning of monitoring devices can be requested as part of the installation service or through a third-party monitoring and verification partner. Another approach is to have the company responsible for initial simulations provide the post-install simulation as part of their service contract.

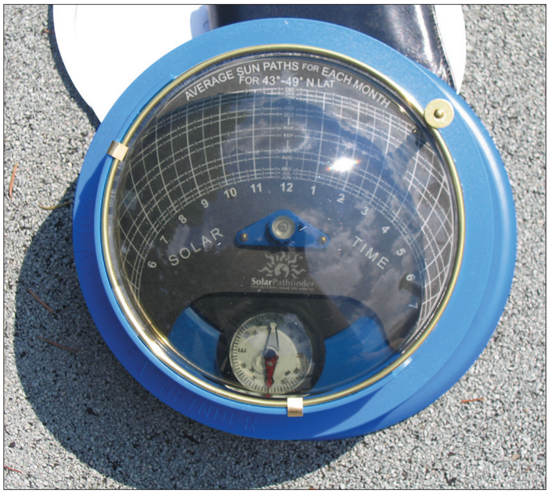
*50 kW$_t$ solar thermal system at Weston Lions outdoor pool. Photo by Lucio Mesquita.*

- To reach as many solar firms as possible, promote the RFP to Canadian Solar Industries Association members.
- Criteria for evaluating an RFP should balance price along with such factors as the experience of the contractors, the ability of the contractors to work with the design team and deliver the components on time, and additional services such as warrantees and maintenance contracts. The planned proposal evaluation criteria should included in the RFP as it allows bidders to understand the expectations of the project developers
- Ensure service providers provide references to other clients for whom they have provided similar work and be sure the check these thoroughly before purchase.
- Details outlining the commissioning of the system need to be included in the RFP. It is recommended that a third party conduct the commissioning, however their services may be provided by a sub contract with the proponent.

## 4. Integrated System Design

Operational difficulties in existing solar installations are often caused by lack of integrated system design. To avoid this, be sure that the initial system design undertaken internally or by service partners identifies and integrates existing building features and processes such as:

- Planned near-term building expansions, retrofits or changes in use or ownership
- Building automation systems
- Equipment set points and failure defaults
- Complementary energy systems (such as back-up systems for solar thermal)
- Building safety mechanisms such as fire dampers (for solar walls)
- Space for ancillary equipment such as solar thermal tanks, inverters, meters, monitoring equipment
- Integration with existing plumbing components (for solar thermal) such as water heaters, recirculation loops, mixing valves and back flow prevention components.
- Grid connection points
- Stamped structural report and drawings for building permits determining wind loading potential and roof structural limits (which determine the installation angles and design of the mounting system).
- System monitoring plan – see point five, below
- System commissioning requirements – see point 7 below




*Solar Pathfinder.*
*Photo by David Nixon.*

- A communications plan to keep all relevant parties among the project team –
- including contractors, management, financiers, communications staff and others up to date on project progress.

100 kW photovoltaic system at Exhibition Place. Photo by Carmanah.

### 5. System Monitoring Plan

A well-designed monitoring plan supports verification of system performance against initial analysis and identifies opportunities to adjust the system over time to ensure optimal performance. Further, it allows system breakdown or failure to be quickly identified and brought to the attention of system operators for timely correction in order to avoid costly generation losses or equipment damage. A monitoring plan should include the following elements:

- Identification of all **data points** to be collected. For solar thermal, this can be done at different levels: a) Metering of monthly energy delivered by solar to the load. With solar data available, this allows basic performance verification. For solar water heating systems this can be done with an energy (BTU) meter with a temperature sensor on the inlet and outlet of the solar hot water system. If the performance is not as expected, then a time stamped data logging system with a minimum of hourly data would be required to help identify the causes of underperformance. If there are no data available for the load, logging it should also be considered as assumptions about load consumption, if incorrect, can have a dramatic effect on solar system yield.
- **On-site sunlight data** is needed for higher accuracy yield verification. The pyranometer should have been calibrated within the last year and mounted horizontally for yield verification. If instantaneous power verification is also required a pyranometer in the plane of the collector is required.
- Data **collection intervals** (hourly, daily, monthly etc)
- Data collection methods (flow meters, electricity meters, etc and recommended types and locations)
- **Data storage** methods to allow for collection of data over long periods (multiple years) should be non-volatile, and logging should resume on its own after power outages or be supported by an uninterruptible power supply (UPS).
- **Data retrieval** process (who gets the data, how often, and where do they put it)
- **System breakdown process** (system for identifying system anomalies indicating failure and alerting a system operator) The person who will be responsible in the short-term (contractor team) and long-term (operator team) for identifying break downs and contacts required to resolve the problem.

- **Data analysis and reporting** methodology (analysis of data sets over time, comparison of performance against estimates, identification and explanation of variances)
- **System optimization** (adjustment of system design to optimize energy performance)
- Clarification of **roles and responsibilities** (identification, from the outset, of who, when and how of monitoring responsibilities for each aspect of the plan

## 6. Installation

- **Assign an internal and/or external service provider to coordinate** components of the installation.
- **Ensure all permits have been obtained** prior to installation and that installers conform to worker safety regulations.
- **Conduct pre- and post-construction roof inspections** Identify and repair any roof damage. If the roof is under warranty, the organization that holds the warranty must sign off on any aspects of the installation that affect the roof. And they should be notified when the project is complete as they may choose to conduct a post-installation inspection.
- **Facilitate timely system commissioning** upon completion of the installation.

*21 kW photovoltaic system at Toronto Parking Authority parking garage. Photo by Carmanah.*

## 7. Commissioning

Commissioning of the installed system is vital to ensuring that the system is functioning as intended. The commissioning requirement and process should be specified in the initial design of the system. If possible, a qualified third-party should conduct the final commissioning. System commissioning should:

- Follow established protocols (commissioning templates are provided on the SolarCity website)
- Check that all components specified were installed correctly
- Ensure that energy and monitoring equipment selected does not pose any incompatibilities and that monitoring equipment is properly commissioned to ensure accurate readings

- Ensure that the operators are properly trained and that operation and maintenance procedures are documented – see point 8 below
- Ensure that all system documentation is collected and provided to the system owner.
- Establish a schedule for regular inspections and re-commissioning

## 8. Operation, Monitoring and Maintenance

Large solar energy systems will require regular maintenance and inspection to ensure continued performance over the long-term. In early phases (first 24 months) operations need be very closely monitored in order to identify and correct any operational deficiencies. To ensure optimal performance, the following need to be addressed:

- **Training of on-site staff** regarding the design and operation of the system and especially with regard to the system's linkages to other building systems (BAS, back-up power, water heating systems, etc) and the procedures to be taken should problems with the system be identified. Care should be taken to ensure that any new on-site staff are made aware of the solar installation and its management requirements
- Ideally, **ongoing contact with the solar installer** should be maintained for several years after the system installation, since they have the most technical knowledge about how the system should perform, and should therefore be consulted in efforts to modify or optimize the system, or remedy performance or maintenance issues. Even if a general contractor is used to manage the project on your behalf, some arrangements such as a maintenance contract should be developed between the site owner and the installer.

*175 $kW_t$ evacuated tube solar thermal system on Toronto Community Housing seniors residence. Photo by Mary Pickering.*

- A re-commissioning of the system at the one year mark should be conducted. Preferably it will be conducted by the original commissioning agent. Yield performance for the year should be part of the re-commissioning process.
- The task of regular monitoring of data and a **protocol for alerting appropriate parties** to data anomalies needs to be clear to all parties involved, so that problems are identified and addressed in a timely manner.

- The owner of the data communication system should be given access to the system to investigate data inconsistencies as soon as they are identified. It may also be helpful to include in the monitoring contract an obligation for the monitoring company to **inform the owner of data collection issues such as interruption in data collection or anomalies in data patterns** immediately.
- **Back-up power supply** (e.g. a UPS) should be maintained and tested to ensure that the data acquisition system is reliable.
- **Regular visual inspection** should be taken by the on-site manager and any anomalies – loose or detached wires, leaks, etc should be reported to the appropriate contact to assess and repair the situation. For solar thermal systems, gauges should be checked for unusual or unexpected readings, such as no flow through the solar heating collectors on a sunny day. The normal operating range should be permanently marked on the instruments so that any observer can determine whether the system is operating correctly. Long term contact information should be included, for the department responsible as well as for the specific employee.
- **Regular solar system maintenance protocols should be established** in consultation with the system installer (ie annual/semi-annual cleaning, fall drainage protocols if necessary; inspection of tanks, pumps, fans etc.
- **Regular roof inspection** needs to be undertaken and concerns reported to building managers.

## 9. Documentation and Knowledge Transfer

Since large solar energy installations are still relatively rare in Canada, documentation of the experience – including successful and challenging aspects – is extremely useful in order to establish best practices, support better installation, give useful feedback to industry representatives, indentify research needs and to improve overall system optimization across the solar sector. Taking the time to document problems, solutions and general performance issues and insights in a brief case study and then offering the information to a public information sharing website hub – such as solarcitypartnership.ca – supports a continuous cycle of improvement for the solar sector as whole.

*Kortright Centre for Conservation has a photovoltaic field test site with a number of PV technologies. Photo by Tim Van Seters*

## 10. Celebration and public communication.

Successful application of distributed renewable energy systems has many public benefits including reduction of local pollution and climate emissions, creation of local employment, and increased energy system reliability. Local installations deserve public attention and support so be sure to work with communications staff to let the public know about your achievements.


*Top: Wilmar Court's 59 kWt solar thermal system. Photo by Mary Pickering. Bottom: F.J. Horgan Water Treatment Plant with a 86 kW building-integrated photovoltaic system. Photo by Rob McMonagle.*

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