## *Software Requirements Specifications (SRS) Document*

Items that are intended to stay in as part of the document are in **bold**; explanatory comments are in *italic* text. Plain text is used to insert wording about the project.

*The document in this file is prepared for specifying software requirements, adapted from the IEEE Standards Association (IEEE-SA) Guide to Software Requirements Specifications (Std. 830-1993).*

*Tailor this to the project specific needs, removing explanatory comments as go along. Where anyone decides to omit a section, might keep the header, but insert a comment saying why the author omits the data.*

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# The Energy and Resources Institute (TERI)



# *"Development of Web-GIS Tool for estimating the Rooftop Solar Power potential for Indian Solar Cities"*

## Software Requirements Specifications (SRS) Document

Supported by
### *Shakti Sustainable Energy Foundation (SSEF)*



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*TERI and SSEF team members shall approve this document.*

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# 1. Introduction

*Renewable energy is a solution for reducing the demand on and air pollution from traditional energy systems. As on-site sources of clean power, solar energy systems can reduce greenhouse gas emissions and air pollution, increasing energy security and creating local jobs. Solar electricity systems (such as, photovoltaic) also have the potential to generate power when it is needed most on hot summer days – thereby relieving strain on the electricity system and reducing the risk of blackouts. Solar PV is emerging in urban and peri-urban sectors and rooftop PV has a huge potential. Ministry of New and Renewable Energy (MNRE) as well as other state level agencies are coming with various rooftop programs and certainly private developers and integrators are looking this as one of the market and opportunities. To develop a sustainable model for our Indian solar cities, we also need to concentrate in promoting the green buildings. Green building is the practice of maximizing the usage of a building's resources i.e., rooftop solar photovoltaic system, solar water heater etc. while reducing the environmental impact throughout its life cycle.*

*Jawaharlal Nehru National Solar Mission (JNNSM), Phase – II has been launched to promote the use of solar energy to households level. Various solar PV systems have been installed across the country to meet the energy demand and to generate the clean and green energy. PV systems have been deployed in India for electrification where grid connectivity is either not possible or, extending the grid connection to that point is not cost effective and feasible. But in urban or, semi urban area, a large rooftop potential is available which otherwise is not used for any purpose, can be used to install the kilo-watt (kW) scale PV plants to cater the energy need hence reduce the extra burden on the transmission and distribution line which otherwise have to be redefined and redesigned due to increased load demand. There are several tools available to estimate the solar rooftop potential, although there is a need of developing more accurate, user-friendly, intelligent and efficient tool which would be India specific and meet the requirements of end users and planners, which can help in preliminary assessment of site specific rooftop solar PV potential. Hence, we are proposing to develop a web based GIS tool for estimating the potential of rooftop solar power.*

*The following subsections of the Software Requirements Specifications (SRS) document should provide an overview of the entire SRS.*

## 1.1 Purpose

*The purpose of this Software Requirements Specifications (SRS) document is to provide a detailed description of the requirements for the Web-GIS solar power estimation tool. This SRS will allow a complete understanding of what is to be expected of the Web-GIS tool. The clear understanding of the Web-GIS tool and its' functionality will allow for the correct software to be developed for the end users (here, the stakeholders) and will be used for the development of the future stages of the project. This SRS will provide the*

*foundation for the project. From this SRS, the Web-GIS tool can be designed, constructed, and finally tested.*

*This SRS will be used by the research team, software engineers and GIS consultants for constructing the Web-GIS tool.  The software engineers and GIS consultants will use the SRS to fully understand the expectations of this Web-GIS tool to construct the appropriate software.  The stakeholders (here, TERI and SSEF) will be able to use this SRS as a 'test' to see if the software engineers and GIS consultants are constructing the system as per their expectations.  If it is not to their expectations the end users can specify how it is not to their liking and the research team, software engineers and GIS consultants will change the SRS to fit the end users' needs.*

## 1.2 Scope

*To promote solar rooftop systems, especially in Indian solar cities, there is a need for a tool to showcase solar resource potential in a user-friendly format so that users can investigate their locations of interest and perform pre-processed analysis. Geographic Information System (GIS) is the obvious tool to achieve this because it provides visual reference – a map of the entire city showing the buildings those have solar installation potential.  An important part of every web-based GIS tool is its mapping or, visualization technology, which makes it possible to show data in the form of maps.*

### 1.2.1 Objective

*To develop a high performing and flexible Web-GIS tool to estimate the rooftop solar power potential for a city.*

### 1.2.2 Study Area

*For developing the Web-GIS tool, Chandigarh city (as shown in Figure: 1) has been considered as pilot city for the development of the tool. Chandigarh (Geographic Extent: 30.6632°N, 76.6827°E to 30.7922°N, 76.8301°E) is a union territory in India that serves as the capital of two states, namely, Punjab and Haryana.*
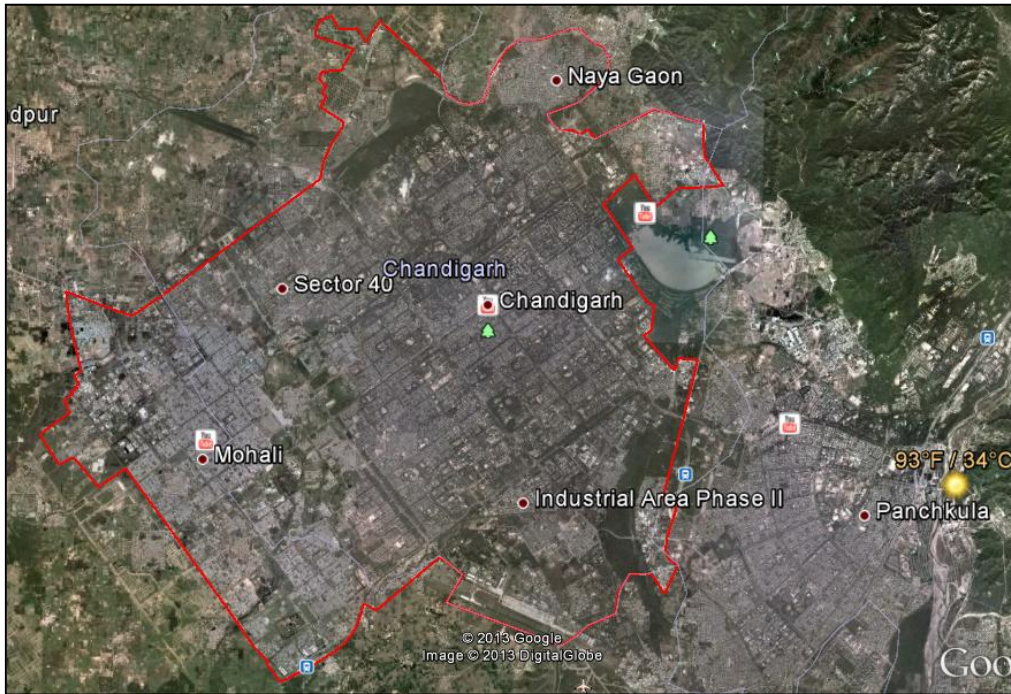
***Figure 1****: GIS Maps for Chandigarh City (<u>Data Source</u>: Google Maps)*

<u>*Note*</u>*: Certain area of Mohali will be covered in this study but it is limited to a total coverage study area of 100 sq-kms.*

## 1.3 Definitions, Acronyms, and Abbreviations

*The definitions of all terms, acronyms, and abbreviations are mentioned in Table 1: Definitions and, Table 2: Acronyms and Abbreviations to properly interpret the SRS.*

### 1.3.1 Definitions

*Table: 1 lists the definitions used in this document with respect to Web-GIS Tool. The definitions given below are specific to this document and may not be identical to definitions of these terms in common use. The purpose of this section is to assist the user in understanding the requirements for the system.*

***Table 1****: Definitions*

| Term | Definition |
|---|---|
| *Address Locator* | *A dataset that stores the address attributes, associated indexes, and rules that define the process for translating non-spatial descriptions of places, such as street addresses, into spatial data that can be displayed as features on a map.* |

| Term | Definition |
|---|---|
| *Client-Server* | *The client-server model is a distributed application structure in computing that partitions tasks or, workloads between the providers of a resource or service, called servers, and service requesters, called clients.* |
| *Cloud Computing* | *Cloud computing is a colloquial expression used to describe a variety of different types of computing concepts that involve a large number of computers that are connected through a real-time communication network (typically the Internet).Cloud computing is a jargon term without a commonly accepted non-ambiguous scientific or, technical definition. In science, cloud computing is a synonym for distributed computing over a network and means the ability to run a program on many connected computers at the same time. The popularity of the term can be attributed to its use in marketing to sell hosted services in the sense of application service provisioning that run client server software on a remote location.* |
| *Crystalline Silicon* | *Mono-crystalline silicon (c-Si): often made using the Czochralski process. Single-crystal wafer cells tend to be expensive, and because they are cut from cylindrical ingots, do not completely cover a square solar cell module without a substantial waste of refined silicon. Hence most c-Si panels have uncovered gaps at the four corners of the cells.* <br> *Poly-crystalline silicon or, multi-crystalline silicon, (poly-Si or mc-Si): made from cast square ingots — large blocks of molten silicon carefully cooled and solidified. Poly-Si cells are less expensive to produce than single crystal silicon cells, but are less efficient.* |
| *Data Flow Diagram* | *A functional model of a software system that describes how outputs are derived from inputs. A diagram contains processes, data flows, actors and data stores.* |
| *Database* | *A collection of data or information typically stored on a computer system and organized to facilitate retrieval and modification.* |
| *Database Management System* | *A software system that enables users to define, create, maintain, and control access to a database.* |
| *Diffused Solar Radiation* | *Diffused solar radiation is the total amount of solar energy falling on a horizontal surface from all parts of the sky apart from the direct sun. The daily diffused solar radiation is the total diffused solar energy for a day.* |
| *Direct Solar Radiation* | *Direct solar radiation (also referred to as direct normal irradiance) is a measure of the rate of solar energy arriving at the Earth's surface from the Sun's direct beam,* |

| Term | Definition |
|------|-----------|
| | *on a plane perpendicular to the beam, and is usually measured by a pyrheliometer mounted on a solar tracker. The tracker ensures that the Sun's beam is always directed into the instrument's field of view during the day.* |
| *Event* | *An occurrence or happening of significance to a task or program, such as the completion of an asynchronous input/output operation.* |
| *Field* | *An element of a database record in which one piece of information is stored.* |
| *Footprint* | *A rectangular or, circular area that is the result of the projection of the field of view of an instrument onto a surface or, a selection of an area of an image or, map.* |
| *Geo-Database* | *The geo-database is the common data storage and management framework which combines 'geo' (spatial data) with 'database' (data repository) to create a central data repository for spatial data storage and management.* |
| *Geo-Processing* | *Geo-processing is a GIS operation used to manipulate spatial data. A typical geoprocessing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset.* |
| *Geo-Referenced Images* | *An image for which the image pixels have been assigned real-world coordinates (projection and datum) on the Earth.* |
| *GIS Team* | *GIS team will consist of the research professional Working on GIS technologies and will be responsible for GIS data creation and the development of Web-GIS Solar Tool.* |
| *Global Solar Radiation* | *Global solar radiation is the total amount of solar energy falling on a horizontal surface. The daily global solar radiation is the total solar energy for a day.* |
| *Graphical User Interface (GUI)* | *A user interface based on graphics (icons and pictures and menus) instead of text; uses a mouse as well as a keyboard as an input device.* |
| *Hit* | *A request to a web server from a web browser or, other client.* |
| *Hover* | *Placing the cursor over a GUI element without clicking on this element.* |
| *Hyperlink* | *An electronic link providing direct access from one hypertext document to another either located in another area or in the same document.* |
| *Image* | *Pictorial representation of a scene recorded by a remote sensing system.* |
| *Interactive Map* | *A map displayed on a graphical display device that can detect mouse clicks and respond using the location of the mouse click on the map to determine the action taken.* |

| Term | Definition |
|---|---|
| IT Team | IT team will consist of the members from IT Department at TERI. |
| Latitude | Latitude is the Angular distance north or south from the earth's equator measured through 90 degrees. |
| Login | The process of gaining access to certain features of the Web-GIS tool. |
| Longitude | The angular distance measured on a great circle of reference from the intersection of the adopted zero meridians with this reference circle to the similar intersection of the meridian passing through the object. |
| Metadata | Data describing the data contained in a database. |
| Object-Oriented | A problem-solving paradigm that is based on abstracting real world entities including their attributes and functions. Interactions between objects generate the functionality of programs. |
| Open-Source | A program in which the source code is available to the general public for use and/or, modification from its original design. |
| Ortho-Rectification | Ortho-rectified imagery is an aerial photograph geometrically corrected ("ortho-rectified") such that the scale is uniform: the photo has the same lack of distortion as a map. |
| Primary Key | A set of fields in a database table that is used to uniquely identify records in the table. |
| Project Team | Project team will consist of the Researchers responsible for overall execution of the project including the Project Advisors and Reviewers. |
| Provider | An organization or individual that will provide metadata for the Web-GIS tool. |
| Query | A user's request for information, generally as a formal request to a database. |
| Record | A unique row in a table in a database consisting of a set of fields that describe a single occurrence of some entity described by the table. |
| Registered User | A user of the AVS system that has an account, for example a validator, provider or an administrator. |
| Relational Database | A database where data is stored in tables, which contain records, which contain fields. Relationships between tables are defined by foreign keys. |
| Remote Sensing | The measurement or acquisition of information about the Earth by a recording device that is not in physical contact with the Earth. |
| Resolution | The fineness of detail that can be distinguished in an image. The real world size of the footprint of a pixel in a |

| Term | Definition |
|---|---|
| | *remote sensing image.* |
| *Scenarios* | *Part of a use case consisting of a sequence of steps describing the interactions between a user and a system.* |
| *Search Engine* | *A program that uses a search pattern to identify a set of web pages matching the search pattern.* |
| *Server* | *A computer that provides services to other computers or to people.* |
| *Site Administrator* | *A person whose responsibility is to manage and maintain the infrastructure of the system.* |
| *Slope and Aspect* | *Slope and aspect are calculated at each point in the grid, by comparing the point's elevation to that of its neighbors.* |
| *Solar PV* | *A Solar Photovoltaic system (informally, PV system) is an arrangement of components designed to supply usable electric power for a variety of purposes, using the Sun (or, less commonly, other light sources) as the power source.* |
| *Spatial Data* | *A spatial database is a database that is optimized to store and query data that represents objects defined in a geometric space.* |
| *Spatial Resolution* | *The smallest object or feature detectable by the sensor. Also known as pixel size or resolution.* |
| *Spectral Resolution* | *The number and width (wavelength) of bands (meaningful portions) of electromagnetic energy detectable by a given sensor.* |
| *Stakeholders* | *Anyone who will make use of this WebGIS Solar Tool.* |
| *Table* | *A collection of records in a relational database.* |
| *Thin-Film* | *Thin-film technologies reduce the amount of material required in creating the active material of solar cell. Most thin film solar cells are sandwiched between two panes of glass to make a module.* |
| *Tool* | *A simple programs that can be combined together to accomplish a task.* |
| *Update* | *The process of modifying, adding or removing existing data.* |
| *Use Case* | *Descriptions, from the user's point of view, of the important operations that provide value to a user.  They describe the interactions between actors and the system.* |
| *Validator* | *The actor who is responsible for verifying the accuracy of new or submitted data.* |
| *Visitor* | *The actor that is the main user of the system and who searches the system for data.* |
| *Web Service* | *A web service is a method of communication between two electronic devices over the World Wide Web (WWW).* |
| *Windows Operating System* | *A computer operating system by Microsoft that provides a graphical user interface (GUI), virtual memory* |

| Term | Definition |
|---|---|
| | *management, multitasking, and support for many peripheral devices.* |

## 1.3.2 Acronyms, and Abbreviations

*Table: 2 lists the acronyms and abbreviations used in this document with respect to Web-GIS Tool.*

*Table 2: Acronyms and Abbreviations*

| Acronyms | Meaning |
|---|---|
| AJAX | Asynchronous Java-Script and XML |
| API | Application Programming Interface |
| CGI | Common Gateway Interface |
| $CO_2$ | Carbon Dioxide |
| CPU | Central Processing Unit |
| CREST | Chandigarh Renewable Energy Science and Technology Promotion Society |
| DBMS | Database Management System |
| DEM | Digital Elevation Model |
| DSM | Digital Surface Model |
| e.g. | for example |
| Ext-JS | Extension Java-Script |
| GeoExt | Geo Extension |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GUI | Graphical User Interface |
| HMS | Hotel Management System |
| i.e. | that is |
| IEEE | Institute of Electrical and Electronics Engineers |
| IMBY | In My Back Yard |
| ISO | International Organization for Standardization |
| JNNSM | Jawaharlal Nehru National Solar Mission |
| kbps | Kilo-Byte Per Second |
| kW | Kilo-Watt |

| Acronyms | Meaning |
|----------|---------|
| kWp | Kilo-Watt Peak |
| LIDAR | Light Detection and Ranging |
| mbps | Mega-Byte Per Second |
| MNRE | Ministry of New and Renewable Energy |
| OS | Operating System |
| PDF | Portable Document Format |
| PHP | Personal Home Page |
| PV | Photovoltaic |
| RAM | Random Access Memory |
| RIA | Rich Internet Application |
| SA | Standards Association |
| SDLC | Software Development Life Cycle |
| SDS | Software Design Specification Document |
| SPV | Solar Photovoltaic |
| SRS | Software Requirements Specifications |
| SSEF | Shakti Sustainable Energy Foundation |
| STD | Software Test Documentation |
| SUD | Software User Documentation |
| TC | Technical Committee |
| TERI | The Energy and Resources Institute |
| URL | Universal Resource Locator |
| VHR | Very High Resolution |
| WMS | Web Map Service |

## 1.4 References

(1) Project Proposal: "Development of Web-GIS Tool for estimating the Rooftop Solar Power potential for Indian Solar Cities";
(2) Project Inception Report: "Development of Web-GIS Tool for estimating the Rooftop Solar Power potential for Indian Solar Cities";
(3) IEEE SA: http://standards.ieee.org/findstds/standard/1074-1997.html
(4) STANDARDS GUIDE for ISO/TC 211 GEOGRAPHIC INFORMATION/GEOMATICS 2009.06.01;
(5) Solar Boston Application: http://gis.cityofboston.gov/solarboston/
(6) In My Back Yard (IMBY) Tool: http://maps.nrel.gov/imby
(7) SWE 626 Team 2 Hotel Management System (HMS) Software Requirements Specifications Document;

### 1.5 Overview

*The SRS is organized into two main sections.  The first is 'The Overall Description' and the second is `the Specific Requirements'.  The Overall Description will describe the requirements of the Web-GIS solar power estimation tool from a general high level perspective.  The Specific Requirements section will describe in detail the requirements of the system.*

## 2.  The Overall Description

*The general factors are described here affect the product and its requirements.  This section does not state specific requirements.  Instead, it provides a background for those requirements, which are defined in section 3, and makes them easier to understand.*

### 2.1 Product Perspective

#### 2.1.1 Detailed Methodology

*The methodology of the proposed study is elaborated in the steps below:*

- *Preparation of GIS base layers: The satellite images for a specified area of Chandigarh city will be procured and required image processing is done for the images to create digital elevation model as well as creation of required vector data such as building footprint, road network etc. The ground survey will be conducted to validate the actual roof information with processed data on a sampling basis.*

- *After preparing GIS base layers, the solar radiation available on building rooftops will be estimated by using any desktop GIS products having Spatial Analyst function. To do this, a Digital Surface Model (DSM) of the city will be built. Then will have to take the bare earth DEM and overlay that with the building heights using attributes available in the building footprints, which results in a three dimensional surface model of the city. On the basis of this prepared surface, the solar radiation tools will be used to calculate the solar radiation availability for each rooftop. The solar radiation tools allow the analysts to model incoming solar radiation and take into account numerous factors, including variation in elevation, orientation (slope and aspect), the shadows cast by topographic features and changes with time of day or, year. The resultant output will be validated with existing solar resource datasets (including satellite derived meteorological data and ground measurements, if available) and will be stored as a GIS layer format.*

- *After completing the analysis in desktop GIS software, the resulted solar radiation map will be published as a 'map web-service' which consist of base layers, an address locator and geo-processing tools, and other layers of interest (e.g., rooftop area, solar radiation, possible system size and its cost considering various SPV technologies such as Crystalline and Thin-Film, available incentives information on SPV systems both at national and state level etc.), on an Open-Source GIS Server for use by the users of this proposed Web-GIS tool. Since, the solar radiation calculations may take some additional time to complete, therefore it is suggested to pre-process the analysis of solar radiation data in order to deliver a faster and efficient web application.*

- *Wrapping the analytics into an easy-to-use Web-GIS tool will be the next step. Presently there is great potential in new user interactive Application Programming Interfaces (APIs) such as, JavaScript which is a client-side technology, rendered by a web-browser. Using any of these advanced APIs will give the developers the capability to combine GIS based web services from a GIS Server with other web content and display it in a fast, visually rich mapping application that can be deployed over the web or, to the desktop.*
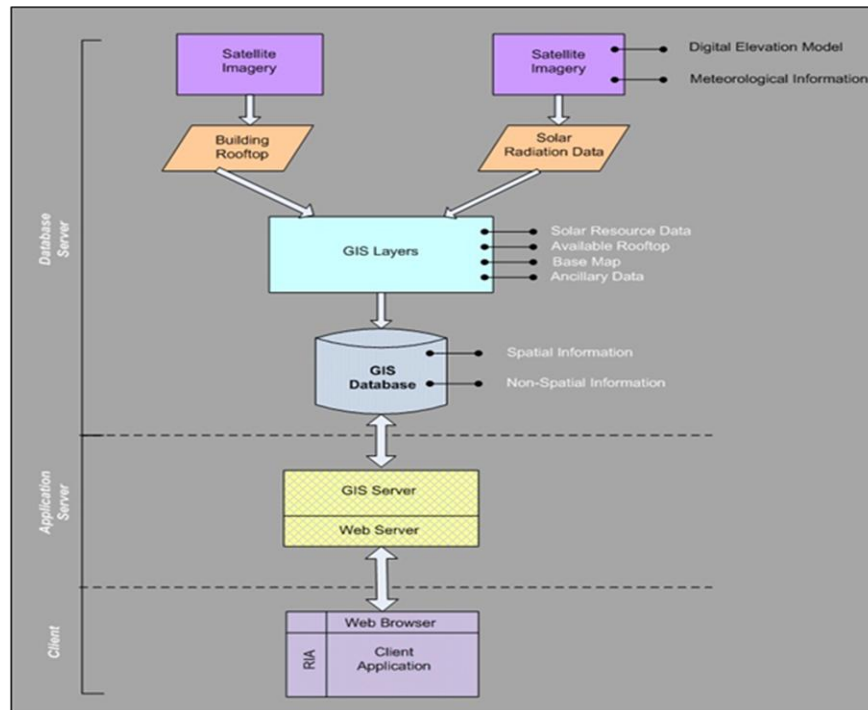


**Figure 2**: *Methodology Flowchart*

*The following subsections describe how the software operates inside various constraints.*

### 2.1.1 System Interfaces

*In order to use this Web-GIS tool at the client-side following are the minimum system requirements:*

| Specification | Description |
|---|---|
| Web Browser | Microsoft Internet Explorer v9.0 or, higher, Mozilla Fire-Fox v12.0 or, higher, Google Chrome v27.0.1453.116m or, higher. |
| Internet Browsing Speed | 512 kbps |

### 2.1.2 Interfaces

- *Registration will be required for accessing the product feature;*
- *User has to provide the valid credentials (such as, User ID, Password, Address etc.) to register on to the Application software (here, Web-GIS tool);*
- *User can change/modify his or, her credentials after successful log-in.*

### 2.1.3 Hardware Interfaces

*Hosting Server Configuration (Minimum System Requirements):*

| Specifications | Particulars |
|---|---|
| OS | Windows 2008 R2 64-Bit |
| CPU | Intel Core i5 - 4 cores |
| RAM | 8 GB |
| Storage | 2 x 1 TB Hard Drives |
| Bandwidth | 4-8 MBPS |

**Note**: *The total no. of simultaneous users or, the hit-counts shall be specified (minimum for 1000 users) and also the Cloud data computing option can be envisaged.*

### 2.1.4 Software Interfaces

**(1) Web Application**:
*Including Open-Source GIS mapping interface,*

- *OpenLayers v2.12 or, Higher;*
- *Ext-JS v4 or, Higher;*
- *GeoExt v1 or, Higher;*

- *PHP and AJAX.*

*(2) Software:*
*Including Open-Source GIS mapping technologies,*

- *GeoServer v2.3.0 or, Higher;*
- *MapServer v3.0.3 or, Higher.*

*(3) Database:*
*Including Open-Source Relational Geo-Database (Enterprise version),*

- *PostgreSQL v8.4.10 or, Higher;*
- *PostGIS v1.5.3 or, Higher.*

<u>*Note*</u>*: Open-Source GIS technologies shall be used to develop the Client-Server application.*

### 2.1.5 Communications Interfaces

*The proposed Web-GIS tool shall be distributed across the network through internet and will follow the mechanism of Client-Server application architecture.*

### 2.1.6 Memory Constraints

*Please refer section 2.1.3 i.e., Hardware Interfaces.*

### 2.1.7 Operations

*The normal and special operations required by the GIS team such as:*

*(1) GIS team has to process the very-high-resolution satellite imagery, which will be provided by the Project Execution Team;*
*(2) Data processing involved Geo-referencing, Ortho rectification, ortho mosiacing etc.*
*(3) GIS team has to create a DSM for getting height of the buildings;*
*(4) GIS team has to calculate the Global solar radiation (including Direct and diffuse, if required) for particular building for each and every month of the specified year, where specification will be provided by the TERI Project Team;*
*(5) GIS team has to do survey for near about 10,000 buildings (for data sampling/validation) in Chandigarh city with the following attributes such as Building Name, Building Address, Building Type (Residential/Commercial/Industrial), and Building Area will be captured;*

*(6) GIS team has to digitize the Buildings foot-print/rooftop using satellite imagery in vector format;*

*(7) GIS team has to integrate the surveyed information and solar radiation datasets with building vector data using GIS data model;*

*(8) GIS and IT team is liable to install the required software on to the hosting server provided by the Project Execution Team. At the same time GIS and IT team will provide the training for the same;*

*(9) In case GIS team requires GIS software products for vectorization, GIS data creation license copy of software products will be provided by the Project Execution Team;*

*(10) Project Execution Team will provide the instruments (handheld device) for measuring the solar radiation at ground level for cross checking the software outputs in case if required;*

*(11) GIS team has to use their owned GPS devices for doing the ground/field survey.*

<u>**Note**</u>*: This is sometimes specified as part of the User Interfaces section.*

### 2.1.8 Site Adaptation Requirements

*Since the proposed Web-GIS tool will be hosted and will run on the TERI/CREST/SSEF server, no additional site adaptation is necessary.*

### 2.2 Product Functions

| S. No. | Particulars |
|:---:|:---|
| *1* | *User Registration* |
| *2* | *User Profile* |
| *3* | *User Login* |
| *4* | *User Logout* |
| *5* | *Website Home Page* |
| *6* | *Map Display Window* |
| *7* | *About Website Info Tool* |
| *8* | *Identify Feature* |
| *9* | *Map Navigation Tool* |
| *10* | *Attribute Analysis Query* |
| *11* | *Solar Radiation Potential Calculation* |
| *12* | *Solar Simulation Functionalities* |

### 2.3 User Characteristics

- *Educational level of Web-GIS Solar Tool – Low*
- *Experience of Web-GIS Solar Tool – None*
- *Technical Expertise – Little*

## 2.4 Constraints

*Since, the proposed Web-GIS Solar Tool to be developed using Open-Source environment, therefore following are the limitations pertaining to the selected technology:*

- *Less training opportunities in open-source GIS software development;*
- *Lack of local knowledge/user-base;*
- *More developer-oriented;*
- *Need to develop in-house technical skills;*
- *Lack of professional support and training.*

## 2.5 Assumptions and Dependencies

- *Availability of very-high-resolution satellite imagery is important for better mapping accuracy;*
- *Detailed Digital Elevation Model (DEM) or, Digital Surface Model (DSM) using LIDAR approach (which is a 3D modeling) can give more precise information, but it cannot be used here due to its very high cost implications;*
- *The proposed tool will give only the macro-level information about the city for rooftop solar PV potential to the users such as annual electricity production, energy savings, simple payback etc. It will also include add-ons like guiding people through incentives, approved vendors and installation procedures;*
- *System sizing and Installation cost of PV System will be assumed by considering selected PV technology (i.e., mono and poly crystalline material based PV modules);*
- *Incentive and other information will be based on latest updated secondary information only. This module will be comprised certain predefined values. Since, open-source GIS technologies give limited flexibility for the user's input based calculations; therefore, the proposed open-source web-GIS tool will have limited flexibility for the users such as, Analysis of potential PV system for a particular building while considering variations in PV cost per watt, incentive in-term of capital subsidy etc.*
- *Due to limitation of open-source GIS platform, addition of new GIS features/objects such as any new buildings into the proposed web-GIS tool would be difficult through user interaction, however inclusion of few latest information to the map/datasets such as any new installation etc. will be possible by the site administrator of this proposed tool having prior knowledge of GIS and the city;*
- *Given that this tool is primarily for high-level potential assessment, stakeholders are advised to conduct micro-siting activities such as structure of the roofs, actual roof-space available, shadow-casts etc. along-with the set-up for their own ground measurement units at the actual project sites for more accurate estimation of data of input resources for their investment decisions.*

## 2.6 Apportioning of Requirements

*Requirements that may be delayed as followed:*

- *Vectorization of the buildings will be start after procurement of the satellite imagery;*
- *DSM generation will start after procurement of the satellite imagery;*
- *Solar radiation modeling will start after procurement of the satellite processed data;*
- *The executing agency would require full cooperation from the supporting agency on several critical aspects such as, receiving letter of authority from a Government agency here, Chandigarh Renewable Energy Science and Technology Promotion Society (CREST) while carrying out the activities, especially during any sample field survey and the publishing/hosting the Web-GIS tool.*

# 3. Specific Requirements

*This section contains all the software requirements at a level of detail sufficient to enable designers to design a system to satisfy those requirements, and testers to test that the system satisfies those requirements. Throughout this section, every stated requirement should be externally perceivable by users, site administrator, or, other external systems.*

## 3.1 External Interfaces

*The Web-GIS Solar Tool will use the standard input/output devices for a personal computer. This includes the following:*

- *Keyboard*
- *Mouse*
- *Monitor*
- *Printer*

## 3.2 Functional Requirements

| S. No. | Features | Functionality | Descriptions (Including Sub-Functionality) |
|--------|----------|---------------|---------------------------------------------|
| 1 | User Registration | *GUI shall be required for user registration on to the website/web software.* | *When user will open the URL of website, GUI should popup for registration.* |
| | | | *GUI will include the basic information about user such as: User Name, E-mail ID, Address, Contact number, Password, City,* |

| S. No. | Features | Functionality | Descriptions (Including Sub-Functionality) |
|--------|----------|---------------|---------------------------------------------|
| | | | *State, Country etc.* |
| | | *[SRSreq 01]* | *All information related to the user, which he/she has entered into the GUI, should store into the relational database.* |
| 2 | *User Profile* | *GUI shall be required to display the user profile after log-in.* *[SRSreq 02]* | *When user will login into the website, there should be a tool to open account settings for the user.* |
| | | | *User should able to change the profile features such as, password, contact number, mail id etc.* |
| | | | *All the modified features should be updated into the database.* |
| 3 | *User Login* | *GUI shall be required to login into the website.* *[SRSreq 03]* | *When user will open the URL of website, GUI should popup for Log-in.* |
| | | | *There should be options like User-ID and Password to login into the website.* |
| | | | *User-ID should be unique into the database.* |
| | | | *If user will enter wrong information, it should give alert or, popup for wrong inputs.* |
| | | | *After successful log-in user should redirect to the home page.* |
| | | | *In-case, the user's registered address is from Chandigarh area, then after login user should redirected to zoom into the particular location (address), which he/she has entered while doing the registration. Also, the user should be able to zoom into any of their location of interest as well as the entire map of the city.* *Note: In-case of those users from outside Chandigarh area, the entire map will be displayed. However, they can zoom into any of their location of interest.* |
| | | *Tool shall be required* | *There should be a tool/button, which enable user logout the user from the website.* |

| *S. No.* | *Features* | *Functionality* | *Descriptions (Including Sub-Functionality)* |
|---|---|---|---|
| 4 | *User Logout* | *to logout from the website.*<br><br>*[SRSreq 04]* | *Only if user is login into the website, then logout tool/button should be visible otherwise it shall be void.* |
| 5 | *Website Home Page* | *Home Page shall be required for website.*<br><br>*[SRSreq 05]* | *Home page contains various core functionalities including about TERI, SSEF etc.* |
| | | | *It should have map control which contains various GIS layers of information in the form of raster and vector layers.* |
| 6 | *Map Control* | *Map control should contain map of the selected location (here, the study area)*<br><br>*[SRSreq 06]* | *It should contain various raster and vector layers.* |
| | | | *Google Maps or, Microsoft Bing Maps should be integrated into it as base-map (WMS) information.* |
| | | | *Very High Resolution (VHR) Satellite imagery (mono image) should be integrated into the map.* |
| | | | *Various vector layers such as, Area Boundary, Building Foot-prints etc. should have also integrated into the map control.* |
| | | | *DSM layer should also be there, if required.* |
| | | | *Tile-Server Caching Mechanism shall be adopted for efficient rendering of raster datasets.* |
| 7 | *About Website Info Tool* | *Info panel shall be required for website and its working behavior (how to operate, assumptions etc.)*<br><br>*[SRSreq 07]* | *User should able to get online help, and user manual (both web-based and documented in PDF) to execute each functionalities of the Web-GIS tool.* |
| | | | *User should able to know product features available into the website.* |
| | | | *Important web-links should be provided for further communication to the authorized nodal agencies or, company details for installation of solar systems or, any specific query.* |
| 8 | *Identify Feature* | *Tool shall be required to identify the features onto the map.* | *There should be a tool which will identify the features such as, buildings (vector data) on to the map.* |
| | | *[SRSreq 08]* | *Following are the details should be populated into an Info-Window:* |

| *S. No.* | *Features* | *Functionality* | *Descriptions (Including Sub-Functionality)* |
|---|---|---|---|
| | | | 1) *Building Name;*<br>2) *Address;*<br>3) *Building Type;*<br>4) *Building Area.*<br><br>**Note**: *Building level information will be limited to the data available from the field survey and secondary information.* |
| | | | *There should be provision to close the identify pop-up.* |
| 9 | *Map Navigation Tool* | *Tool shall be required to navigate the map.*<br><br>*[**SRSreq 09**]* | 1) *PAN: This tool should able to panning the map;*<br>2) *Previous: This tool should redirect the map on previous location;*<br>3) *Next: This tool should redirect the map on previous location;*<br>4) *Full Zoom: This tool will zoom out the map at full extent.* |
| 10 | *Attribute Analysis Query* | *Attribute query analyzer tool shall be required to do attribute query for further analysis.*<br><br>*[**SRSreq 10**]* | *There should be a tool to do attribute query, having options to select the query layer, its attributes (fields), various operations for doing query, as well as unique values of fields.* |
| | | | *Query layer will be all vector layers shown on to the map.* |
| | | | *All fields associated with the layer should be visible for selection.* |
| | | | *Various operations should be there like $<,>,=$ etc.* |
| | | | *User should able to select one layer at a time.* |
| | | | *User should able to select the queried feature color.* |
| | | | *User should able to clear the selected features from the map.* |
| | | | *User should able to clear the query from the query panel.* |
| | | | *User should able to save the query.* |
| | | | *User should able to get help to run the tool.* |
| | | | *If user has already have saved the selected layers on the basis of the specified query,* |

| S. No. | Features | Functionality | Descriptions (Including Sub-Functionality) |
|--------|----------|---------------|---------------------------------------------|
| | | | *then on the next time if user will login the website, that saved queried features should be visible to him/her on to the map.* |
| 11 | *Solar Radiation Potential Calculation* | *Solar Radiation Tool shall be required for estimating Solar resource potential for a particular building level or, for cluster of buildings and selected area.* <br><br> *[SRSreq 11]* | *There should be a provision to get solar radiation potential for a particular building or, for cluster of buildings and selected area.* |
| | | | *User will select the building (spatially) and will get entire specified year (from January to December) Solar Resource information in kWh/sq. meter.* |
| | | | *User should able to select cluster of buildings on to the map for calculating the solar radiation cumulatively.* |
| | | | *User should able to select an area on to the map for calculating the solar radiation through pre-processed datasets.* |
| | | | *User should able to see the interactive graphical representation (Line or, Bar Chart type) of solar resource availability.* |
| | | | *User should able to save or, export the graphs.* |
| | | *Solar Simulation Tool shall be required for solar system (here, PV system) sizing calculations and cost of implementation.* | *User should able to select the building for solar simulation calculation.* |
| | | | *GUI should pop-up for calculation solar simulation model.* |
| | | | *User should able to choose the percentage utilization of roof space to estimate the size of the possible PV system that can be installed.* |
| | | | *Size of the system in kWp should pop-up automatically.* |
| | | | *User should able to select type of building such as residential, industrial or, commercial.* |
| | | | *Other inputs such as, de-rating factor, tilt angle, azimuth angle, and electricity rate (INR/kWh) should pop-up automatically.* |
| | | | *When user will apply the inputs summary of solar simulation results should pop-up.* |
| | | | *Solar simulation results include the payback calculations like initial cost as per* |

| S. No. | Features | Functionality | Descriptions (Including Sub-Functionality) |
|---|---|---|---|
| 12 | Solar Simulation Functionality | [SRSreq 12] | suggested system and total, rebate on total investment, tax credits, and after incentives etc. |
|  |  |  | Solar simulation results will also include the system outputs which will show the amount of electricity (units) generated in-terms of kWh by the PV system through-out the year. |
|  |  |  | Using Solar Simulation tool, user should able to get the information on $CO_2$ savings/GHG emissions for the specified PV system. |
|  |  |  | User should able to save or, export the results. |
| 13 | Spatial Editing Toolbar | Basic editing functionalities such as, draw points, line polygon etc. shall be required.\n\n[SRSreq 13] | User should able to draw points, line polygon etc. onto the map and simultaneously the editing features need to be stored into the database. |
|  |  |  | Only Site Administrator should have the provision to draw points against new building features onto the map and update the corresponding information such as, rooftop space area, solar resource, PV installations etc. into the database. |
| 14 | Home Page GUI Design | Pre-defined information will be required at tool/website Home Page.\n\n[SRSreq 14] | Additional features such as, company name, logo, tool assumptions etc. shall be required. |

**Note**:  All the features as specified under fictional requirements related to the proposed Web-GIS Solar can be envisaged on the basis of realistic possibilities using open-source technology/environment.


## 3.3 Performance Requirements

This subsection specifies both the static and the dynamic numerical requirements placed on the software or, on human interaction with the software, as a whole.  Static numerical requirements may include:

(a) *The number of terminals to be supported;*
(b) *The number of simultaneous users to be supported;*
(c) *Amount and type of information to be handled.*

*Dynamic numerical requirements may include, for example, the numbers of transactions and tasks and the amount of data to be processed within certain time periods for both normal and peak work-load conditions.*

*Performance requirements define acceptable response times for system functionality.*

- *The load time for user interface screens shall take no longer than specified seconds;*
- *The log in information shall be verified within specified seconds;*
- *Queries shall return results within five seconds, however specified time limit shall be incorporated for Spatial Queries.*

## 3.4 Logical Database Requirements

*This section specifies the logical requirements for any information that is to be placed into a database. This may include:*

- *Spatial Geo-Database including Raster and Vector datasets;*
- *Non-Spatial Information.*

## 3.5 Design Constraints

*The Web-GIS Solar Tool shall be a client-server application running in a Windows environment. The system shall be developed using Open-Source software technologies as mentioned in section 2.1.4 i.e., Software Interfaces.*

### 3.5.1 Standards Compliance

*There shall be consistency in variable names within the system. The Graphical User Interface (GUI) shall have a consistent look and feel.*

*IEEE SA Software Document Definitions (International Standards for Software Development) shall be followed as mentioned below:*

- *SRS – Software Requirements Specification: IEEE 830;*
- *SDS – Software Design Specification Document: IEEE 1016;*
- *IEEE SA (Std.) 1074-1997 IEEE Standard for Software Development Life Cycle (SDLC) Processes;*

- *STD – Software Test Documentation: IEEE 829;*
- *SUD – Software User Documentation: IEEE 1063.*

*Following International Geospatial Standards shall be adopted while processing of GIS Datasets:*

- *ISO Technical Committee 211 (ISO/TC 211);*
- *Open Geospatial Consortium, Inc. (OGC).*

*Role of OGC Interoperability:*

*The goal of GIS interoperability is to support users in finding, utilizing, and deploying data from various geographic information systems. In addition to interoperability, key success factors that enable GIS users to successfully work in heterogeneous environments include having a GIS infrastructure that fulfils the following requirements:*

- *Secure*
- *Reliable*
- *Scalable*
- *Extensible*
- *Usable in mobile, desktop, server, and cloud (if required)*
- *Easy to use*

## 3.6 Software System Attributes

*There are a number of attributes of software that can serve as requirements.  It is important that required attributes by specified so that their achievement can be objectively verified.  The following items provide a list of software system attributes:*

### 3.6.1 Reliability

*Specify the factors required to establish the required reliability of the software system at time of delivery.*

### 3.6.2 Availability

*The Web-GIS tool shall be available, up and running for 24*7 throughout the year except due to the routine maintenance activities.*

### 3.6.3 Security

*Site Administrator and Users with valid credentials will be able to log in to the Web-GIS tool. Site Administrator will have access to the database structures at back-end. Site Administrator will have the rights for modifications as well as any Updation work for the*

*datasets and website. Access to the various subsystems will be protected by a user log in screen that requires a user name and password.*

### 3.6.4 Maintainability

*The Web-GIS tool is being developed using Open-Source technology. Therefore, minimal efforts shall be required during the O&M activities through-out its life cycle and shall be easy to maintain.*

### 3.6.5 Portability

*The Web-GIS tool shall run in any computer environment (such as, Microsoft Windows) which is having Web Browser and Internet connection, as mentioned in section 2.1.1 i.e., System Interfaces.*

*Once the relevant characteristics are selected, a subsection should be written for each, explaining the rationale for including this characteristic and how it will be tested and measured. A chart like this might be used to identify the key characteristics (rating them High or, Medium), then identifying which are preferred when trading off design or, implementation decisions (with the ID of the preferred one indicated in the chart to the right).*

| ID | Characteristic | H/M/L | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|----|----------------|-------|---|---|---|---|---|---|---|---|---|----|----|----|
| 1 | Correctness | H | | | | | | | | | | | | |
| 2 | Efficiency | H | | | | | | | | | | | | |
| 3 | Flexibility | M | | | | | | | | | | | | |
| 4 | Integrity/Security | M | | | | | | | | | | | | |
| 5 | Interoperability | M | | | | | | | | | | | | |
| 6 | Maintainability | H | | | | | | | | | | | | |
| 7 | Portability | M | | | | | | | | | | | | |
| 8 | Reliability | M | | | | | | | | | | | | |
| 9 | Reusability | M | | | | | | | | | | | | |
| 10 | Testability | H | | | | | | | | | | | | |
| 11 | Usability | H | | | | | | | | | | | | |
| 12 | Availability | H | | | | | | | | | | | | |

*Definitions of the quality characteristics not defined in the paragraphs above as follow:*

- *Correctness - extent to which program satisfies specifications, fulfills user's mission objectives*
- *Efficiency - amount of computing resources and code required to perform function*
- *Flexibility - effort needed to modify operational program*
- *Interoperability - effort needed to couple one system with another*
- *Reliability - extent to which program performs with required precision*

- *Reusability - extent to which it can be reused in another application*
- *Testability - effort needed to test to ensure performs as intended*
- *Usability - effort required to learn, operate, prepare input, and interpret output*

## 3.8 Additional Comments

## 4. Change Management Process

*Changes to this document may be made after approval from the project Principle Investigator (PI) and the client approval officer (here, member from SSEF).*

## 5. Document Approvals

### 5.1 Team One Approval (here, TERI)

| | |
|---|---|
| Mr. Amit Kumar/ Mr. Alok Kumar Jindal | Date |

### 5.1 Team Two Approval (here, SSEF)

| | |
|---|---|
| Mr. Deepak Gupta | Date |

# 6. Supporting Information

*The required documentation such as, SDS, SDLC, STD and SUD will be developed in separate deliverables.*

## 6.1 <u>Activity Schedule</u>

| S. No. | Core Development Activities | Duration (in Days) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 |
| 1 | Image Processing and GIS Data Creation | ▓ | ▓ | ▓ | ▓ | | | | | | | | |
| Deliverables*: SDS, GIS Data Layers (in Shape file), and Complete Report on GIS Data Model. | | | | | | | | | | | | | |
| 2 | Geo-Database/Spatial Database | | | | | ▓ | | | | | | | |
| Deliverables: Spatial Geo-Database. | | | | | | | | | | | | | |
| 3 | Client/End User Application Interface | | | | ▓ | ▓ | ▓ | ▓ | ▓ | | | | |
| Deliverables: Web-GIS Tool, Report on Software Development Framework (SDLC), and User Manual. | | | | | | | | | | | | | |
| 4 | Application/Software Testing | | | | | | | | ▓ | ▓ | | | |
| Deliverables: Debugging Checks and Test Report (STD). | | | | | | | | | | | | | |
| 5 | Application Hosting | | | | | | | | | | ▓ | | |
| Deliverables: Dedicated Uniform Resource Locator (URL) for Web-GIS Tool, and User Manual (SUD). | | | | | | | | | | | | | |
| 6 | Training and Workshop | | | | | | | | | | | ▓ | ▓ |
| Deliverables: Two Training Programs in Delhi and Two Workshops in Chandigarh and Delhi. | | | | | | | | | | | | | |
| *Subject to Data procurement/availability. | | | | | | | | | | | | | |