Title	Safe and secure solar power generation in Japan : dual mode solar panel system (DMSPS) : proof of concept : Concentrated solar power
Sub Title	
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Abstract	The project focused on the solution proposal for safe and secure solar power generation system that is most appropriate for Japan and its future. Japanese government is expecting to increase the solar power generation capability by 10 times in 2010 and by 40 times by 2030 but strong and convincing solution is still missing. This report proposes the Dual Mode Solar Panel System (DMSPS) as an enabler of the government target growth. The basic concept of how it does so is proven in this work. The key aspects of this report are the followings: • Clarifies the problem • Some important problem analysis • Solution proposal • Financial analysis of the proposal • Conclusion and needed future work In the problem statement section it is found that increasing the attractiveness of the solar power generation system for residential houses is the key for Japan's success in solar power generation capacity building. The system performance uncertainty due to its strict reliance on the sunlight existence and also negative VOCs of the system were both considered as a starting point for the new proposal and using OPM, CVCA, and creative brainstorming DMSPS was found to be a perfect solution. DMSPS is a system with the solar panel that can also function as an advertisement display. Depending on the weather condition it chooses its operating mode to maximize the value creation. The simulation showed the system is capable to produce 2.6 times more cash flow in exchange of 45% power generation in a year with 4kWh system. The scope of this report is limited to the proof of the concept but it is found that the proposed solution, DMSPS, is a very promising solution. Therefore it is strongly recommended to start further investigation of the system.
Notes	Student final reports Group 10
Genre	Research Paper
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO40002003-00002010-0381

Group 10

Group 10's Theme Proposed by Delft University of Technology

Theme 6:

ALPS "safety and security" theme title: Concentrated Solar Power

Proposer Organization's Name: Delft University of Technology, the Netherlands.
Supporter Name and contact info: dr.ir. Gerard P.J. Dijkema

Theme Abstract:

Who – Japan at large
What – secure, safe sustainable electricity supply
Where – part of the assignment
When – part of the assignment
Why – ensure long-term security and sustainability of electricity supply in Japan by reducing dependency on foreign fossil resources; reduce Japan's CO_2 footprint

The CSP assignment involves design and development of large-scale energy infrastructure, and is strongly related to local geography, water management;

It requires large-scale system design, suitable governance, selection of site(s), embedding in Japanese institutions and advanced program and project organization.

Fig. 1: PV with Fresnel concentrators

Fig. 2: Solar Two, Mojave Desert, US

ALPS Final Report 2010

Group 10

PROJECT TITLE:
"SAFE AND SECURE SOLAR POWER GENERATION IN JAPAN - DUAL MODE SOLAR PANEL SYSTEM (DMSPS): PROOF OF CONCEPT -"

Theme:
"Concentrated Solar Power"

Proposer Organization: Delft University of Technology

Proposer Organization's Supporter: Gerard P.J. Dijkema

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Group 10

SAFE AND SECURE SOLAR POWER GENERATION IN JAPAN - DUAL MODE SOLAR PANEL SYSTEM (DMSPS) : PROOF OF CONCEPT -

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1. EXECUTIVE SUMMARY

The project focused on the solution proposal for safe and secure solar power generation system that is most appropriate for Japan and its future. Japanese government is expecting to increase the solar power generation capability by 10 times in 2010 and by 40 times by 2030 but strong and convincing solution is still missing.

This report proposes the Dual Mode Solar Panel System (DMSPS) as an enabler of the government target growth. The basic concept of how it does so is proven in this work. The key aspects of this report are the followings:

- Clarifies the problem
- Some important problem analysis
- Solution proposal
- Financial analysis of the proposal
- Conclusion and needed future work

In the problem statement section it is found that increasing the attractiveness of the solar power generation system for residential houses is the key for Japan's success in solar power generation capacity building. The system performance uncertainty due to its strict reliance on the sunlight existence and also negative VOCs of the system were both considered as a starting point for the new proposal and using OPM, CVCA, and creative brainstorming DMSPS was found to be a perfect solution.

DMSPS is a system with the solar panel that can also function as an advertisement display. Depending on the weather condition it chooses its operating mode to maximize the value creation. The simulation showed the system is capable to produce 2.6 times more cash flow in exchange of 45% power generation in a year with 4kWh system.

The scope of this report is limited to the proof of the concept but it is found that the proposed solution, DMSPS, is a very promising solution. Therefore it is strongly recommended to start further investigation of the system.

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3. PROBLEM STATEMENT

Japan is a country with very small natural resources for power generation therefore dependency on foreign fossil fuel supply has been significantly high. Basic Energy Plan of 2010 describes that it is necessary for Japan to realize secure energy resource supply, environmentally-friendly transition, and economic efficiency to sustain safe and secure state activity.

Promotion of renewable energy is considered to be one of the solutions for Japan. Among them, photovoltaic power generation is considered to have the highest potential for installation in Japan. The Ministry of Economy, Trade and Industry (METI) roughly estimates that in year 2020 the total solar power generation needs to become twenty times more than that of 2005 to achieve the goal which was set in "Action Plan for Achieving a Low-carbon Society" by the Fukuda Cabinet in July 2008 [1].

Solar power generation has increased in a quadratic manner since 1993 in Japan (Figure 1). The government subsidy for panel installation at residential houses and also for excess electricity purchased by the electric companies has driven the growth.

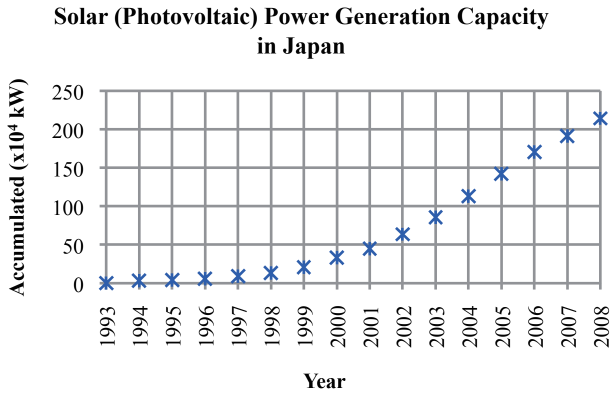


Figure 1 Solar (Photovoltaic) Power Generation Capacity in Japan. [Reference: Japan Photovoltaic Energy Association]

Despite the increase of the solar power generation capacity, the growth rate is not sufficient to meet the Fukuda Cabinet's action plan target. The growth prediction curve based on 1993-2008 and the action plan target curve are shown in Figure 2. With the Fukuda Cabinet's action plan curve, METI has calculated that 70% or more of the capacity must be provided from the solar power generation systems in residential houses. A solar power generation strategy mainly focused on such distributed micro systems is what makes Japan unique in the world.

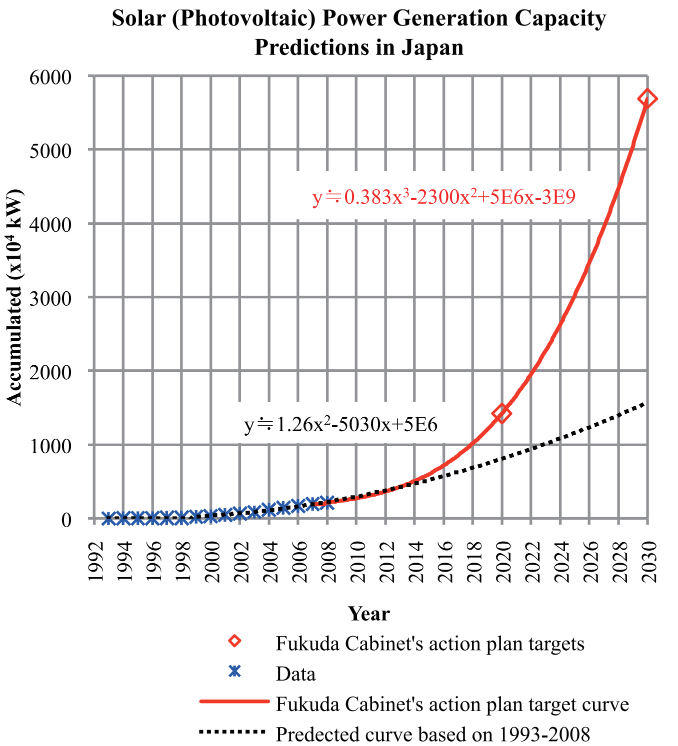


Figure 2 Solar (Photovoltaic) Power Generation Capacity Predictions in Japan.

The METI has doubled the solar power generated electricity purchase price and changed to 48 Yen/kWh in November 2009 to stimulate the capacity growth however the market response has not been identified yet as of this moment (November 2010). From **Figure 2** it is obvious that the capacity must start growing in a cubic behavior to achieve the action plan targets, therefore, analysis of the divergence between the market response and the red curve in the figure becomes important measure of validating the METI's decision.

The Japanese government's basic strategy for solar power generation capacity growth is to increase the cost per unit electric power generation (Yen/kWh). One way of interpreting this is that the system is being improved so that it pays for itself faster. The simplest way that an immediate effect can be expected is to increase the purchasing price of the solar power generated electricity. This has been done to a certain degree as mentioned in the previous paragraph but it is very difficult to make a large impact in the solar power generation capacity growth dynamics. Other approaches of the government are to make further innovative improvements in energy conversion efficiency of the solar cell and production cost reduction of the solar power generation system. These approaches are effective but it is likely to take long time. To meet the Fukuda Cabinet's target curve, faster solution must also be considered.

From the discussions above, it is obvious that the key to succeed in solar power generation capacity building in Japan is to make solar power generation system more attractive for residential house owners. The attractiveness is known to be related with the several items shown in Table 1 based on the interviews with several potential house owners. From the interviews it can be said that house owners are most concerned when and how much their solar power generation system actually benefits them.

Table 1 Residential House Solar Power Generation System Attractiveness Factors.

Degree of electric bill reduction
Initial cost
Maintenance
Degree of house disfigured
Environment friendliness

The system performance uncertainty of the solar power generation system highly contradicts with the house owners primary concern. The system performance is uncertain because the solar power generation system ultimately relies only on the existence of the sunlight. Therefore large fluctuation in the performance is inevitable. Some examples of fluctuating system performance is shown in Figure 3. To increase the system attractiveness it is important to smoothen the system performance variation and to assure constant productivity.

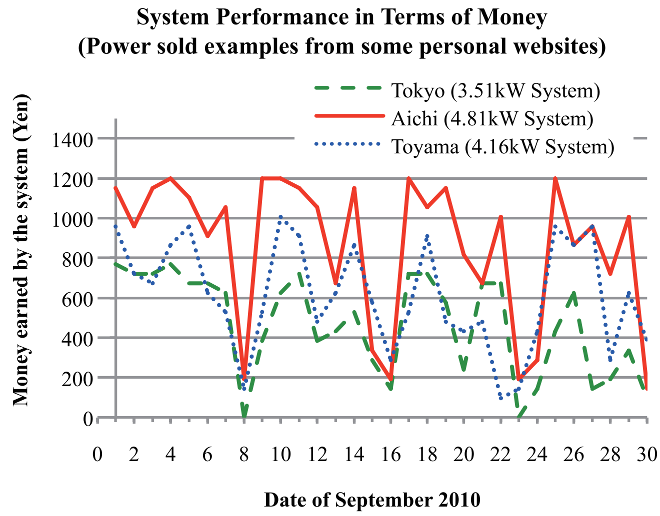


Figure 3 System Performance Fluctuation Examples.

The problem needs to be solved to realize safe and secure solar power generation system in Japan is found that the system needs to be improved so that it can attract more residential house owners to install it.

4. ANALYSIS AND DISCUSSION OF ALPS METHODS

Through the ALPS course, more than twenty tools/methods were introduced by various lecturers. Some of them really helped the team to move forward with the project and some helped to clarify the problem or the weaknesses of the argument. Following is the list of tools the team applied for the project. The tools from 4.1 to 4.8 are the ones that the team felt more helpful. In other words the output from one tool was used for the next and created a convincing scenario that the proposed solution has advantage over the conventional system and it is plausible.

[Tools the team found more helpful]

4.1 Prototype

There were two types of prototypes created in the project. One was "prototype rapidly" and the other was "rapid prototyping". The former prototype is the one created overnight and its purpose was to show the basic concept of the Dual Mode Solar Panel System (DMSPS) and to convince the audience that the concept is actually socially compatible. DMSPS is the solar power generating system with the solar panel that also functions as a display when it is not generating power.

The Figure 4 and Figure 5 are some examples of the prototype. They are showing the city image with the proposed Dual Mode Solar Panel System.

Figure 4 Prototype Rapidly: The View of DMSPS on the Building Roof.

Figure 5 Prototype Rapidly: The Sky View of DMSPS Installed on the Residential House Roofs.

The second prototype, "rapid prototyping", is shown in the Figure 6. It consists of a solar panel and a computer monitor. It is virtually demonstrating the mode switching function of the system.

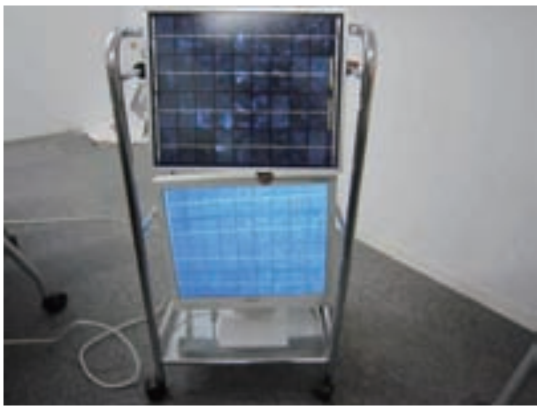


Figure 6 Rapid Prototyping: DMSPS Prototype.

4.2 Scenario Graph

To start drawing a Scenario Graph we started with finding an appropriate main function. So we asked ourselves "what is the main function of a concentrated solar power system?" to set the starting point. Then we thought about "where". The locations for solar panel installation that unique for Japan were listed. For instance, we focused on questions such as where is the most suitable place that geographical features in Japan are made the best use of? Secondly we thought about "what". We listed what activities are done around the area that we listed for "where". A lot of ideas came out for this. Thirdly we thought about "who". Here few potential stakeholders showed up. Finally we thought about "when". As for the solar panel, "when" is a significant factor and it is limited for solar power system. Accrual condition generating electricity using solar power system depends on whether and season at the site location.

Using brainstorming method, items in the scenario graph each were found out. For the time being, the most realistically achievable scenario was chosen as the key scenario. When our ideas for the project become more concrete, we will modify the key scenario.

The next step is to continue brainstorming with comparing the mindmaps that each member has drawn. As a result a true key scenario can be discovered. We can link this result to CVCA.

During this homework process the true necessity of Scenario Graph did not become clear. It is understood, however, that the Scenario Graph is certainly helpful to consider various possible scenarios. It was difficult to make a good use of Scenario Graph to create a CVCA and in other words we were not sure how to make a good Scenario Graph so that will be helpful to create a CVCA.

The record of scenario graph creation and the result is attached in the ANNEX C.

4.3 OPM

Object-Process Methodology (OPM) is a system modeling language to architect a system with complexity. Using OPM, systems can be described with two types of classes, objects and processes. Objects are physical things or information and processes transform objects. To use OPM, function and restriction of the system are clarified.

OPM is designed after overview of the system is obtained. Therefore tools such as Brainstorming, Scenariograph or Mindmap may come before OPM modeling. If relation with stakeholder is needed to consider restrictions, CVCA is also useful before OPM is completed. After objects and process are cleared with OPM, system functions can be designed with QFD or A set of Use Case / Morphological Concept Generation.

To architect the application of solar panel generation at OPM level 0, we first described the general solar power system and then extended based on the findings. When the solar panel generation system is in operation and electrical power is yielded from sunlight, generated power is transmitted and sold to electric power company. Therefore productivity of the solar power system is highly and complexly depended on various factors such as weather, hours of daylight, latitude of the site and so on. So we defined the role of *system integrator* who surveys those factors and ensure the productivity of the solar power system. To spread solar power systems in the real community, *system integrator* needs to contribute both commercial and government sites and also has various roles such as engineering, installing, financing, leasing, and etcetera. Using OPM, relations between objects are well complemented and the system can be designed in the point of sustainability. The OPM we created is shown in the Figure 7.

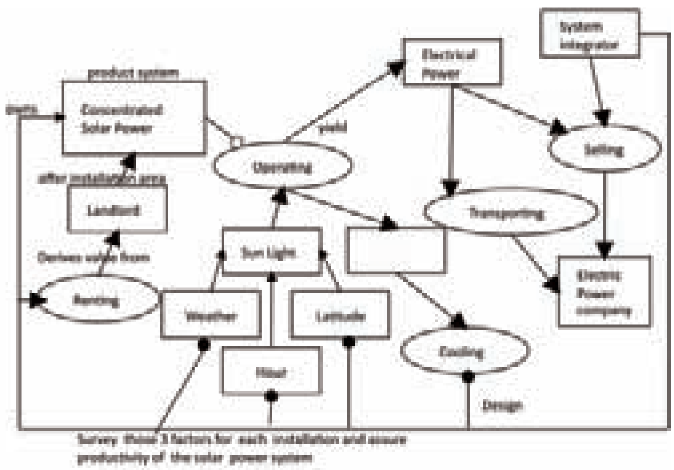


Figure 7 OPM level 0 Diagram of DMSPS.

However we defined the role of *system integrator* to reduce productivity risk of solar power generation, restriction and other considerable issues are not enough understood. Further discussion after interview and deeper investigation, we will most likely reform the paradigm of OPM. The investigation must include more detail information about technical, financial and legal issues and system's functions can be designed with QFD or A set of Use Case / Morphological Concept Generation.

Comparison with other types of power plants is also necessary to present the effectiveness of the system. Combined with other tools such as PEST, 3C, and SWOT it might be useful to clarify strength and weakness of CSP.

Even we believed that we know about the system well, describing in the modeling can derive more insights. To clarify objects and processes in the system using OPM, we can find difficulties and points of compensation. In case of our solar power system, dependence on the solar in the process of generating value was figured out and it conducted to the breakthrough of our project adding another value into the system.

The OPM level 0 diagram used to identify the system weakness is also attached in the ANNEX E.

4.4 Brainstorming

Before we start brainstorming we decide one and only rule that was necessary to keep in mind is "positive mind". So we could get a good start because we had done rapport formation before ALPS#WS1. First we shared individually gathered information of latest concentrated solar power technology and system. The information was answers for questions such as "what is a market share?", "who are stakeholders?", " what are stakeholders doing?", and "what is a market structure?" Then we discussed about various cases in Japan with little help from relative literatures and scholarly papers. At the end we summarized the results as a Scenario Graph and CVCA with using KJ method.

Our big insight is that the idea became more evolved with brainstorming. We were able to create more interesting and unique ideas by stretching ideas with free association. Another big insight is that in order to create system it is necessary to manage psychological condition of stakeholders. When one usually think about "concentrated solar power" one is tend to look into power generation efficiency and monetary value, however, we were able to find a key factor for working system of concentrated solar power when we were expanding ideas on stakeholder's benefit. It is essential to design a structure for circulating a new sense of values instead of money. The important thing to consider for creation of feasible and sustainable concentrated solar power system is not only the power generation efficiency and cost but also psychological effects of stakeholders.

The next step of this study will be to find more critical issue with taking a closer look at the insight and feedbacks form the interviews with stakeholders. We will continue to use brainstorming method because we think it is a powerful tool to find critical issues that are not explicitly apparent. We are planning to synthesize more creative hypotheses and conduct interviews to look this project in a new light.

Despite some successful outcome for the project so far, there are some improvements that we need to make for the next time. One is a time management and another is to manage the agenda. We often had to extend our meeting time when we were brainstorming. Also our discussion was tending to be far from agenda from time to time. These are something we would like to improve but it cannot always be a bad thing. We believe that it is our strong point that members are willing to discuss and make progress in the project with great passion. To leverage our strong point we will consider managing our brainstorming session with IDEO theory (RapidBI, 2010) and make it more effective.

Some records and results from brainstorming are attached in the ANNEX B.

4.5 More Observation/Interview, VOX(benchmarking) Insights

We used VOX as keys for concept generation. To start VOX, we considered both internal and external voices. To be specific, external voices are Voice of Society, Voice of technology, Voice of Competition, and internal voice is Voice of Business. To clarify above voices, we all visited an exhibition about solar power technology, PV Japan2010[1)], and observed and interviewed many stakeholders such as solar panel manufacturer, solar system seller, and institution who study solar power. PV Japan 2010 is an event that a variety of companies, universities, and autonomies related to solar power exhibit their booth to inform their activity to us. Therefore, we were able to get many up-to-date information of solar power fortunately.

With VOX and Interview, what stake holders think is clarified. And then we were able to generate main concept, Solar panel with advertisement. In addition, we got some other ideas about business model of solar power by interviewing and observing at PV Japan 2010. For example, we were surprised at solar cooker and stirring machine of pool as shown in the Figure 8 and Figure 9. They hinted to us that there is a way to use solar power without connecting solar panels to smart grid, that we had not considered bottom of the pyramid as customer.

Figure 8 Solar Cooker.

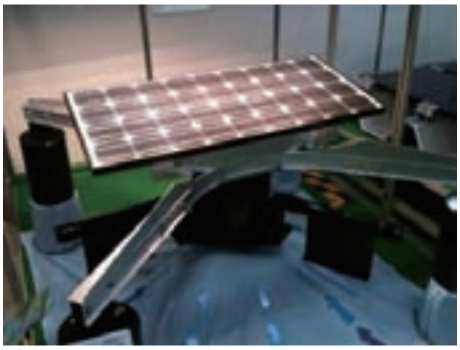


Figure 9 Pool Stirring Machine.

Through our interview and observation, we were able to learn a lot of things other than above things. Above all, technology to improve efficiency of photovoltaic solar power such as concentrated photovoltaic solar power is very impressive to us. And, we got to know that many people have interest on solar power. At PV Japan 2010 about 450 organizations exhibited and more than 44000 people attended during 3 weekdays.

PV JAPAN 2010 website
<http://www.pvjapan.org/en/index.htm>

4.6 CVCA

Customer Value Chain Analysis (CVCA) is a methodological tool that enables us to comprehensively identify pertinent stakeholders, their relationships with each other. By performing CVCA as shown in Figure 6, we are able to recognize our business model as "DMSP System Integrator" and it is showing the new value flow generated by the advertisement in the red arrows.

The analysis showed that the system is highly dependent on subsidies from the government unless the power generation performance of the solar power system improves drastically. And, it also showed that adding a new value flow with introducing the advertisement industry into the solar power system is able to substitute or decrease the subsidies.

Our process of making a CVCA seemed to be a process of creating an outline for business plan. We learned it is necessary for complicated business model such as DMSP System Integrator to clear relationship with each other by using CVCA

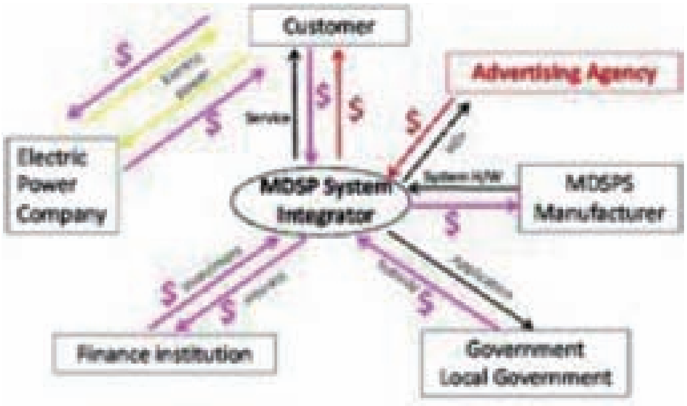


Figure 10 CVCA of DMSP System Integrator.

4.7 Causal Loop Diagram

The causal loop of the DMSPS and the conventional system was created to verify the advantage of the concept (**Figure 11**, **Figure 12**). As shown in the figure since the solar panel creates the extra positive loop the Money Earned will have two positive arrows. This clearly explains that the DMSPS has two different revenue behaviors. It is important to note that these two different arrows does not occur simultaneously because one represents the earnings from solar power generation and the other represents the advertisement revenue and these two modes cannot be operated simultaneously.

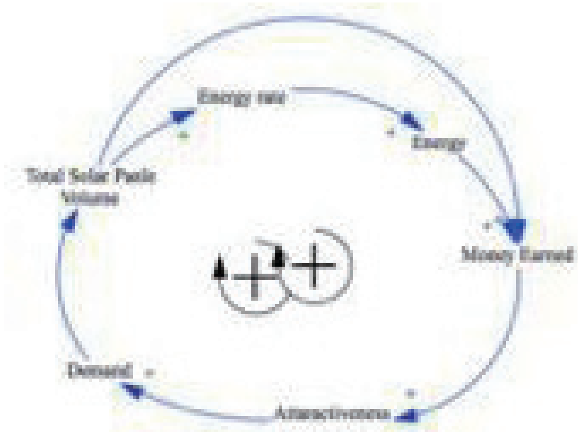


Figure 11 Causal Loop of the DMSPS promotion.

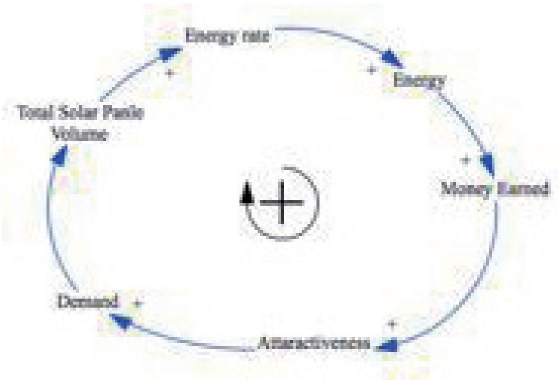


Figure 12 Causal Loop of the conventional system promotion.

The both causal loops will be used in the System Dynamics simulation to verify that the number of DMSPS will grow with much faster rate than the conventional system.

We did not know the way to express the idea of two different revenue behaviors in the beginning but with the advice from Professor Minato we did find the causal loop diagram is the best way to visually express the point.

4.8 System Dynamics.

Using the System Dynamics it was possible to generate a convincing simulation results that proofs the DMSPS does have higher potential to increase the number of solar power generation installed in Japan faster than the conventional system. For the simulation the DMSPS causal loop (**Figure 11**) discussed in previous paragraphs and the numerical figures found in METI's data and near future scenario (ANNEX G) were mainly used. They are shown in the **Table 2**. The assumptions used in the equations are in the **Table 3**. The total hours of daylight per year was obtained from the Japan Meteorological Agency. The ratio of solar power generation during daylight and average advertisement revenue per year is obtained from the MATLAB/Simulink® simulation that we created. The attractiveness coefficient was mathematically identified from the data of solar power generation capacity curve from the METI in the ANNEX G.

Table 2 DMSPS Simulation Parameters and Equations.

Item	Equation	Initial Condition
Total Solar Panel Volume (units)	$\int$ Demand	320,000
Energy rate (kW)	Total Solar Panel Volume *4.5	--
Energy (kWh)	Energy rate*1960*0.4	--
Money Earned (Yen)	Energy*48+Total Solar Panel Volume*642,676	--
Attractiveness	Money Earned/1.95e6	--
Demand	Attractiveness	--

Table 3 Assumptions for the simulation.

Energy rate per solar panel unit	4.5	kW
Total hours of daylight per year	1960	hours
Ratio of solar power generation during daylight	0.4	
Solar power selling price	48	Yen
Average advertisement revenue per year	642,676	Yen
Attractiveness coefficient	1.95e6	

The result of both the conventional system and the DMSPS is shown in **Figure 13**. The simulation assumes that DMSPS promotion starts at 2005 just because we did not have the latest data of 2009. The figure shows that after three years DMSPS will exceed the conventional system in solar power generation capacity.

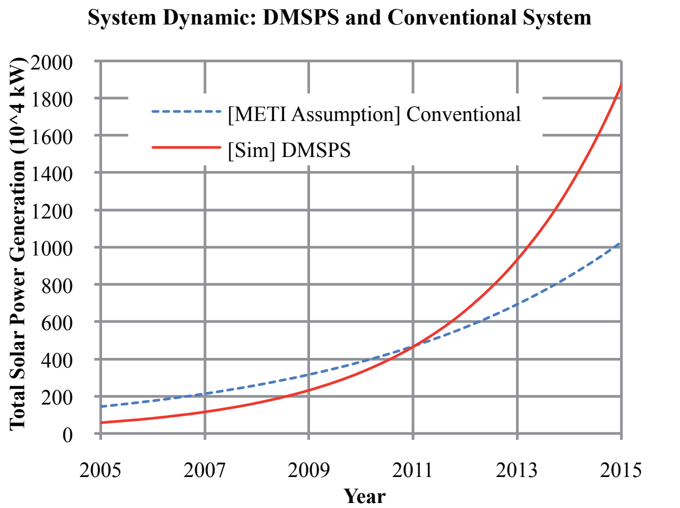


Figure 13 Conventional System and DMSPS System Dynamics.

4.9 Interview

Considering with whom we have interviews, we tried to find knowledgeable person or organizations in the point of solar power technology, location of the solar panel and promoting the solar power generation. From three key points, we had interviews with (1) Professor Haruki Sato at System Design Engineering Department, Keio University, (2) Motosumiyoshi train station at Tokyu Toyoko Line, (3) Yokohama municipal government.

(1) Prof. Haruki Sato at System Design Engineering Department, Keio University

At the interview, we were taught that solar thermal power generation is not drawing much attention in Japan these years. There are three dominant reasons and they are: failure of the Sunshine Project at Shikoku region, high dependency on nuclear power plants as greener energy source, and Japan had advantage of starting intensive researches on photovoltaic technology for solar power generation.

The Sunshine Project started in 1973 when oil shock affected many countries that depended mainly on imported natural resources and Japan was one of them. As a national project, there were various researches to develop alternative energy sources but the project was terminated with unsuccessful results in 1993.

(2) Motosumiyoshi train station at Tokyu Toyoko Line

Photovoltaic solar panels were installed on the loop of the Motosumiyoshi train station in September 1996 as shown in Figure 14. According to Tokyu Rail Way Company introducing green energy is one of the responsibilities in a social point of view and solar power panels were equipped to reduce CO2 at the station. In comparison with other stations installation of solar panels were relatively easy because the station was a new building at the time and was able to adopt a new design with solar panels and also the location was considered suitable to appeal as a greener company to the public. In addition, there were not tall buildings around the station and solar power generation seemed to be highly effective at the site.

Figure 14 Photograph of Motosumiyoshi Train Station.

(3) Yokohama municipal government

Yokohama city has their unique aim to reduce 30% of CO_2 emission by the year 2025 and it is called CO-DO30 policy. To accretive it, they are promoting solar power generation including solar thermal power generation with subsidy. As a result solar power panels were installed at 900 sites last year it is expected to reach 2,000 sites this year.

It was very interesting to find out that despite thermal power generation is introduced in many countries because of its high efficiency, Japan has a fever to promote photovoltaic solar power. And, we found photovoltaic solar power has particularly high potential for installation in Japan.

4.10 To_By_Using Statement

All the results from Scenario Graph, CVCA, and brainstorming were integrated together to synthesize a To_By_Using statement. The "To" sentence is an overall purpose of our project. Secondly the "By" sentence is a statement of process which in our case explains the business model shown as the CVCA diagram. Finally the "Using" sentence is a statement of techniques which in our case are solar panel with display and operation controlled autonomously/manually to optimize the system performance. Therefore the result of the tool is shown the Table 4.

Table 4 To By Using Statement.

To:	Increase the number of solar power system in Japan in order to decrease oil dependency of electric power generation.
By:	A business model which provides a valuable service in return for having a solar power system on one's house roof.
Using:	Concentrated solar power system with advertising media function.

The deliverable of the tool is a guideline or a principle of the project and this is something that the team can always revisit whenever during the project and remember what they were thinking at the very beginning of the process. This becomes very important especially when the project stretches for the long period of time and both the individuals and the team start to lose focus of the project.

It seems that by purposely giving a degree of freedom to one of the three components of a completed To_By_Using statement, we could start brainstorming for alternative solutions such that, for example, *achieve the same purpose with different form but using the same process* or *use different process while using the same form and achieving the same purpose* and so on. This might sound over constrained brainstorming method but it was helpful to become aware of similar or derivative ideas of the project.

4.11 QFD1.2 & Cost-Worth Diagram

Using all The results from Value Graph, brainstorming and past achievements of ALPS#1 and 2, we developed QFD & Cost-Worth Diagram. First we shared latest information and understood about customer requirements (VOX) and Engineer metrics. Then we had considered to weighted average for customer requirements and created "CR's/EM's matrix" as a QFD1. Before we made QFD2, we had considered to Physical Structures as solutions elements and created "EM's/SE's matrix" as a QFD2. Then relative weight becomes clear as a result for calculating that Cost-Worth Diagram. Cost-Worth Diagram is tool to study about balance of cost and value for our solution. The Cost-Worth Diagram contains keywords in requirement analysis (Figure 15).

The result of the tool is a guideline or a principle of the evaluation of priorities of quality, functions and delivery. This is something that the team can always revisit whenever during the project and remember what they were thinking at the very beginning of the purpose. This becomes very important especially when the project have problem during the long project and it helps up to find a solution.

It is important that QFD & Cost-Worth Diagram created at middle stage of the project is revised and updated as project proceeds and its components and outputs become more concrete and detailed. The next step for QFD & Cost-Worth Diagram is to create more concrete business plan that is appealing to the stakeholders and is sustainable. Although we must be careful that in QFD & Cost-Worth Diagram we put a value into all variables with subjective view. So we have to reaffirm the results of QFD & Cost-Worth Diagram when changing the project premise.

Our process of making a QFD & Cost-Worth Diagram seemed to be a process of creating an outline for business plan. However, at first we could not understand QFD because we did not clearly understand difference between value graph and scenario graph. So we spent long time to create satisfied QFD. To start take part in ALPS#3 we need review one more the things that one has learned in ALPS ever before.

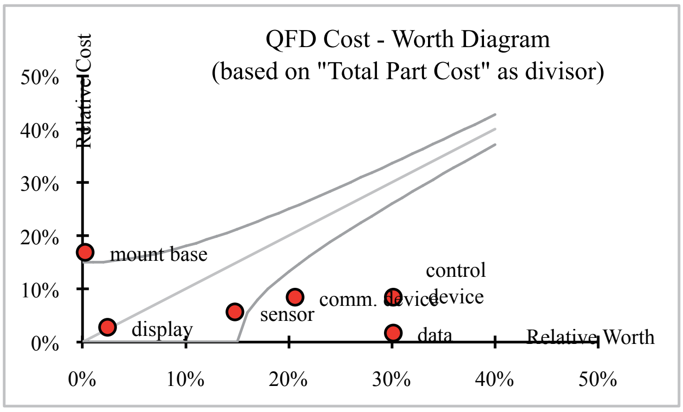


Figure 15 Cost-Worth Diagram

4.12 A set of Use Case / Morphological Concept Generation based on Functions/ VOC/ EM's

Use Case is also called "User Scenario" or "Task Analysis" and it is a tool to examine VOC and Functions. In the Use Case, we imagine actual usage of the system which we try to develop, and find functions of it. If a prototype is available, it helps to have a concrete idea of the usage. Stakeholders, who are clarified through CVCA process may use the system or are affected by the system.

In our solar power system, customer is a landlord of the property and system integrator installs a panel, sell electric power and display advertising on the panel. With Use case, we can examine all the stakeholders can coexist with the sustainable solutions. The use case is shown the Table 5.

Table 5 Use Cases.

Basic Flow	
1	Get panel installed on the roof and have it connect to a electricity grid. LAN into the house for status monitor.
2	1 week controller adjustment.
3	Start operation. Activity can be checked on a status monitor in the house or on any device with web browser.
4	Sell electricity during a fine day: <GENERATING> Advertisement after the sunset: <Advertisement by OOO>
5	Total earning from the panel is accumulated and shown on the monitor at the end of the day, week, month, season, and year.
6	Pay monthly maintenance and technical support fee to the system integrator.
Mode Switching Flow	
4	Power generation and advertisement are switched according to the temperature, sunlight radiation, historical data and weather forecast. The activity status is shown on the monitor.
5	Total earning from the panel is accumulated and shown on the monitor at the end of the day in comparison with power generation only case.

Morphological concept generation is a tool to find a better solution of the functions. For each function, more than several, hopefully five solutions are listed in a matrix and best solution is chosen by Pugh selection method.

Use case can drive functions and VOC also find them. Use case is based on actual usage of the system. On the other hand VOC inclusively response stakeholder's requirements, and the result of the VOC might be unpractical. Therefore dual use of VOC and Use case is very important to examine functions.

Morphological concept generation also work to examine solutions which are derived by QFD. QFD is a powerful tool to choose better solutions considering value, but Morphological concept generation has potential to find sky-high solutions.

We need to examine solution by QFD carefully. After solutions are decided we have to consider about how the system development is being executed. Project management is the next phase we will face on, and project charter and milestone is the tool we work on in sequence.

Relation between Morphological concept generation and QFD was not clear at the beginning. However EM is the key part of QFD, Morphological concept generation does not seem to relate with it. Morphological concept generation can derive solutions and parameters of them correspond to EM. Functions are often described as verbs and EM are described as adjective or adjective verb.

4.13 Project Charter & Milestone Chart

Project charter is a document which the project is officially approved with. The document must consist of List of team members, Project purpose (business needs), High-level requirements, Success criteria and Milestone. Terms of the project and each team member's purpose to participate the project may also be contained in the document.

Usually project charter should be created at the beginning of project or time when outline of the project is figured out. Each time content of the charter is changing, it is necessary to revise the charger, for example: number of team is increased after concept of the project is concreted and it goes forward to the detail design.

In our ALPS project, Project purpose is promotion of the solar panel with fewer subsidies, and High-level requirements is to find a compatible condition of solar panel witch display advertisement and generate electric power efficiently. However we created the project charter to build system as an assignment, we did not create one for our actual ALPS project considering the workshop schedule. With project charter, stake holders and their boundaries of responsibility can be clarified. Those points were not clarified during our workshop assignments and we consumed more time to pursuit them. To succeed the project, misunderstanding and weaving must be minimized. Well defined milestone which considers constrains contribute to suppress total cost of the project to pursuit the schedule on time.

After project charter is defined, progress management and revise of the schedule are next step. For robust achievement of the project, prototyping and interview are also necessary to verify of the design at each phase of the projects.

However milestone must be defined to develop schedule, some projects are started without project cheater. If each team member and stakeholders have different recognition of the project, the team will be face on many problems. It is tough to define project charter perfectly, but the attitude to write project charter as a document to reduce misunderstanding is quite important to manage the project for success.

4.14 Roadmap that includes specific results from all tools you have used so far

A roadmap is chart to visualize a sequence of applied tools in a project. With a roadmap, we can comprehend when and how which tool is used. In a process of creating roadmap, we have to make project objective clear and deliberate sequence of tools. Ideal number of applied tools is minimal and we can aim to have a project work more efficient, however it is necessary to understand purposes and contexts of each tool and arrange sequence of tools logically in a roadmap.

A roadmap should be created at the beginning of a project and it is need to be revised often during a project. Output of each tool is expected, but it is not guaranteed that we can obtain desirable output when roadmap is created. During a project, the sequence of tool must be flexible and it may be need to go back in the original sequence to apply same tool or apply different tool which was not planned to be used.

At the last of the project, reviewing roadmap to check a sequence and find key moments is also necessary to understand appropriate usage of tools. It will be able to apply for the next project and it is also contribute to educate skills of project management.

The roadmap of our ALPS project is explained in Chapter 7. In the roadmap we have key moments. Since our project is more based on concept design, most of key moments are in a concept planning phase, however tools to estimate detail design, e.g. QFD, were also used.

A roadmap should be created at the beginning of a project and it is need to be revised often during a project. At the last of the project, reviewing roadmap to check a sequence and find key moments is also necessary to apply appropriate usage for the next project.

Because roadmap is a sequence of the using tool in the project, rough schedule can be estimated creating roadmap. The project schedule should be updated simultaneously when roadmap is revised.

4.15 Mindmap

To create a mindmap we started with thinking about the states of "safety and security". The states were considered in positive and negative phases. For instance "Risk" and "Danger" are in the negative phase. Then more branches were derived from these key words. We repeated the process many times to create a mindmap. During the process we had one thing in my mind and it was to try to find the key word that is related to solar power generation in some way.

As we mentioned in the previous paragraph we tried to choose the words related to solar power generation while creating a mindmap. This really helped me to discuss the ideas with the group and especially was effective for spreading idea for a Scenario Graph creation.

Mindmap was made individually and it helped our team to create a creative Scenario Graph and CVCA. This experienced taught us that mindmap should be created occasionally during the project to expand thoughts and ideas.

The one of surprising discoveries is that many findings and insights obtained from different thinking tools are often found to be related or connected to each other. While we was creating a mindmap We have found that so many words and phrases were common with those in brainstorming or primitive Scenario Graph. So the mindmap method is quite useful to understand implicit relations of words and phrases related to the theme.

4.16 FMEA

The Scenario Graph created earlier in the project is shown in Figure 16. Boxes filled red are the ones chosen as a key scenario.

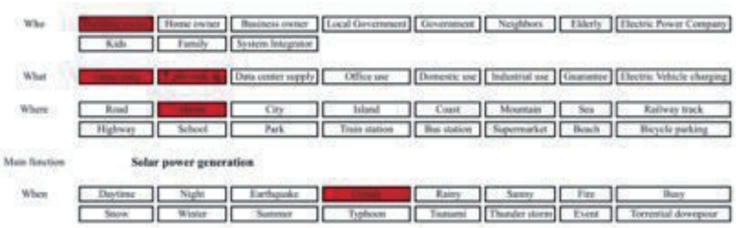


Figure 16 Scenario Graph. (Larger image in ANNEX H)

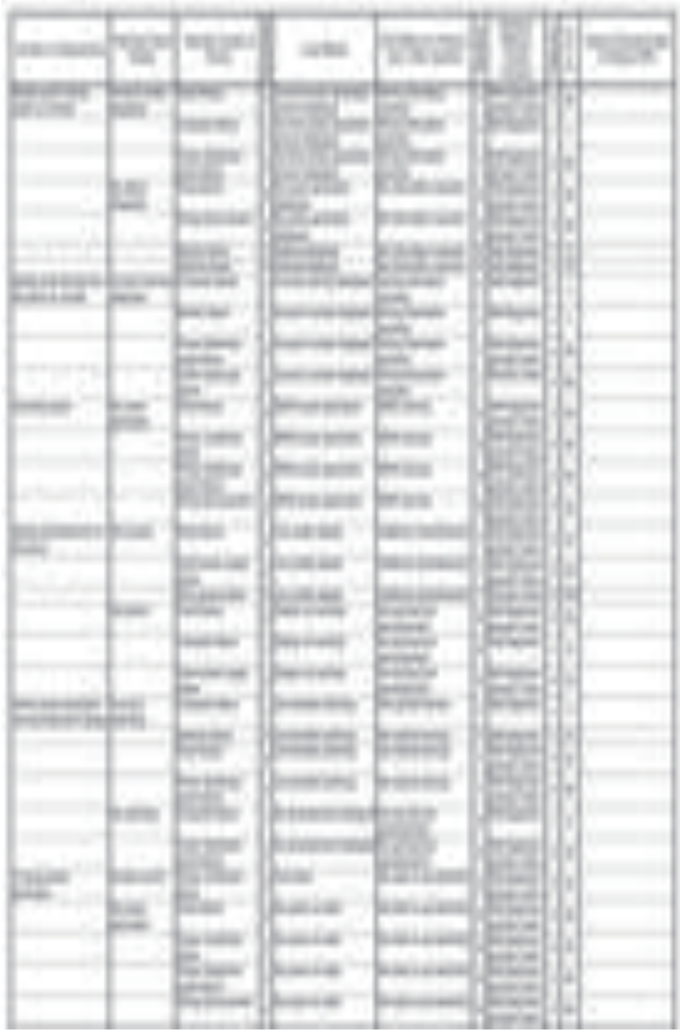
From the scenario graph few unconventional failure modes are found and listed in Table 6.

Table 6 Unconventional Failure Modes From Scenario Graph (Larger image in ANNEX H)

Function or Requirement	Potential Failure Modes	Potential Causes of Failure	Occurrence	Local Effects	End Effects on Product, User, Other Systems	Severity	Detection Method/ Current Controls	Detection	RPN	Actions Recommended to Reduce RPN
Emergency power generation soon after the earthquake	Fuse blow	Excess current because not enough current drawn	3	No current	No power supplied	9	Load and current monitoring	1	27	Emergency power generation mode must have different set of fuse
Display advertisement	No display	Outside operating temperature due to snow	5	Display does not startup	Unable to use display	8	Temperature monitoring	1	40	Heater, Warmup operation

FMEA derived from Use-Case is shown in Table 7. Use-Case is attached in the ANNEX A.

Table 7 FMEA from Use-Case (Larger image in ANNEX H)



4.17 DSM

The Design Structure Matrix for this project is shown in Figure 17 Design Structure Matrix for Dual Mode Solar Power System Implementation

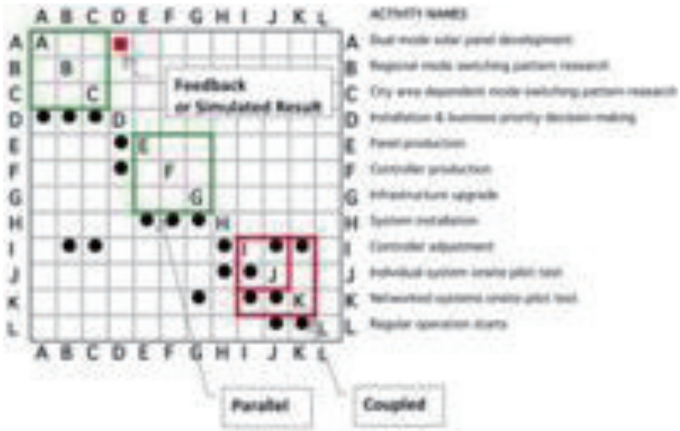


Figure 17 Design Structure Matrix for Dual Mode Solar Power System Implementation

In the DSM several feedback marks are found in the upper right region of the matrix. Marks in row *I* represents iterations to setup appropriate control adjustments for a specific implementation case. It is found that this iteration occurs at every installation site and cannot be avoided to realize optimal switching operation for the location. Another finding from the DSM is that there will be a feedback from activity D, installation & business priority decision-making, to activity A, dual mode solar panel development. This is expressing that installation and business priority and the panel's operation efficiency is highly correlated. In other words, the business priority reflects the panel's operation efficiency and vice versa. Therefore panel development team will receive requirement for panel efficiency obtained as result of business profitability simulation.

Task-based DSM is selected to represent the project. This is mainly because this project is business model oriented and process to realize the system in profitable way is a challenge.

The structure of the project is shown as colored rectangles in Figure 17. Green rectangle is representing parallel processes and red rectangle is representing coupled processes. Processes without any colored rectangle mean that they are in series with adjacent processes.

Mainly there are two groups of parallel processes in the earlier half of the project and the later half consists of coupled processes. To better organize the project it is important to control the feedback between activity D and A with effective simulation and engineering assumptions.

4.18 Robust Conceptual Design

The sources of variation that may prevent people from earning money robustly are shown in Table 4.

Table 8 Sources of Variation

variation of the amount of power generation	variation of climate	temperature	high
			low
		humidity	high
			low
		sunshine	faint
variation of price of advertisement	variation of area	population	low
		order	bad
	variation of economy	economy	bad

In high or low temperature, system should consider which operation can earn much money by simulating in advance because of variation of efficiency of power generation. In high or low humidity, system also should consider that.

In low population or bad order area, the price of advertisement is assumed to be low. And, in bad economy, the price of advertisement is also assumed to be low.

However, the fact remains that the dual-mode solar panel system is much more profitable than a conventional solar power generation system.

4.19 Scorecarding, Design of Experiment

Scorecarding is a management tool to clarify factors to accomplish project objective. Project objective (biggest Y) is a measurable value and maximizing value of Y is goal of the project. Factors mainly consist of Control Factors (X's) and Noise Factors (V's). With transfer function, F() , relation between factors and Y is described as Y=F(X,V).

In this theme, project objective (Biggest Y) is number of installation of "Hybrid Solar Panel" to spread solar power generation in the point of safety and security. In this point, it does not have to gain enormous amount of profit installing the panel, but soundness of related business is necessary for growth and sustainability of this solar power generation system. Therefore we choose those three objectives as the objectives of measures (small y), which correspond project objective (Biggest Y): return (revenue from each panel), investment (cost of each panel) and Potential number of installation. This return and investment are figures of ROI for customer who gain or pay money by installing the panel, and the good ROI is a source of motivation for installation. Potential number of installation is also important to spread the panel in the nation. Even a panel makes profit, large number of area where the panel can be installed are needed to be counted as nation's energy resource. For the project objective, how to increase return and potential number of installation, and decrease investment are need to be clarified. Scorecarding is a tool of the clarification and the composition is shown in the table next page.

Control Factors (X's) and Noise Factors (V's) found at the current survey are listed in the table, however we believe that there are more factors in actual situations and will face in experiments. Furthermore some of X's are obviously interacted each other and complex to be designed. For example, to increase efficiency of power generation, we try to choose a solar panel which produce good performance in a various conditions but usually the cost of the panel is higher than others.

Experiments should be designed to balance Control Factors(X's) and accomplish project objective. If effects of Noise Factors (V's) are relatively low and mechanism of transfer functions are well known, simulation is very useful to find preferable control factors and it helps to save lots of time and cost for experiments. But effects of Noise Factors (V's), such as weather and public opinion are difficult to expect at different region and physical experiments are necessary to develop this hybrid solar power system.

Table 9 Composition of Scorecarding

Objective Measures (Small y)	Transfer Function	Control Factors (X's)	Level of X	Noise Factors (V's)
Return (revenue from each panel)	Engineering Design	Efficiency of power generation Power consumption of display Life period	EM	Weather Deterioration with age Technology changes
	Design of switching algorithm	Subsidy advertising contract	component	Weather Emission trading power generation cost from other source
	Advertising	price of advertisement content	component	Economy
Investment (cost of each panel)	Engineering Design	Solar panel Display Control Unit Software	component	Variation of material price Technology changes
	Choice of Supplier	Assembly shipping	component	wage variation custom duty
potential number of installation	Engineering Design	Weight View angle Brightness	EM	Number of housing constriction style of building
	regulation	landscape policy	component	public opinion

5. DESIGN RECOMMENDATION

The recommended design is called the Dual Mode Solar Panel System (DMSPS). The system is integrated so that its appearance is almost the same as the conventional solar power generation system on the residential house roof (Figure 18). The system consists of a solar power panel that can also function as a display thus the system has two completely different revenue behaviors: selling power during the solar power generation or by displaying advertisement when it is not generating power. The operating mode can be controlled either manually or autonomously to optimize the system performance.

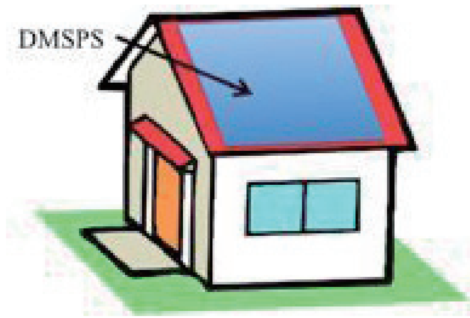


Figure 18 DMSPS Appearance.

The basic function design of the DMSPS is shown in Function Flow Block Diagram in Figure 19. It is very simple but note that power generation and advertisement display never happens simultaneously.

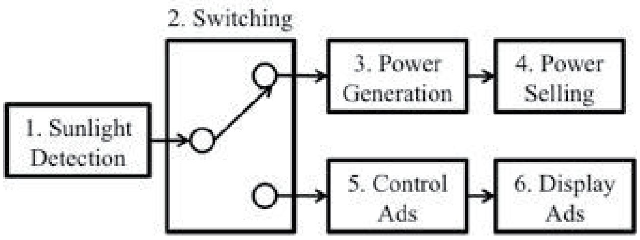


Figure 19 Basic Function Flow Block Diagram of the DMSPS.

The Figure 20 describes the basic architecture design of the DMSPS. In this architecture the System Integrator is capable of manually operate the Dual Mode Solar Panel.

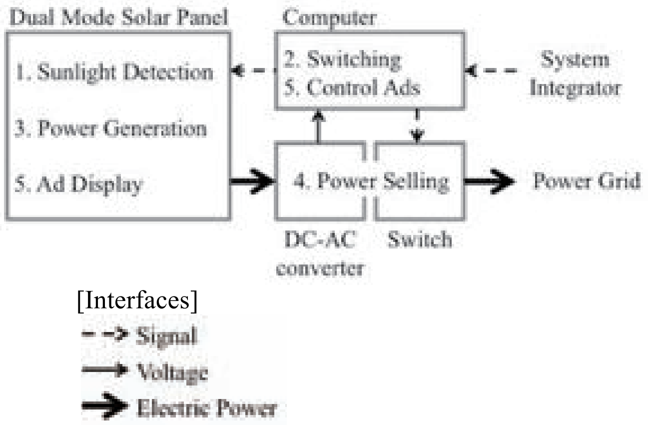


Figure 20 Basic Architecture Design of DMSPS.

The Figure 21 shows an example of the implementation plan of the DMSPS. Few details are added to the architecture design. Some of the protocols such as RGB, LAN, or WAN is explicitly described. In this plan the system can be accessed by the System Integrator over the internet. Also a diode is added between the Dual Mode Solar Panel and the DC-AC converter to prevent adverse current.

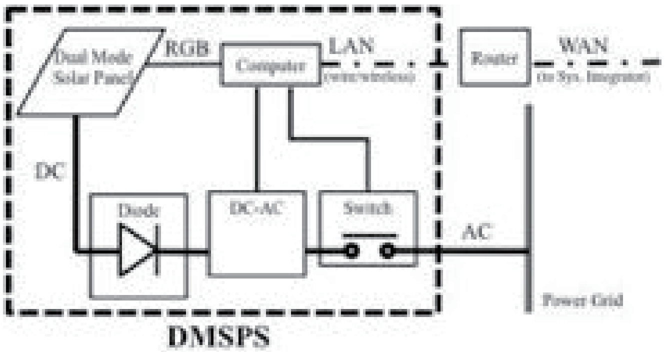
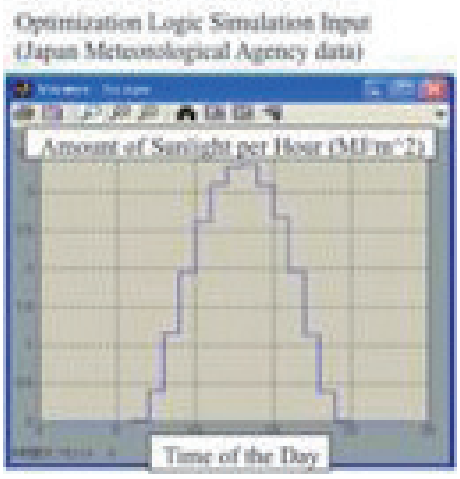


Figure 21 Implementation Plan of the DMSPS.

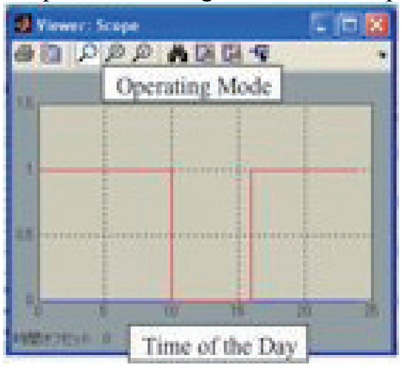
There are two reasonable configurations for implementing the Dual Mode Solar Panel. It is either transparent solar cell and display or transparent display and solar cell. These transparent device are recently researched in various institutions and successful outcomes has been reported [2-4]. There is also another configuration where solar cell itself is capable of displaying still or motion pictures. The in depth technical feasibility study needs to be conducted to decide which of three configurations is the best for solar power generation located on the roof of residential houses. Illustrations of each configuration is shown in the Figure 22.

Figure 22 Three Possible Configurations for Dual Mode Solar Panel.

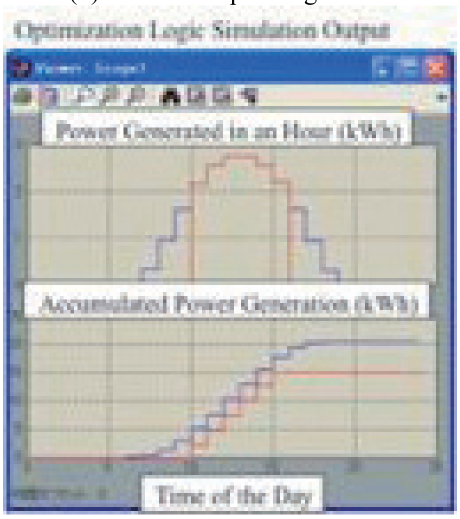
The system performance optimization is based on the simple logic of comparing the solar power sales and advertisement rate. When it is operating autonomously the system chooses whichever more profitable thus resulting the maximum value creation. The simulation results shown in the Figure 23 best describes the idea of performance optimization. The Figure 23(a) shows the amount of sunlight per hour as the system input. The Figure 23(b) shows the operating mode of the DMSPS. When it is at one it means it is operating in the advertisement display mode. The red curves in the Figure 23(c) and (d) shows the behavior of power generation and the system earning of the DMSPS. As in the Figure 23(d), DMSPS earns twice as much and also it generated about ¾ of the power as conventional system. Please note that this is the result of a case of simulation with several engineering assumptions just to explain the basic concept of system performance optimization. The detail of the simulation is discussed in the following paragraph.



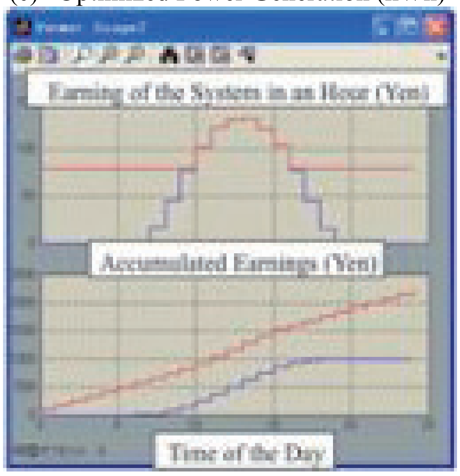
(a) Optimization Logic Simulation Input



(b) DMSPS Operating Mode



(c) Optimized Power Generation (kWh)



(d) Optimized System Earning (Yen)

Figure 23 System Performance Optimization Logic Simulation.

A simple MATLAB/Simulink® simulation was build to verify the performance advantage of the DMSPS over conventional system (Figure 24). The daily meteorological data of the year of 2009 at Tokyo was obtained from Japan Meteorological Agency website and used as the input for the simulation [5]. The parameters for the simulation are listed in the Table 10. It is assuming a 4kWh system, which is common for residential house system, and it is assuming DMSPS has lower efficiency than conventional system by 85%. The Ad rate is assumed as 2.0 Yen/m^2*h which seems reasonable from the market study. The power consumption by ad is assumed as 0.5 kWh for now. These values are the design values that can be investigated further in the further technical investigation.

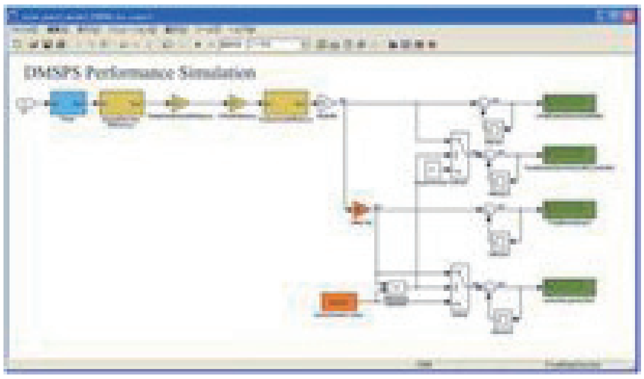


Figure 24 MATLAB/Simulink® DMSPS Performance Simulation. (Larger image in ANNEX I)

Table 10 Simulation Parameters.

Solar Panel Efficiency (%)	13
Solar Panel Area (m^2)	30.7
Power Conditioner Efficiency (%)	93
Other Efficiencies (%)	81
DMSPS Efficiency (%)	**85**
Ad rate (Yen/m^2*h)	**2.0**
Power Consumption by Ad (kWh)	**0.5**
Electricity Purchase Price (Yen/kWh)	15.58
Electricity Sell Price (Yen/kWh)	48

Simulation results are shown in the Table 11 and also in the ANNEX A. The result shows that by appropriately setting some design values the DMSPS could be highly beneficial than conventional solar power generation system with a trade off of total power generated.

Table 11 Simulation Results.

Total Power Generated	kWh	Ratio
Conventional System	4,303	--
DMSPS	2,380	0.55

Total Earning	Yen	Ratio
Conventional System	206,600	--
DMSPS	536,100	2.60

The use case of the DMSPS is described below.

<USE CASE: Basic Flow>
1) Get panel installed on the roof and have it connect to a electricity grid. LAN into the house for status monitor.
2) 1 week controller adjustment.
3) Start operation. Activity can be checked on a status monitor in the house or on any device with web browser.
4) Sell electricity during a fine day: <GENERATING>
Advertisement after the sunset: <Advertisement by OOO>
5) Total earning from the panel is accumulated and shown on the monitor at the end of the day, week, month, season, and year.

6) Pay monthly maintenance and technical support fee to the system integrator.

<USE CASE: Bad Weather Flow>
4) Power generation and advertisement are switched according to the temperature, sunlight radiation, historical data and weather forecast. The activity status is shown on the monitor.
5) Total earning from the panel is accumulated and shown on the monitor at the end of the day in comparison with power generation only case.

6. COMPETITIVE ANALYSIS

Our financial goal is to be a rapidly growth and to make a profitable business for serving national interests in Safety and security of energy supply. DMSPS proved to be able to achieve our goals in our analysis (See attached pdf document). The financials that are enclosed have a number of assumptions.

We are considering funding of 500 million yen in the early stages. The breakdown is mainly dual mode panel development costs for demanding our capabilities. The development costs are assumed to be in collaboration with companies that have already completed the initial development.

Revenues will grow at an annual average rate of 28%, increasing 20%~25% in 1st and 2nd year due to a historical jump in revenues. We anticipate this increase throughout the following year to account of new consumer buying our solution. Estimates for sales revenue and growth are intentionally low, while anticipated expenses are exaggerated to the high side to illustrate a worst case scenario for new and growth areas.

This analysis did not use cost of interest income and system management income in our calculations of net sales because most of sales are coming from selling PV system. We included all costs in the operating expenses area of the profit and loss table. Product sales are a minimal part of our market. We are quite sure how much revenue will be derived from products so we took a low ball approach and estimated sales volumes. However, We are not quite sure how much revenue these products and services will generate, because not yet ready to estimate precise about market. We are certain that in time these services will be a large part of our revenue, but to err on the conservative side, we estimate loss from these products and services to be only ¥78,575,000 for expanding business in the first year. Therefore, to assure the start-up funds for financially stable, we have to attract investor interest for investing to our project. However, operational cash flow has increased sharply for the third year, and attractiveness of this project is considered to be high as an investment. We have discussed in business environment with financial aspect. As a result, this project proved to be worthy of investment projects.

A detailed study has not done business strategy, within the scope of this project assumes that you have taken a dominant strategy. As a business model that can be deployed in Japan, the reason that if it is not careful allocation of resources that may not be able to control our cost structure.

Our solution is a model that is protected by intellectual property rights. In such cases, but is realistic to secure sales through strategic alliances, Therefore examined the feasibility that project evaluation requirements established by dominant strategy when was adopted for Yokohama city.

During the launch of this project, we have to require attention to cost structure of PV systems. It affects not only the profits but also have a significant impact on cash flow. Because, PV systems would be significant sales over 300 million yen per unit, and it is not only affecting the amount of gross profit but also increasing fixed cost and tax payments.

Moreover, it is also important to control receivables and payables. Because PV system, a large amount per unit, is rising sharply of sales leads to a sudden increase in accounts payable and accounts receivable. Therefore, we need to require attention to securing working capital. Of course, the development of dual mode panel has also become an issue of estimating initial investment cost. We are able to examine the three directions of Development Time / Risk for;

(1) In-house Development
(2) Joint development, OEM
(3) M & A

After considerable discussion, Intellectual property ownership and development time and risk, with these points in mind that (2) is realistic choice as our choice. In that case, whole sales volume is less to produce materials, but to be a solid low-risk business. However, this is not only financial aspect but also technology aspect, basically development time and costs are remaining unresolved issues as a future work. If it is proven that this solution will work, to invest in this project from the point of national interest would be justified.

The cost basis calculation is based on the assumption that;

-The initial development costs is reasonable expenditure by government after considering the benefits to national security.
- Product cost is piling up on the average prices of existing technologies, and technology is also being developed that the interviews into the company's engineers, estimated the price at the time of production.
- Other costs are found out with necessary resources that a assumption that entrepreneurs in Yokohama city.

To use two information as a basis for forecasting revenue;

(1) Japanese growth ratio for PV industry [6, 7]
(2) Penetration ratio for residential PV system [8]

We have the basis for calculating profits to take a market share, 500 unit in first year, that backward from the first year sales required for this model to work.

The retail price of a typical residential solar system (4kw model) in Japan will be about 4 million yen. In contrast, our solution will require the cost of the two materials that are LCD panels and power generation panels. However, we are not only selling equipment, but also expect revenue from system integration and installation loans. Therefore, we can distribute goods and services more efficiently with market price. As a result, a payback period will be shorter. Because end users will generate cash flow than normal PV system. Therefore, we have a competitive edge than normal PV system.

PV industry is the fastest growing industries in the world, the next 10 years, high-potential industry which attains the highest growth. According to ARC Advisory Group's latest survey, the solar inverter market in 2008 was 3.1 billion U.S. dollars, 2014 is expected to exceed 120 billion dollars.

According to numbers by Yano Research Institute available in 2009, Japanese PV market size is predicted from 2829 billion yen in 2009 (compared to fiscal 2008 172%) to about 1.2 trillion yen in 2015 (compared to fiscal 2008 618%) [6]. On the other hand, the government is promoting policies to increase the number of households owning photovoltaic power generation to 530 million households in 2020 to 530,000 households in 2005 [7]. Therefore, there is little doubt but that PV industry will grow a large market in the near future.

It is difficult to forecast about market share because we will provide new product that is Dual Mode PV system. Among them, we calculated the market size and share using the above process and following process;

-Household penetration rate: 2%
-Penetration growth: 16.7%
-Yokohama's households: about 1.5 million
- Assume that our market share in Yokohama: 10%

Thus, we will be able to gain share at least five years with 1300 units per year. In addition, we are building a financial model for success in first year sales of 500 units that it is significantly lower than the potential our market share.

Our solution is not only solar power equipment sales, but also advance the formulation Social system model. Therefore, we can continue to expand the business cooperation with many manufacturers without having to compete with existing companies.

We estimate loss to ¥7,857,500 at the end of the first year of business. However, our business model will be to increase sales volume. Therefore, It will estimate to increase to more than ¥262.869,750 by the third year, as the reputation of our solution, its services become apparent to the general public. After Second year revenues also anticipate to increase more than market growth.

These estimates assume that there is a market to be accepted our solutions. However, we are focused on proof of concept as the scope of this ALPS project whether see if our solution works better for spreading PV system in Japan. Accurate development cost, market size and market share for considering the business model are on the left as future work.

We have calculated financial forecast that are NPV, IRR and Payback Period from several date. Analyzing result is shown below;

: Discount Rate assumes that	10%
: Net Present Value (NPV)	¥18,487,501
: Internal Rate of Return (IRR)	45.16%
: Payback Period	7 years

As a result (Figure 25), it is of value to invest in our solution, because almost of numbers show how effective investment it is.

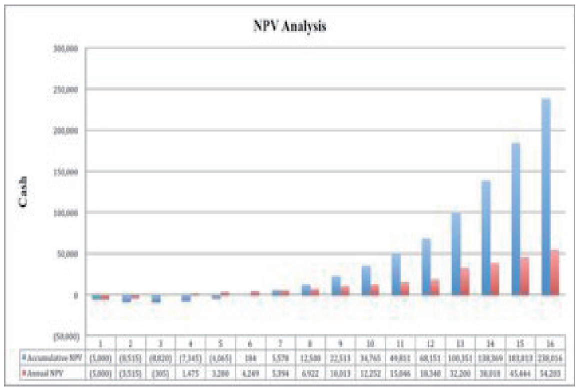


Figure 25 NPV Analysis Result.

We have to analyze sensitivity analysis and Monte Carlo DCF method by Monte Carlo simulations using a “crystal ball”. As a result, we could get some interesting insights from the analysis results. It is not only that we had expected thing, but also had unexpected thing. We would not recognize most important factor for our solution.

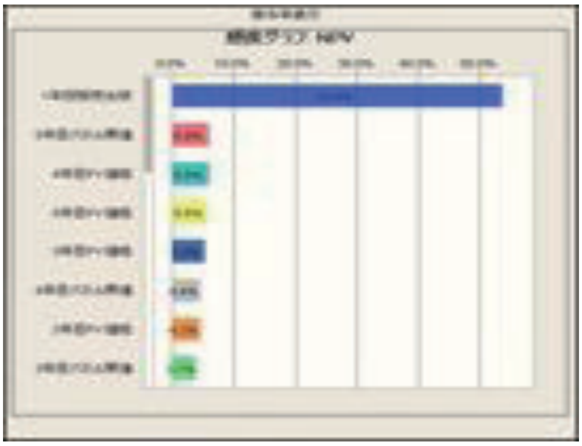


Figure 26 Sensitivity Analysis Result.

The Figure 26 is a sensitivity graph that analyze contribution ratio for finding key factor to drive our financial model. As a result, finding that the most important contribution ratio is sales volume in 1st year. It is extraordinarily effective, with contribution ratio at 53.6%, for calculating NPV more than other factor. Therefore, we should be focus on 1st year sales volume for starting business.

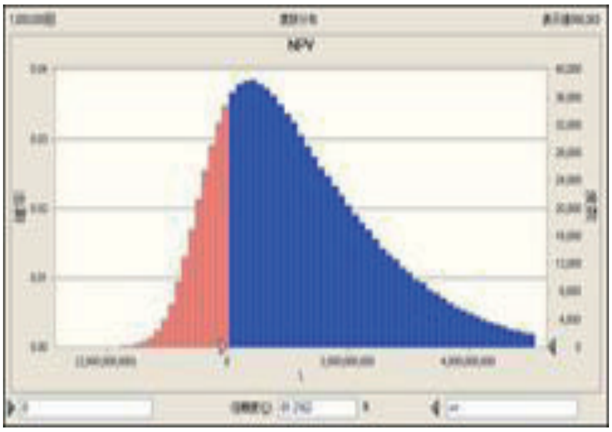


Figure 27 Monte Carlo DCF Result.

Analyzing the project NPV after exhaustive Monte Carlo simulation, called "Method of Monte Carlo DCF ", is to give information to additional factor for thought in considering (Figure 27);

- Profit that will be able to move into the black with 81.2 % of the time.
-The maximum likelihood value close to the NPV = 0, It might be due to changes in assumptions to affect the outcome.

Considering to protections strategy against competition, electricity supply business has two features that it is not only business aspects, but also public interest aspects. Who competes in this case? We recognize clearly that are three players in the market;

- PV
Efficiency and smart grid
- Alternatives Green power -
Wind, tidal, vibration
- Existing
Nuclear

However, the value of our solution is not so much production as business model to whole system. Therefore, to protect intellectual property is our core strategy.

This chapter is summarized as follows;

- This project is well thought-out model for probability of success that is considered from Technical aspect, financial aspect, social aspect.

- Significant changes in initial investment by the decision of whether any development strategy. It depends on how much you want to take the result.

- Rational behavior that the government pay for initial development. Because, the value of our solution is not so much technical products as financial terms and system configuration.

- According to sensitivity analysis, the risk of first-year sales and return the most important factor than others. Therefore, broader range of partnerships is effective way.

- Consider with the business side and public side, the model should be a partnership involving government forces and the existing company rather than a monopoly.

- If you secure a market exclusively, it is imperative that quickly gained an overwhelming market share, so it is important to secure the support of the user.

7. ALPS ROADMAP AND REFLECTIONS

Roadmap in our ALPS project is shown in the Figure 28. We applied 12 tools during ALSP workshop and obtained key moments.

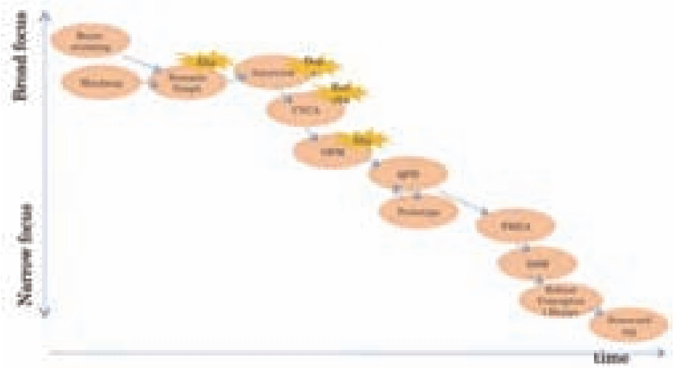


Figure 28 Roadmap.

Creating scenario graph we had “Aha” moment in which we found key discovery; solar power generation highly depends on weather and income by selling electricity is not stable. Next key moment was in the interview. Though our original theme was about “concentrated solar power”, we did not found positive ideas to spread “concentrated solar power” system in Japan. It was “Oops” moment.

Break thorough moment, ”Eureka”, was in CVCA work. Our proposal to spread solar panel in Japan is based on new value creating function in solar panel and this idea became concrete adding new stakeholder in the CVCA chart. Since our project is more based on concept design, most of key moments are in a concept planning phase, first half of the roadmap figure.

If we have an ALPS project again, roadmap will be similar to the last one but might be changed to create Project charter and Roadmap first. With Project charter, role and purpose of the member are more cleared and sharing schedule help for time management. Creating roadmap at the beginning of the project is tough if we do not know about tools much. But if we know the sequence of tools and understand context, understanding about tool will be easier.

About tools comprehension about tools were much varied between students. Follow up class for ALPS tools might help to learn tools more. Tools in ALPS are widely used in industry and learning those tools at school will be advantage to overcome another future issue if we acquire them.

8. CONCLUSION AND FUTURE WORK

The detailed system analysis and the financial evaluation conclude that the concept of DMSPS is plausible and it is a solution for the safe and secure solar power generation system for Japan.

Although the concept of the DMSPS seems to be feasible and promising, this proposal includes certain amount of R&D of the key technology. The critical points in the R&D are 1. Energy conversion efficiency, 2. Energy consumption by the display function, and 3. Production cost. These must need to be carefully examined using the simulation created in the project and several sets of target values must be determined. Some very conservative assumptions must be simulated to develop a contingency plan.

There are few more things need to be investigated in detail to complete the project. They are in depth technical investigation and the detailed financial evaluation.

The in depth technical investigation is required to determine the cost and the delivery impact of different configurations of the panel and to determine the R&D strategy. For the technical investigation at least three engineers with appropriate knowledge of solar cells, OLEDs, and solar power generation system are needed. The investigation should take no longer than 18 months and the CPM chart for the process is shown in the Figure 29. After this investigation we will be able to make decisions such as amount of R&D needed, technical licensing, M&A of company with key technology and so on.

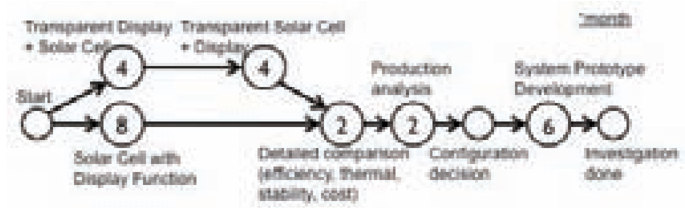


Figure 29 CPM chart of DMSPS technical investigation

The detailed financial evaluation needs to be done based on the technical investigation. This evaluation should include detailed information of R&D cost and schedule so more accurate calculation can be done. Also one more very important aspect needs to be clarified is the volume of the potential market of DMSPS. Due to time and resource constraint it was not possible to design an appropriate market research method therefore this must be done immediately. The volume of houses at appropriate location and orientation for DMSPS needs to be counted or carefully estimated through the process. The methodology for market size estimation must be developed so it could easily be applied to different cities or regions in Japan.

9. ACKNOWLEDGMENTS

We really thank Professor Keio Shimazu for supporting our project and helping our team to stay together. Also a great gratitude to Professor Gerard Dijkema for being a generous proposer of the project.

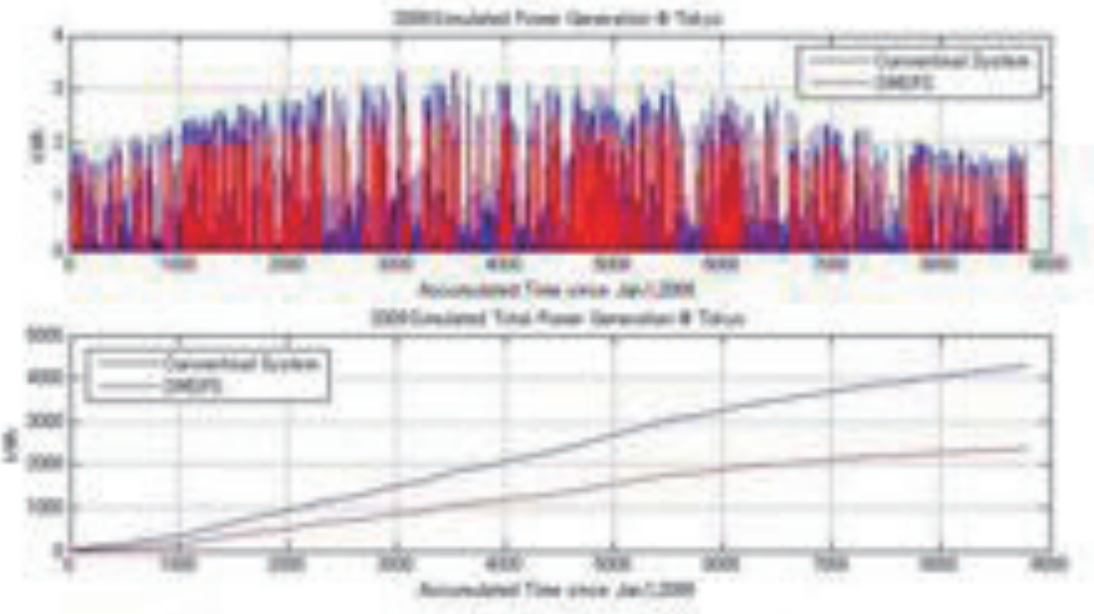
10. REFERENCES

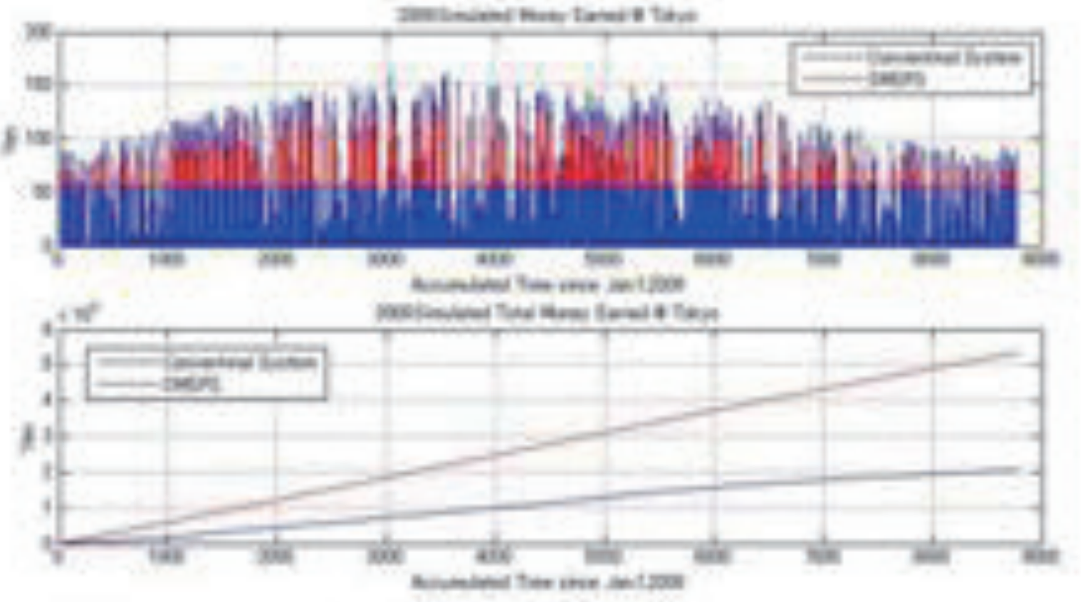
[1] Prime Minister Y. Fukuda, "In pursuit of "Japan as a Low-carbon Society"," ed: Prime Minister of Japan and His Cabinet, 2008.

[2] S. Brusaw and J. Brusaw. (2010, *Solar Roadways*. Available: http://solarroadways.com/
[3] PC Watch. (2010, November 18). *FPD International 2010 Report*. Available: http://pc.watch.impress.co.jp/docs/news/event/20101111_406031.html
[4] IB Times Writer. (2010, November 18). *Development of Transparent Solar Panel Material*. Available: http://jp.ibtimes.com/articles/11573/20101109/62065.htm
[5] J. M. Agency. (2010, November 10). *Meteorological Statistical Data*. Available: http://www.jma.go.jp/jma/index.html
[6] Yano Research Institute, "Present and Future of PV systems Market," 2009.
[7] METI New Energy Subcommittee on Energy and Natural Resources Committee, vol. 36, ed, 2009.
[8] Ministry of Public Management, Home Affairs, Posts and Communications, "Housing and Land Survey," ed, 2008.

ANNEX A

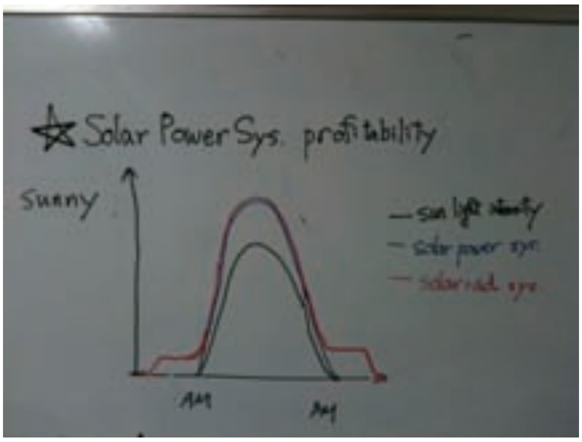
SIMULATION RESULTS

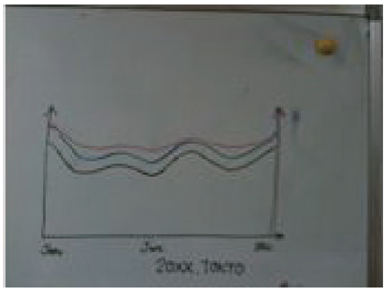


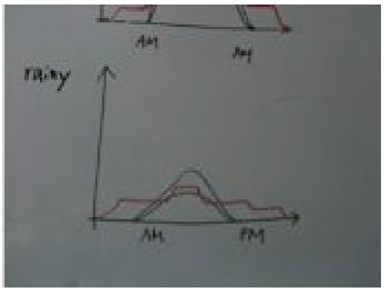


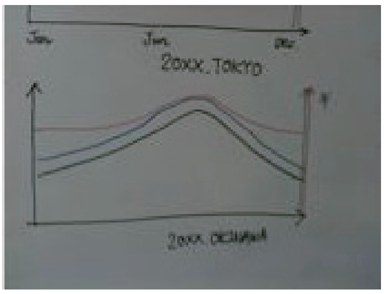
ANNEX B

RECORDS OF BRAINSTORMING



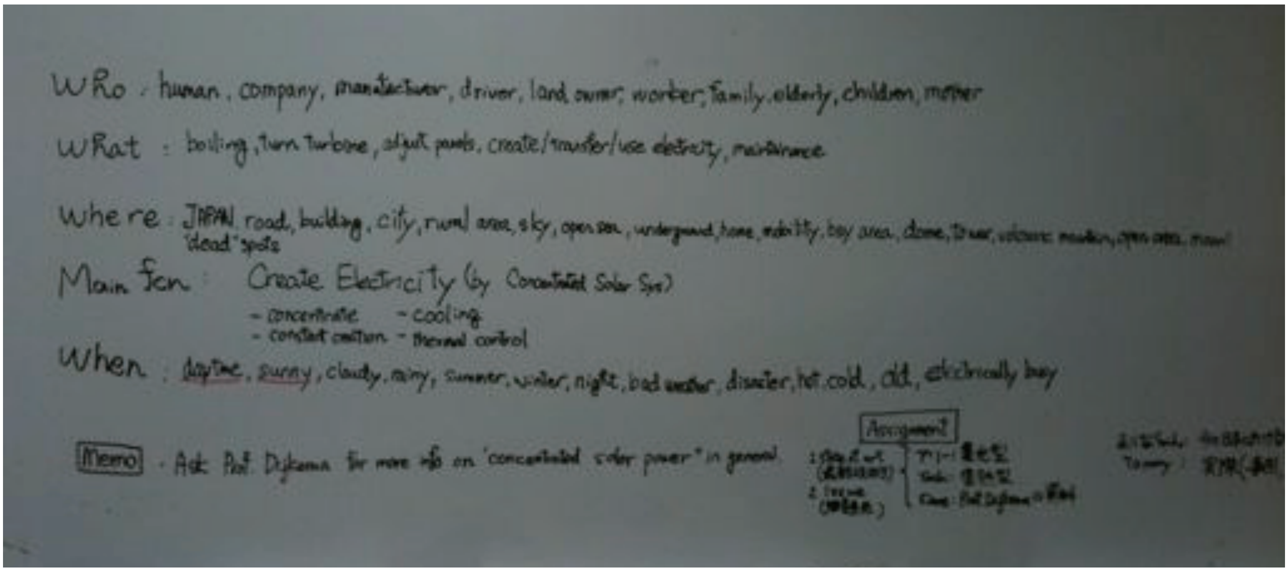




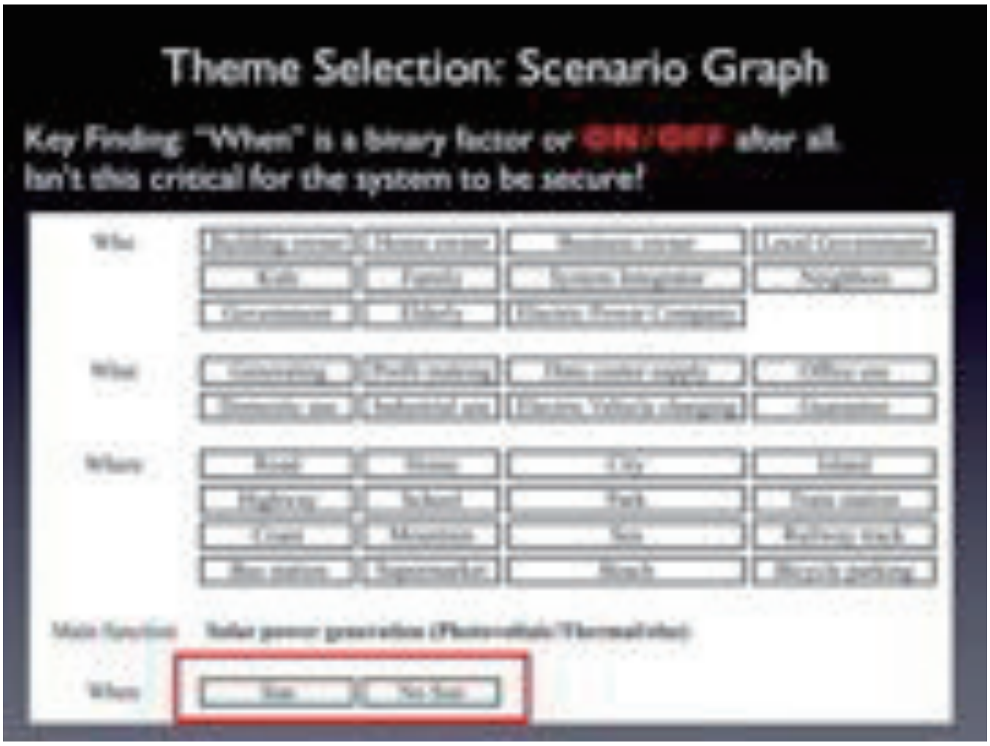


ANNEX C

SCENARIO GRAPH RESULTS



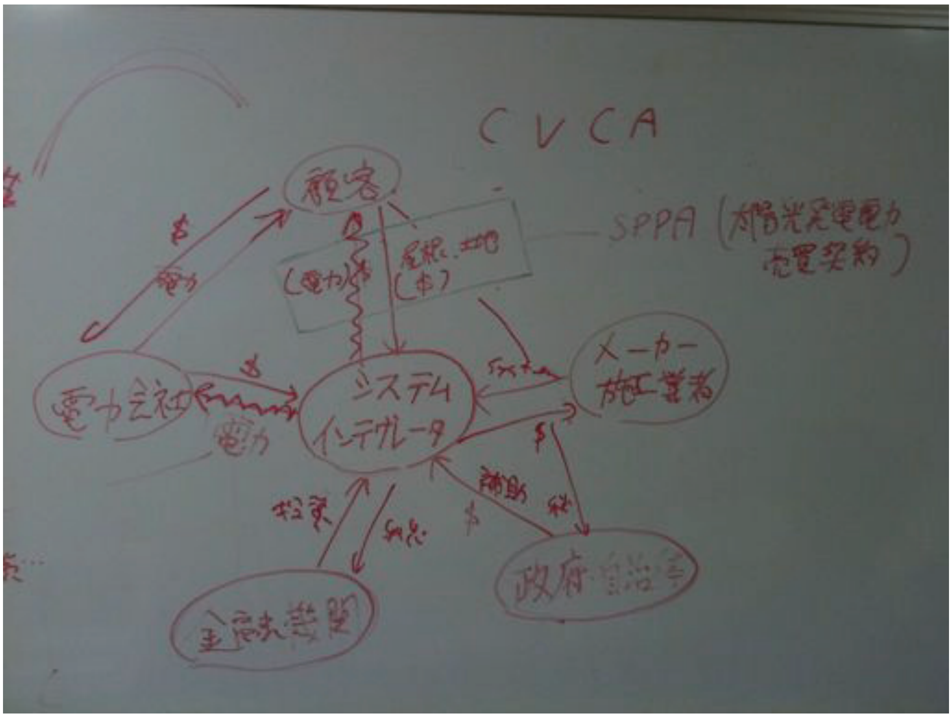
Early scenariogprah.

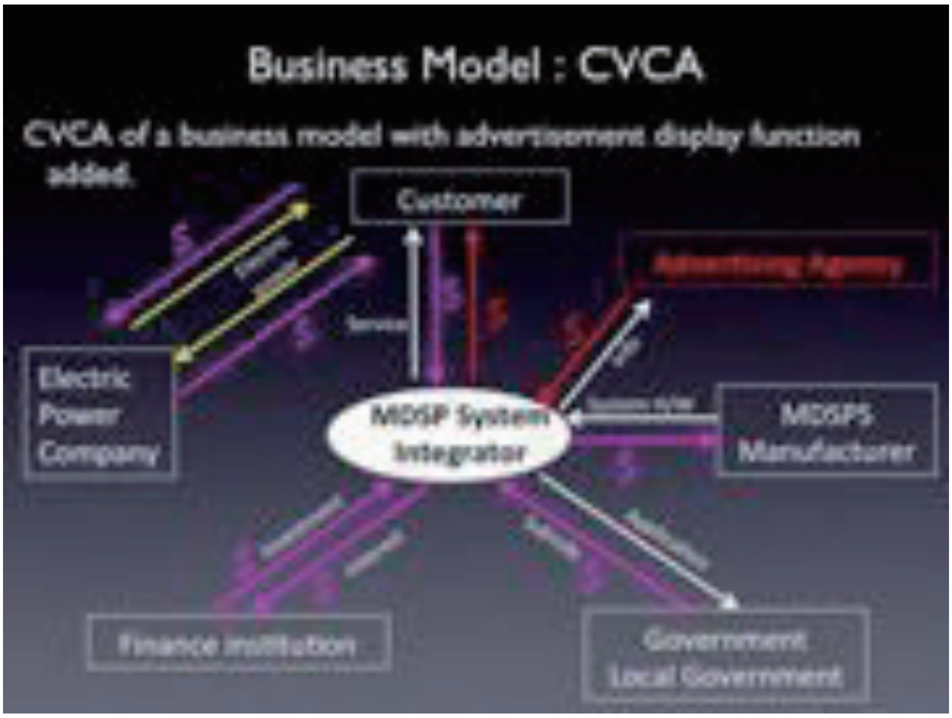


Final scenariograph.

ANNEX D

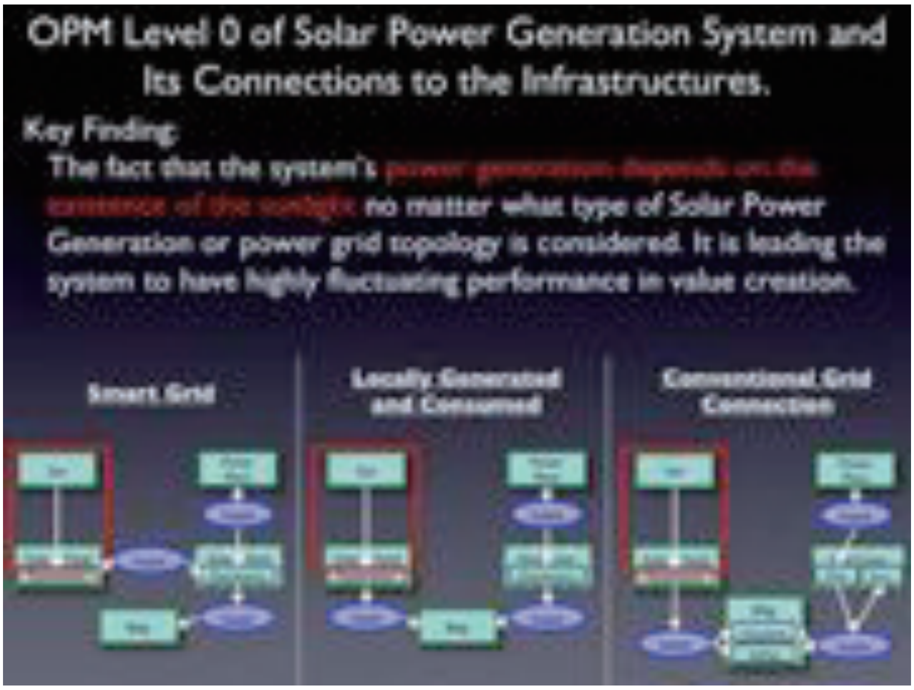
CVCA RESULTS

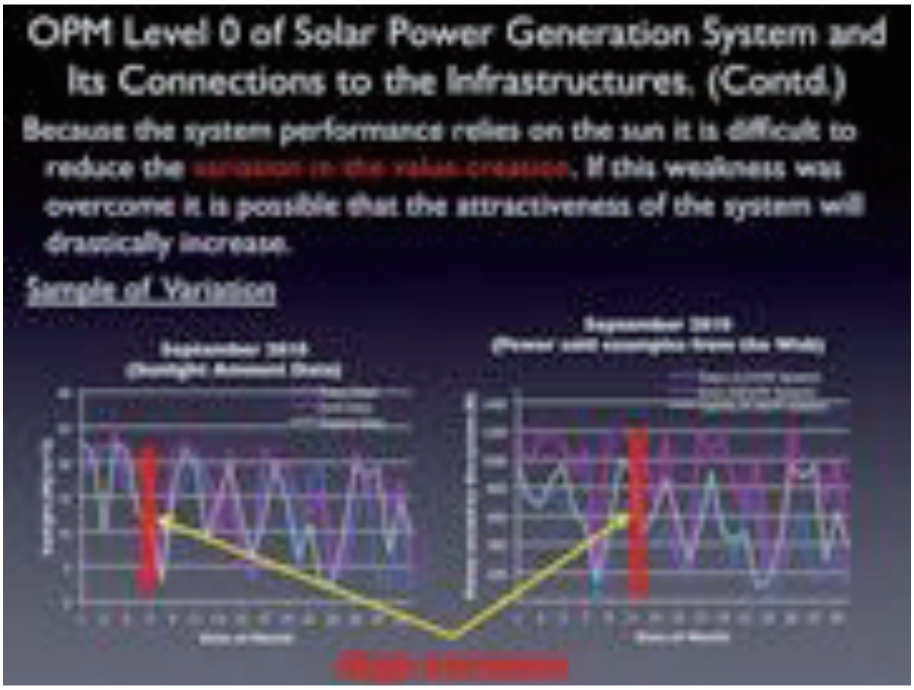




ANNEX E

OPM LEVEL 0 DIAGRAM RESULTS



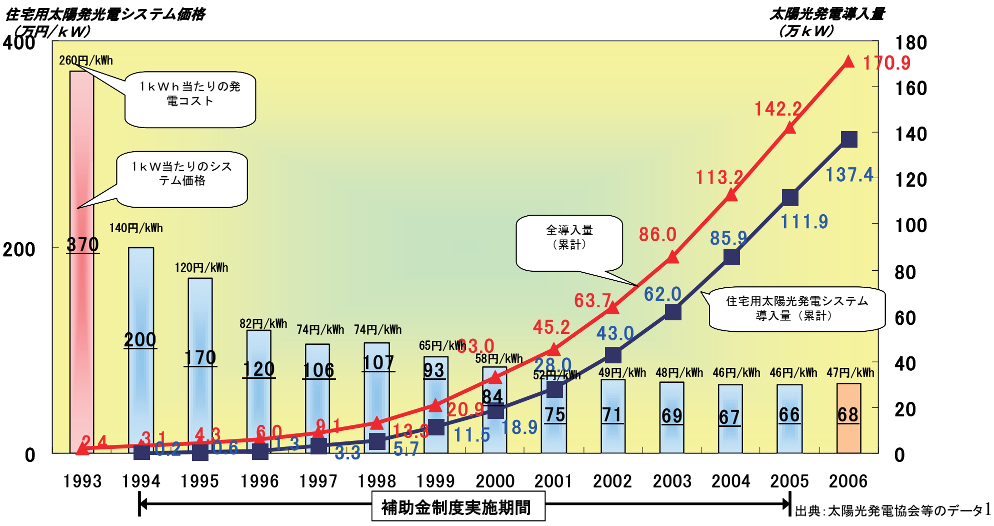


ANNEX F

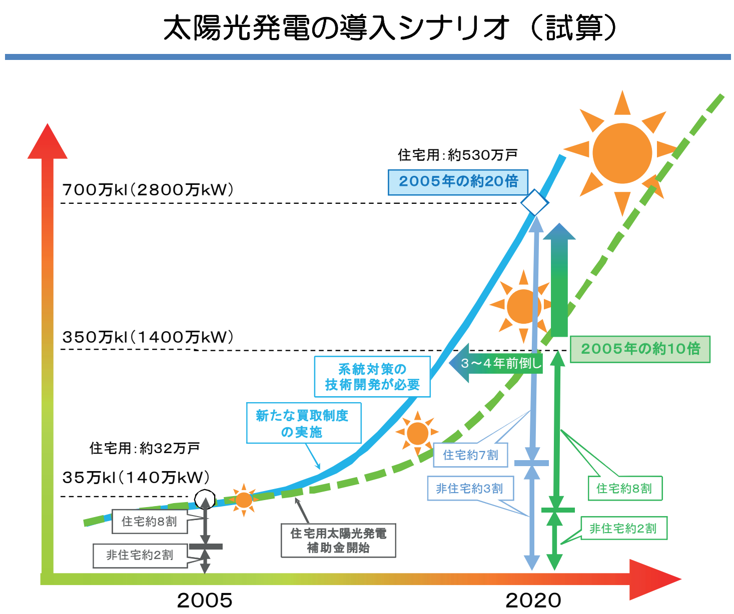
FIELD STUDY

ANNEX G

GOVERNMENT DATA AND PREDICTIONS.



Solar Power Generation Capacity in Japan (MEXT)
from “The current status of the solar power generation and the direction of the future policy plans” July 24th,2008



Solar Power Generation Capacity Building Scenario (MEXT)
“総合資源エネルギー調査会 新エネルギー部会 36th Meeting Material1-3” July 22nd, 2009

ANNEX H

FIGURES IN 4.16 FMEA

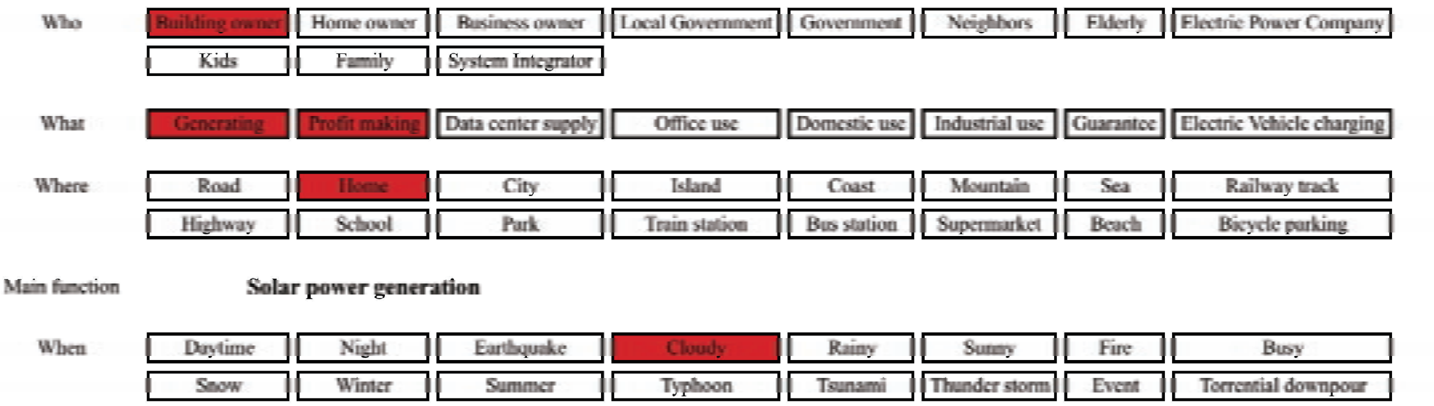


Figure 14 Scenario Graph (Large)

Function or Requirement	Potential Failure Modes	Potential Causes of Failure	Occurrence	Local Effects	End Effects on Product, User, Other Systems	Severity	Detection Method/ Current Controls	Detection	RPN	Actions Recommended to Reduce RPN
Emergency power generation soon after the earthquake	Fuse blow	Excess current because not enough current drawn	3	No current	No power supplied	9	Load and current monitoring	1	27	Emergency power generation mode must have different set of fuse
Display advertisement	No display	Outside operating temperature due to snow	5	Display does not startup	Unable to use display	8	Temperature monitoring	1	40	Heater, Warmup operation

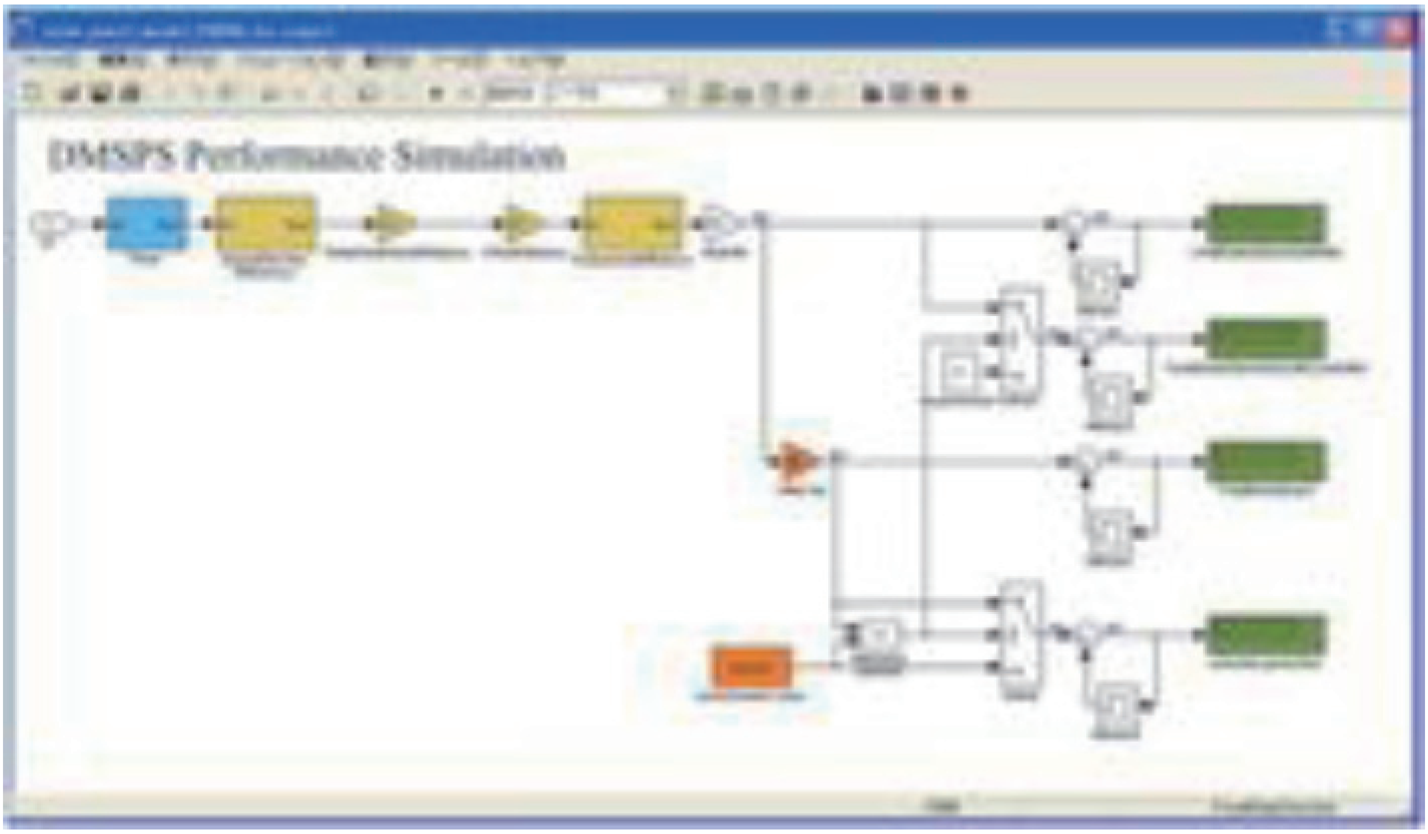
Table 6 Unconventional Failure Modes From Scenario Graph (Large)

Function or Requirement	Potential Failure Modes	Potential Causes of Failure	Occurrence	Local Effects	End Effects on Product, User, Other Systems	Severity	Detection Method/ Current Controls	Detection	RPN
Display panel activity status on monitor	Incorrect status displayed	Panel failure	2	Incorrect power generation amount displayed	Wrong information received	7	Self-diagnosis, periodic check	3	42
		Computer failure	1	Incorrect power generation amount displayed	Wrong information received	7	Self-diagnosis	1	7
		Power distribution board failure	2	Incorrect power generation amount displayed	Wrong information received	7	Self-diagnosis, periodic check	2	28
	No status displayed	Panel failure	2	No power generation displayed	No information received	6	Self-diagnosis, periodic check	3	36
		Wiring disconnection	2	No power generation displayed	No information received	9	Self-diagnosis, periodic check	3	54
		Monitor failure	1	Nothing displayed	No information received	6	Self-diagnosis	1	6
		Network failure	3	Nothing displayed	No information received	6	Self-diagnosis	1	18
Display total earning from the panel on monitor	Incorrect earning displayed	Computer failure	1	Incorrect earning displayed	Wrong information received	7	Self-diagnosis	1	7
		Monitor failure	1	Incorrect number displayed	Wrong information received	7	Self-diagnosis	1	7
		Power distribution board failure	2	Incorrect number displayed	Wrong information received	7	Self-diagnosis, periodic check	2	28
		Public power grid failure	2	Incorrect number displayed	Wrong information received	7	Periodic check	4	56
Generate power	No power generated	Panel failure	2	ZERO power generation	ZERO earning	8	Self-diagnosis, periodic check	3	48
		Power conditioner failure	2	ZERO power generation	ZERO earning	10	Self-diagnosis, periodic check	2	40
		Power distribution board failure	2	ZERO power generation	ZERO earning	10	Self-diagnosis, periodic check	2	40
		Wiring disconnection	2	ZERO power generation	ZERO earning	10	Self-diagnosis, periodic check	3	60
Display advertisement on the panel	Dim picture	Panel failure	2	Low quality display	Ineffective advertisement	7	Self-diagnosis, periodic check	3	42
		Panel power supply failure	2	Low quality display	Ineffective advertisement	7	Self-diagnosis, periodic check	2	28
		Dirty panel surface	5	Low quality display	Ineffective advertisement	7	Periodic check	3	105
	No picture	Panel failure	2	Display not working	No earning from advertisement	8	Self-diagnosis, periodic check	3	48
		Computer failure	1	Display not working	No earning from advertisement	8	Self-diagnosis	1	8
		Panel power supply failure	2	Display not working	No earning from advertisement	8	Self-diagnosis, periodic check	2	32
Switch power generation and advertisement display	Incorrect switching	Computer failure	1	Uncontrolled switching	Not optimal earning	7	Self-diagnosis	1	7
		Network failure	3	Uncontrolled switching	Not optimal earning	7	Self-diagnosis	1	21
		Panel failure	2	Uncontrolled switching	Not optimal earning	7	Self-diagnosis, periodic check	3	42
		Power distribution board failure	2	Uncontrolled switching	Not optimal earning	7	Self-diagnosis, periodic check	2	28
	No switching	Computer failure	1	No advertisement displayed	No earning from advertisement	8	Self-diagnosis	1	8
		Power distribution board failure	2	No advertisement displayed	No earning from advertisement	8	Self-diagnosis, periodic check	2	32
In-house power generation	Excess current	Power conditioner failure	2	Fuse blow	Not able to use electricity	8	Self-diagnosis, periodic check	2	32
	No power generated	Panel failure	2	No power at outlet	Not able to use electricity	8	Self-diagnosis, periodic check	3	48
		Power conditioner failure	2	No power at outlet	Not able to use electricity	10	Self-diagnosis, periodic check	2	40
		Power distribution board failure	2	No power at outlet	Not able to use electricity	10	Self-diagnosis, periodic check	2	40
		Wiring disconnection	2	No power at outlet	Not able to use electricity	10	Self-diagnosis, periodic check	3	60

Table 7 FMEA from Use-Case (Large)

ANNEX I

FIGURE 22 ENLARGED



Group 10’s Final Presentation Slides

Safe and Secure Solar Power Generation System for Japan

-DMSPS：Proof of Concept-

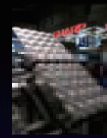
ALPS 2010

Group 10
Yosuke Arimori
Kanenori Ishibashi
Yoshio Muraoka
Marina Nagayama
Yoshikazu Tomita

Background Research on Concentrated Solar Power Generation in Japan

Daido Steel

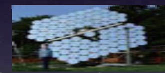
- The sunlight energy is concentrated with a lens.
- Technology that obtains high amount of power generation
- The condensing magnification is 550 times. The area of the semiconductor becomes 1/1,000.



PV Japan 2010

Mitaka Kohki Co., Ltd.

- "Sunlight condensing experiment device" developed on August 17, 2009.
- Pursues the sun by the automatic operation.
- Leads sunlight to the receiving heat part.



http://yaplog.jp/sunhatuden/archive/248

Kansai Electric Power Co., Inc.

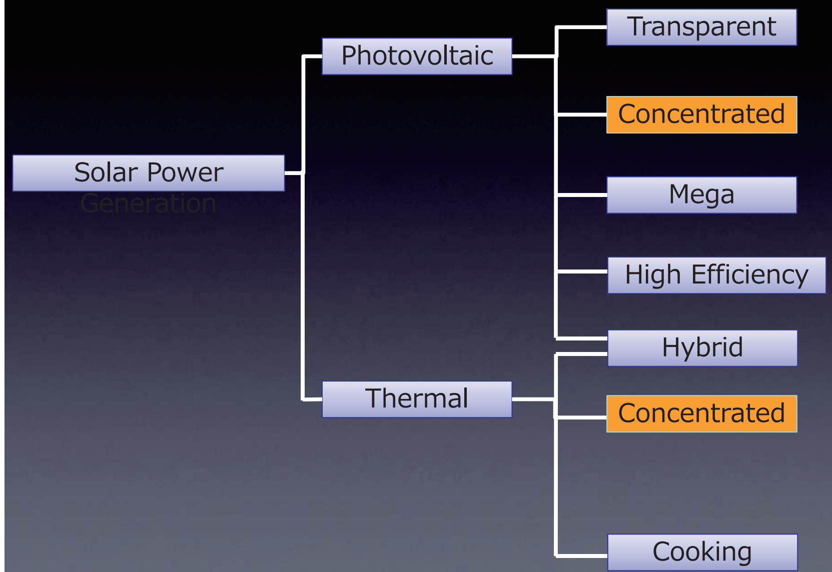
- Mega-solar power generation plan in Osaka Prefecture Sakai City seaside part.
- Area→ About 20ha
- Output of power generation→ 10MW [10,000kW]
- Generation Capability→ About 11 million kilowatt-hour/year
- Amount of CO2 cuts→ About 4,000t/year
- Able dayof operation→ October, 2011

Kansai Electric Power Co., Inc.hp

AIST&NREL Joint Research on Concentrated PV.

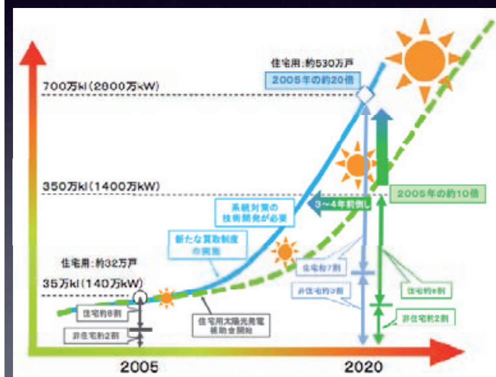
- The same condensing type photovoltaic generation system is set up in Japan-U.S..
- The power generation performance is verified comparison.
- First in Japan to set up the condensing type photovoltaic generation system in a domestic foothill.

Concentrated Solar Power Generation in Solar Power Generation Family Tree



WhatSolar Power Generation Provides to Japan?

"Since Japan has a low degree of energy self-sufficiency, it positions solar power generation as ***an important domestic energy source****among renewable energy sources, for* *<u>its particularly high potential for installation</u>."* [METI Nov. 2008]



A scenario for Solar Power Generationpromotion [METI Jul. 2009]

The key is to accelerate the installation and to build Solar Power Generation capability faster.

This is being executed by making the system **"pay for itself"** with government subsidy in electric purchase price.

Theme Selection: Scenario Graph

Key Finding: “When” is a binary factor or **ON/OFF** after all.
Isn’t this critical for the system to be secure?

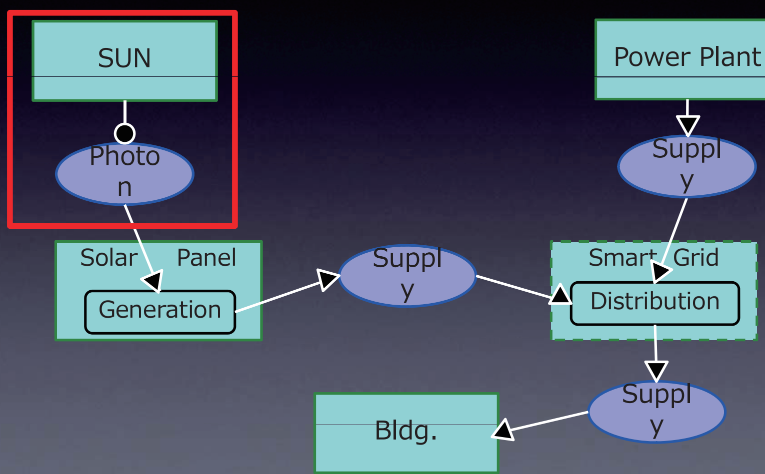
Who	Building owner	Home owner	Business owner	Local Government
	Kids	Family	System Integrator	Neighbors
	Government	Elderly	Electric Power Company	
What	Generating	Profit making	Data center supply	Office use
	Domestic use	Industrial use	Electric Vehicle charging	Guarantee
Where	Road	Home	City	Island
	Highway	School	Park	Train station
	Coast	Mountain	Sea	Railway track
	Bus station	Supermarket	Beach	Bicycle parking
Main function	**Solar power generation (Photovoltaic/Thermal/else)**			
When	Sun	No Sun		

OPM Level 0 of Solar Power Generation System and Its Connections to the Infrastructures.

Key Finding:
The fact that the system’s power generation depends on the existence of the sunlight no matter what type of Solar Power Generation or power grid topology is considered. It is leading the system to have highly fluctuating performance in value creation. Some examples.

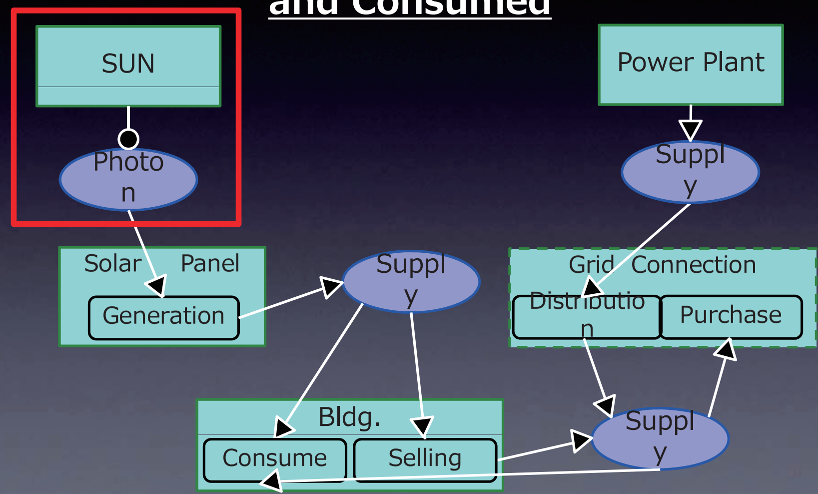
OPM Level 0 of Solar Power Generation System and Its Connections to the Infrastructures. (Contd.)

Smart Grid



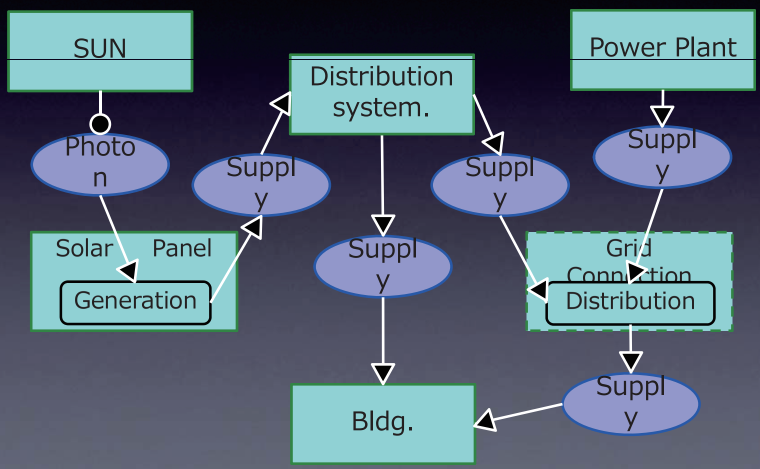
OPM Level 0 of Solar Power Generation System and Its Connections to the Infrastructures. (Contd.)

Locally Generated and Consumed



OPM Level 0 of Solar Power Generation System and Its Connections to the Infrastructures. (Contd.)

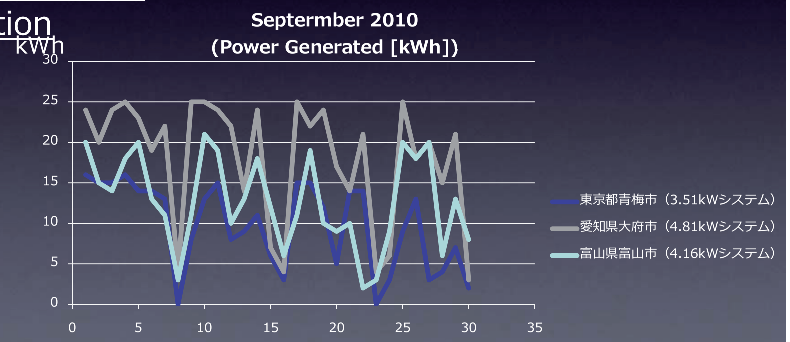
Conventional Grid Connection



OPM Level 0 of Solar Power Generation System and Its Connections to the Infrastructures. (Contd.)

This is preventing the system to become more profit robust and more attractive for residential house owners to invest. Thus acceleration of Solar Power Generation system installation is not happening.

Sample of Power Generation



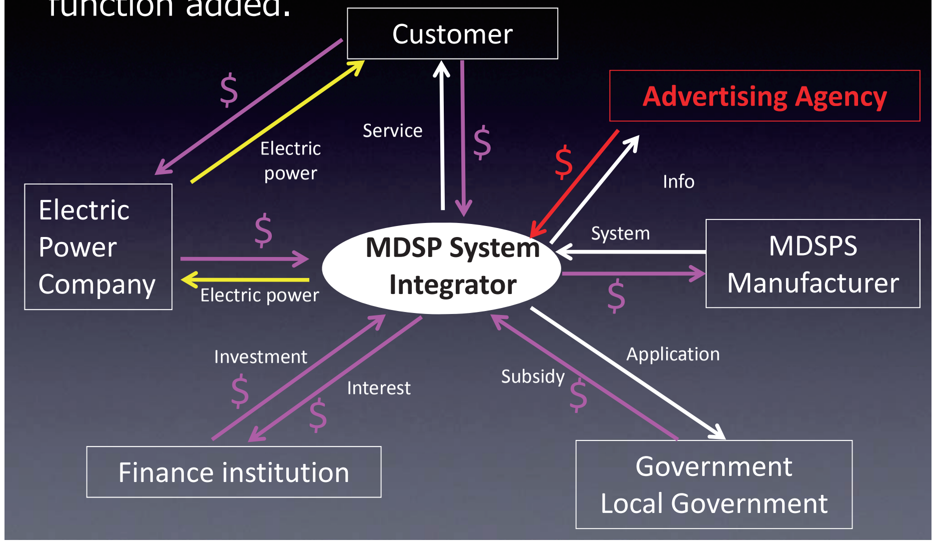
Creating an Additional Value Flow in the System

Based on negative VOCanalysis and Brainstorming the advertisement display was found a **"killer"** addition.
The suitable business model to handle such system was investigated by creating a CVCA.

Solar Power Generation Negative VOCs		Characteristics of Digital Signage
Does not work at all when at night or bad weather.	⇔	Visibility is higher at night or bad weather.
It's looks ugly on the roof.	⇔	Wants to be placed where highly visible.
It requires large area to install a decent amount.	⇔	Wants larger area for display so that more people can see.

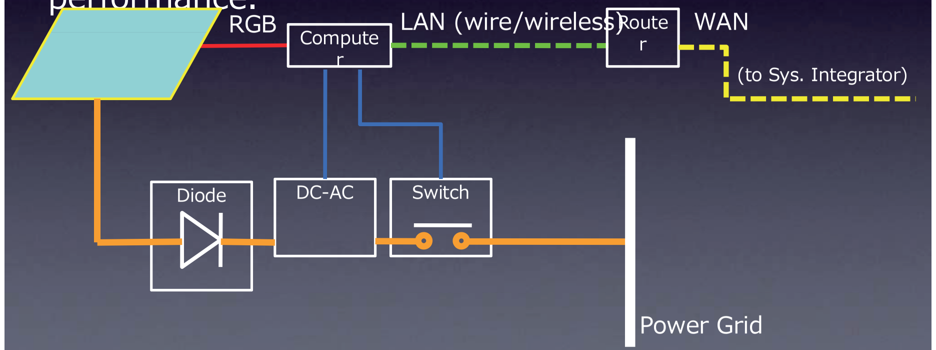
Creating an Additional Value Flow in the System

CVCA of a business model with advertisement display function added.



System Description

Name: Dual Mode Solar Panel System (DMSPS)
What it does: The system with the solar panel that functions as power generator and also as digital signage. The operating mode can be controlled autonomously/manually to optimize the system performance.



Is DMSPS Technically Feasible?

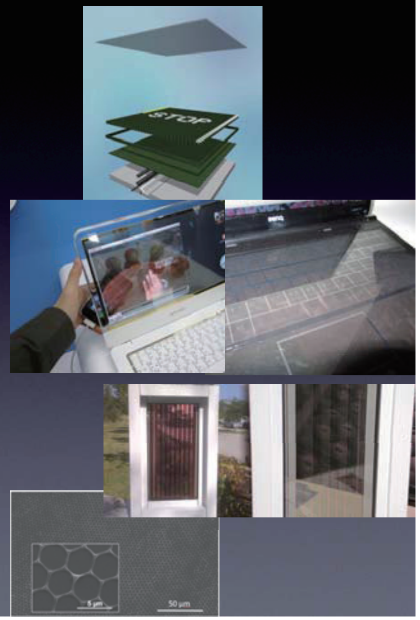
Yes it is!!

Layered Structure Technology
-> Solar Roadways (2010) <http://solarroadways.com/>

Transparent Display Technology
-> Samsung OLED (Nov. 2010)
-> AUO Transparent keyboard with solar panel (Nov. 2010)
<http://pc.watch.impress.co.jp/docs/news/event/20101111_406031.html>

Transparent Solar Cell Technology
-> Dr. MirceaCotlet's research group (Nov. 2010)
<http://jp.ibtimes.com/articles/11573/20101109/62065.htm>

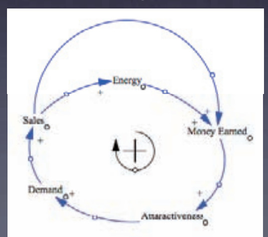
->Konarka's solar glass (May 2009)
<http://news.cnet.com/2300-11128_3-10000835-3.html?tag=mncol;txt>



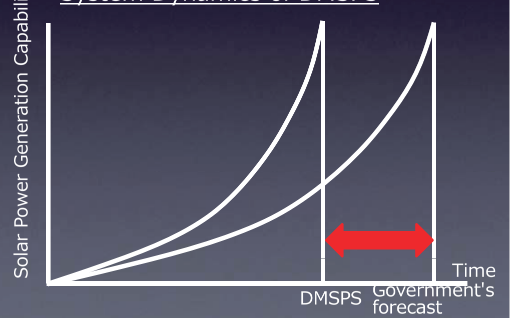
Why DMSPS is a Better Deal for Japan?

From dynamic prospective the DMSPS enables larger volume to be installed much faster than conventional system. Therefore it results faster increase of Solar Power Generation ratio in Japan.
In condition of maintaining the current government supports (initial cost subsidy and generated power purchase price subsidy), further government support should be invested to the DMSPS technology development.

Causal Loop of DMSPS



System Dynamics of DMSPS



Conclusion

Critical weakness of Solar Power Generation system can be addressed and attractiveness of the system can be dramatically improved by adding another operating mode to the system.
The advertisement display mode does compensate very well with the weaknesses of the Solar Power Generation.
The government intention to increase the power generated by Solar Power will be achieved faster with the approach DMSPS provides.

DMSPS is the way to go!!

Future Works

- Technical investigation in depth.
  - Need to determine the cost impact of different configurations of the panel and decide R&D strategy.
- Second round financial evaluation.
  - Based on the R&D cost analysis, financial evaluation must be revisited.