

UNCERTAINTY AND PLANNING ITERATIONS IN SOLAR SUPPLY CHAIN

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ABSTRACT

Solar supply chain in Indian context has a number of uncertainty factors in demand and supplies. Some of these factors are internal to company and some are on external in nature. Supply chain planners are facing challenges on account of such uncertainty. To optimize interest of all stakeholders of supply chain, it takes extra planning iterations, depending on factors latest in demand and supply framework. The paper tries to bring out some of such factors which cause extra iteration in planning. This paper can be helpful to develop a proposed planning framework for solar supply chain related to Indian context.

Keywords: Planning, iterations, Solar Supply Chain planning, Changes in planning, iterations in planning.

Introduction:

In a matured supply chain it is expected that the number of planning iterations are at minimum. This situation is dependent on degree of demand and supply visibility and variations in it. In solar industry demand and sources of supplies are dependent on state regulations and support (Shukla and Mali, 2015), creating larger dependency on external factors. In addition, there are a number of other salient reasons at lower level of abstraction, causing extra number of planning iterations, as compare to a typical matured supply chain like in FMCG.

The research paper highlights some of such factors causing extra planning iterations in solar industry which directly affects demand and supply, unlike a matured supply chain planning. The research also tries to bring up a model based on best causes influencing planning practices used in solar industry to achieve an optimum supply chain results. Such supply chain influences are harnessed either by designated industry planner or by firm's senior management to make planning decisions. (Shukla and Mali, 2015).

Nine hypotheses are discussed in this paper to compare number of iteration in solar industry than "in practice" (referred to FMCG) along with the correlation to their causes.

Body of Research Paper:

Literature Review:

Solar Supply chain planning iteration specific variables, used to take decision across the industry, to improve supply chain efficiency, is not specifically covered in available literature. Closest available general supply chain literature covers a number of supply chain studies on "coordination, "Collaboration" and "integration". Any loss of coordination, collaboration or integration affects planning iterations in short term.

From this standpoint the term supply chain may be too limited and a more appropriate term is the value delivery network which contains all channel members who align their activities to improve performance of the overall chain and deliver customer value (Kotler and Armstrong, 2011) [12]. Value delivery for solar supply chain cannot be aligned unless specific unique solar variables are studied objectively and relationship is established to improve unwanted planning iterations.

A number of factors have been suggested to affect the decision like supply chain planning areas, such as the frequency of need, uncertainty, asset specificity, capabilities and resources, coordination requirements, and strategic control and risks (Hayes, 2005; Heikkilä and Gordon, 2002; McIvor, 1997) [9].

In existing literature, frequency of planning is typically sub-divided into horizon and hierarchical based planning levels. Minimal focus is given to establish various factors affecting planning iterations. An adaptive planning (iterative) is a method of planning in which the plan of a supply chain is modified periodically by a change of parameters of the supply chain or characteristics of control influences on the basis of information feedback about a current condition of a supply chain, the past and the updated forecasts of the future. (Ivanov, Sokolov, 2010) [11]. Solar industry specific factors, related to inter functions like engineering, procurement and business development is creating such uncertainty in demand, requires coverage in further studies. An adaptive nature of game played by actors, an information bank for such decision coordination can be further helpful with future research (Watson, Oliva 2007) [19].

For capital intensive projects, material supply often constrains the project schedules and affects the system-wide costs. Hence, it is clear that supply chain decisions and project decisions are intertwined. While one can maximize the project scheduling/planning flexibility; the inventory costs can be prohibitively high (Chen, Zhao) [4]. When company faces time or cost deviations in projects, uses to modify only the procurement Strategies (Papallo) [18]. In solar industry major investment goes into large scale capital intensive solar projects, attracting high inventory cost. Inventory relationship in solar project and planning is drawn in the next step in this paper, to minimize dependence on short term procurement strategies alone. When multiple processes work united it is obtained in a successful way the final product (Mula, Polar, Garcia, 2004) [15]. Identification of some of conflict centers for solar project is considered in the paper for further study.

Researchers have correlated organizations integration and performance, (e.g. Frolich and Westbrook, 2001) [7]. (Gao, Joseph, Bird 2005 & Murray, Kotabe, Zhou, 2005) [8] [16] suggest that mutual dependence with specialized processes & unique products and services, is required. Therefore the focus in present thesis has been kept on studying planning iteration very specific to solar industry business segments for better “integration” in future. This integration facilitates forecasting and planning of real-time customer demand and on-going supply capacity constraints (Esper, 2010) [6]. Very functionally oriented SCM tend to discourage communication and encouraged creation of measures that optimized locally, not globally (Pagell, 2004) [17]. Low level of integration has direct linkage with the consensus on strategy of supply chain. Results for this non-consensus leads to multiple planning changes (iterations) not sufficiently studied by literature since it can have dependency on industry sector (Pagell, 2004) [17].

Subjective forecasting faces multiple challenges like over-confidence, anchor and adjustment, and optimism. The idea as given by author indicate that without an optimized number of iteration the factors of subjective forecasting will leads to a poor forecast (Makridakis, 1998) [3]. Solar iterations also face such overconfidence to manage demand and supply side. Provided poor forecast, one may spend a little effort to ensure that forecast are accurate. The part, which calls in the direction of that “a little” need, is to be researched for a sector (Beach, 1986) [2]. If a certain function in the organization or member of the supply chain plans for a given capacity to meet their perceived demand, the other party would prefer not to invest in any more capacity as a part of explanation of misalignment. These aspects direct towards need of arriving at more realistic optimum scenario by skillful iteration process (Kraiselburd and Watson 2007) [13]. Quality of demand and supply planning can be roughly related to quality of information used, the quality of the inferences made from available data of forecast and plan, and the organization’s conformance to the plan that are generated. The same needs demonstration is a particular industry under discussion (Kraiselburd and Watson 2007) [13].

The study of (Amaro 1999) [1] points that, for non make-to-stock companies, customization is only a qualifier to compete with similar companies. In consequence, the companies are forced to improve order management and production planning/scheduling functions. If the operation can’t satisfy schedules dates, the situation is analyzed and the order might be delivered late or the delivery date is renegotiated with the customer. In both cases, the customer service quality is reduced and time is spent trying to fix the situation between marketing and operation. Re-planning (iterations) is also a key issue to deal with instability of the demand (due to very flexible order management. To avoid frequent changes of plans (that give too much “noise” to the system), schedules are fixed, for a short planning horizon, and only just before its implementation.

It suggests three methods to improve material handling: better capacity utilization, higher asset turning, and improved supply synchronization. Asset turning involves the reduction of expensive stock (Christopher 2005) [5]. Solar projects focuses in such stock optimization efforts leading to extra number of planning iterations, substantiated in the hypothesis under further study presented here.

Research Methodology:

It was difficult to get a ready available data indicating number of iterations from solar organizations to prove hypothesis objectively. An estimate, based on multiple respondents and averaging them out was considered for hypothesis testing. On an average iterations in solar projects and product planning are indicated as below.

Three sets of business segment representative were the prime respondent to understand the reasons for planning iteration in solar industry. These three sets of respondents are solar manufacturer, solar EPC contractor or developer of solar projects and solar products. These solar segments have a varied dynamics and thus research is intended to put a balanced focus on all the three business segments. A small case study understanding from one major solar company is used to put forward research question and hypothesis. The case studies company chosen in such a way that it should represent all major business segments. Thus we chose Tata Power Solar to build our hypotheses.

During case study an understanding of supply chain planning iterations were hypothesised. A broad understanding is considered to bring out elements, which may be different than a conventional supply chain to draw attention towards planning iterations specific to solar industry.

Population under study: Objective of research is to study area of Bangalore region wherein there are approximately five major solar players, manufacturers of solar cells or modules - Tata Power Solar, EMVEE solar, HHV Solar and Kotak Urja. In addition about 8 small solar product distributors and whole sale retailers are considered for samplings who are distributing solar products. Some major players from across India were also included to be interviewed from out of Bangalore region, significantly contributing to solar industry in India. These players considered for sampling include Lanco Solar, Indo-solar, Vikram Solar, Moser Baer and some other smaller players.

Research is to find out planning iterations from the solar industry for a period between years 2010 to 2015, under given market conditions. Limited period of research specifies certain prevalence of specific state policy, market conditions and planning practices adopted. These practices were required to be studied in relation to planning iterations, affecting during this period.

The study is conducted based on 25 semi structured interviews of respondents followed by 297 surveys to test the hypothesis objectively. An interview questionnaire is prepared to research the focused area through hypothesis. This interview questionnaire is designed to capture all the key themes emerging across the industry based on the case study. The objective is to substantiate the hypothesis formulated based on case study. Each of the interview questions is posed in front of interviewer with the best of language he can understand. A basic premise of the topic is explained to respondents, in the form of sequence of events happened in solar industry between year 2010-15, to bring out relevant images from the interviews. Interview respondent were requested to think through before they response, they were also asked to relate to the particular solar segment, they operate in. Interview questionnaire was sent in advance to respondents to go through as a pre-read, to minimize the discussion time and bring out more relevant voices and images on questions. Questionnaire is planned in such a manner that there are leading questions and then follows up questions. Follow up questions are to create better understanding on the questions under hypothesis.

Interview is followed by an objective survey. A questionnaire is made to capture quantitative and objective data from a larger group of respondents. This questionnaire is a mix of objective questions on Likert ranking scale 1 to 5, Yes/No or interval scale responses. The base objective themes for questions were derived from interview responses to convert them into discrete numerical data, as estimated by survey responses. Survey was conducted during Inter Solar Summit, India on 22nd September, 2014 in Bangalore, to maximize the responses from respondents from solar industry.

Analysis, Findings and Discussion:

Number of planning iterations in “existing practice” (from FMCG) is benchmarked as 2, by speaking to a few FMCG planners. These planners work on forecast, which is sometimes revised once just before the supply or twice in case sudden increase or decrease in demand or supply. Planners in FMCG indicated that their average iterations are pegged at 2. Number of iterative changes in small solar project (less than 1 MW), solar project (more than 1 MW) and solar products is referred as 8, 24 and 3 respectively. This is summarized in the Table (I) below.

Table I

Solar Business Segment	Average Iterative Changes
Small solar project (less than 1 MW)	8
Large solar project (more than 1 MW)	24
solar products	3

Following nine sub-hypotheses, from HA 01 to HA 09 are formulated to compare number of iteration in solar industry than in practice (referred to FMCG). HA 01 is a basic hypothesis used to test the salient issue creating planning iteration in solar industry. Explanation of all nine hypotheses is substantiated

based on survey data and interview responses, to establish an objective correlation supported by their explanation.

HA 01: Immature iterative design engineering, faster demand inflow than cash collection, inadequate safety stocks increases number of iterations.

This is a basic hypothesis, explaining problem salient to solar industry. Issues of immature design engineering, faster demand inflow than cash collection from customer and playing on minimum stock seems a chief cause for planning iterations. This hypothesis was derived from the basic case study conducted before beginning of detailed interview and survey. This hypothesis is included to build a foundation to validate, whether these are industry facts or just related to one company under case study. We started our interviews with a leading question on these three aspects and found respondents agreeing that solar industry planning has strong dependence on first time right design to meet customer requirement but it is almost impossible to capture accurate project requirement upfront before start of designing work. Design engineering of solar projects in India is relatively young, therefore first time right design is a constraint, creating material planning challenges for planners. Solar power projects, are relatively new entrant in Indian market, thus design engineering is still an iterative in natures to match customer and project design expectations.

Solar projects are heavy capital intensive and required substantial liquidity in material procurement. During the course of project execution, there seems mismatch between inflow of cash from customer and outflow of cash in direct and indirect procurement. The basic reasons for mismatches are poor customer requirement capturing, immature project design and non-availability of buffer inventory stock to absorb any delay is material from a number of reason attributed to supply variations. These basic reasons, put pressure on planner to match interest of buyers and suppliers, by planning iterations.

Demand frequency count, is more than the instances of cash collection from customers, and non-availability of sufficient stocks causes extra planning iterations in expediting or de-expediting.

Reasons for extra planning iterations were grouped under following four categories as below.

- 1) Project site and design related changes
- 2) Availability of material related changes
- 3) Cost reduction related iterations changes
- 4) Customer requirement related changes

It was observed that reasons of iterations were also dependent on size of solar projects. Following data shows variations in number of iterations (Changes) in small project, large projects and solar products categories as estimated by survey respondents.

This Chi-Square, P-value=0.332, suggests that there is no relationship between the reasons of iteration and type or size of solar project. The below tabulation of number of iterations suggests that even though total numbers of iterations are dependent on size of project but causes of iterations are not related to the number of iterations. Some of major site and design related changes are attributed to project site changes, as against planned. In addition, a rough estimate of site at the time of project bidding and unclear quality assurance plan (QAP) causing these iterations.

Table II

Reasons of iteration	Small Projects	Large Projects	Solar Products
Site & Design Changes	13	44	4
Material Availability Changes	4	45	3
Cost reduction changes	5	15	2
Customer requirement changes	10	25	3

Lower level causes in supply chain planning iterations are analyzed under following eight more hypotheses formulated based on the case study company.

HA 02: Deviation in sequence of material procurement and dispatch, from a planned sequence, for project installation, increases number of iterations.

Solar projects or product installations follow a sequence of supplies, based on sequence of requirements. An ideal sequence is project foundation, installation of supporting structure, mounting of modules, connection of electronics equipments followed by installations of power transformers. During project execution, critical material requirement becomes bottleneck to carry out installation in right sequence to meet customer requirement.

An ideal expected sequence of supply of major solar material group is as below

First – “Supporting Structures Group”>Second – “Solar Module Group”>Third – “Power Transformers Group”>Fourth- Other Balance of Systems (BOS)

A typical sequence in practice is observed as below during our interviews

First – Modules & small quantities of structures group >Second – Full modules & structures group >Third – Power Transformers group >Fourth- left out Balance of Systems (BOS) group.

A solar support structure is required immediately after civil foundation work. Non-availability of structures on time or in adequate quantities to continue project, have been found as show stopper. It has been learnt during interviews that solar companies ship the immediate available material in their stock to project sites, even prior to structures, which falls before in the sequence. Structure supplier’s capacity and quality problems have been observed as a factor being dealt by large scale solar companies. Volumes of solar structures are so huge that logistics and continuous supplies from suppliers to remote project site is challenging. Solar developers receive excise duty concession on structures, so suppliers are required to be approved in advance from Ministry of New and Renewable Energy (MNRE) to get such benefit. A bottle-neck of structure supply in large quantity, does not allow switching to an approved alternate suppliers, in event of failure to meet the required quantity or quality. In the event of non-performance of suppliers, changing and resuming supplies is observed a challenging, since approval of suppliers from MNRE is a long drawn process. Much lesser constraints have been observed in supplies of solar modules, as it is readily available from inventory of global sources or from continuous running manufacturing lines domestically.

It is observed that most of the companies are not able to dispatch material in an ideal sequence to allow continuity of an uninterrupted installation work. This causes increase in number of iterations by planners at the last moment to minimize such interruption at site. TABLE III indicates number of respondents interviewed agree or disagree on their observations to follow correct sequence of material dispatch as per requirement.

Table III

	Response	Number of responses
Ideal Sequence being followed	Yes	8
	No	30
	Sometimes	25

Most of the respondent agreed that change in sequence provide a short term leverage of booking revenue early on, during the project execution but it further leads to increase in number of iterations for planners. Thus it becomes one of the challenges for the planner to ensure material is planned in such a way to follows sequence, as close as possible. Close to an ideal material supply sequence helps a continuity of project execution at lowest cost.

HA 03:03: Ambiguous project starting point, to begin material planning process, leads to increase in number of planning iterations.

Material planning for solar projects seems to have no clearly defined starting point to begin placing firm order on suppliers. The reason for such ambiguous start point is unclear confirmation of an order receipt from customer and beginning of installation. This uncertainty in clarity is because of the stage, when an order is considered as “firmed” from customer.

A solar project order get matured with a number of stages starting with a Letter of intent, Signing of Power Purchase Agreement, Financial closure, receipt of advance etc. There have been a number of cases where customer order not getting firmed up it had high probability. Once order is confirmed by customer, but if the cash advance is not receipt by contractor, it has been viewed as a weak commitment. Respondents have told us that even after cash advance and firm contract, some order has not been through from MNRE and causes order cancellation at later stage. There are a varied practice to start placing purchase orders on suppliers, depending on planners own learning from previous projects and understanding of nature of customer. A solar organization generally tries to delay placing orders on their suppliers to minimize inventory days in stock. A missed order after procurement of material, can lead to excess stock and solar contractor may fall in the trap of liquidity constraints, to perform other firmed orders which can rotate cash faster. Material procured for a custom designed solar project may not even get consumed in other projects to free up liquidity.

Our interview revealed that there are multiple points during the various stages of order winning, when a planner starts planning and placing orders on suppliers. Different solar players had different terminology of stages of an order. Some contractor has more stages of orders than other. We tried to capture these stages the way it was put forth by respondents in front of us. Later on a most rational four stages have been finalized for the purpose of analysis. These varied starting points are

1. Order discussion with customer
2. Receipt of letter of intent
3. Receipt of firm order
4. Receipt of advance payment from customer

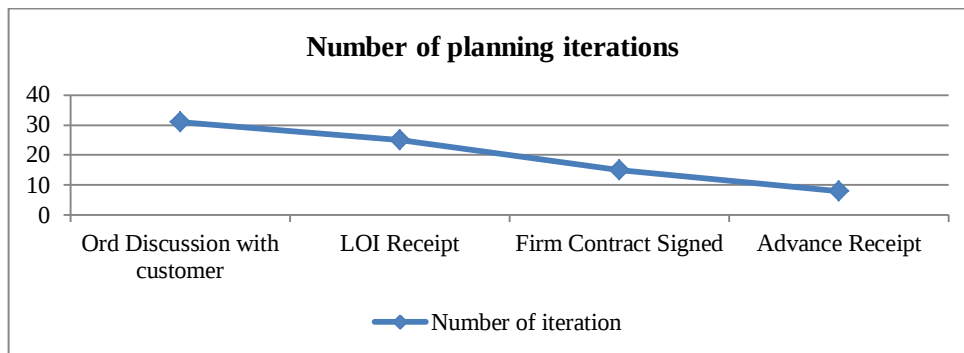


Fig (I)

Planners feel, a late starting of planning process during customer acquisitions stages, allows less number of iterations as estimated and shown in the correlation coefficients with R-Square 99% & P-value 0.004. The respondents are of the opinion, even if contractors begins planning material at early stage of an order, clarity of customer need of “design of project” and exact requirement of material gets firmed up later. Customer’s interactions with sales and design team of contracting company help educating developers regarding various options to choose from, to better meet their requirements. A late order placement satisfies developer better for their requirements and reduces number of iterations for planners, even though it causes some delay in project commissioning.

HA 04: Multiple projects execution at the same time leads to increase in number of iterations in supply chain planning.

Solar projects are mostly supported by one or other government sponsored program. Project approval and release of funds from government mostly takes place during the second half of the financial year, due to availability of fund allocation to ministry and processing time thereafter. Second half and especially last quarter of financial year, is the time when all projects are being executed at the same time in parallel. These multiple project execution takes place with only marginal increase in resources, including planners. Such skewed timing of projects, in a limited period of time, causes planners to plan

large quantities of material at the same time. Situation of planning material having multiple configurations, is sometime beyond the manageable limit of planners. Expediting and de-expediting to meet projects requirement leads to extra iterations per project. Planners face challenges of managing multiple suppliers and variety of material at the same time. This duration of time is considered as chaotic by most of planners, especially in the event of non-ERP based planning which is more common in Indian solar industry. Respondent indicated that this situation causes approximately 20-40% extra number of planning iterations depending on the time and project.

Table IV

Solar Segment	Nos. of iteration per project in First Half FY	Nos. of iteration per projects in First Half FY
Small Project	6	11
Large Project	20	45
Products	2	4

Solar procurement teams and equipment suppliers told during the interview, that peak manufacturing and solar system integration load is pushing them into ad-hoc internal supplies and resource management. Requirement of raw material and skilled manpower goes up by 30-40% during peak time. Additional resources are difficult to ramp up for only half of the year. An ad-hoc project management leads to sub-standard resources, deterioration of quality of supplies and logistics, as been faced by respondents.

HA 05: Number of iterations is function of fund availability to pay to suppliers by contractors on time.

Indian solar industry is cash crunched most of the time due to heavy liquidity suction in manufacturing plant, machineries and projects. Less investor confidence and high cost of funds, adds to the problem of material planning as per requirement. Non-availability or delayed availability of funds with contractor leads to more number of planning iterations to satisfy customer requirements. Below tabulation compare responses from respondents whether fund availability pushes more planning iteration.

Table V

	Iteration increases	Iteration does not increase	No Impact on iterations
Fund Availability	170	97	30

The data above indicates a clear difference in number of estimated planning iteration for solar material planners.

HA 03:06: Strict norms of declaring excess inventory in solar organizations impacts number of planning iterations.

There was a profound concern on keeping extra buffer inventory than required to fulfil a customer order, in solar industry. There have been restrain exercised among respondent to promote ex-stock sale, as found during interview. Solar organizations have their very strict norms to declare an inventory as non-moving or excess stock. Some solar companies are stricter than other depending on their internal norms and financial liquidity comfort. Three types of inventory norms to declare excess/non-moving/obsolete were being used in most of the organizations, during the period of research – greater than 60 days, greater than 90 days and greater than 120 days. The frequency of analyzing inventory as excess, non-moving or obsolete, were not very well established across solar organizations, but planners interviewed agreed, that their companies follow one of these inventory norms. Some larger solar companies are very particular in analyzing inventory aging fortnightly, than other smaller companies who analyze once in a quarter. The strict norms for excess or non-moving inventory put pressure on planners to plan very tightly. They ensure a very thin safety stocks or no material stocking, if order is not firmed up. Control is to minimize the risk of inventory excess or obsolescence, as laid down norms

in their company norms. Solar project material fulfilment expectation still remains high, similar to off-the-shelf solar products. Planners struggle to establish a balance to optimize availability and strict inventory norms laid down in their company. This is achieved by continuously refining and revising planning as the demand visibility increases.

Table VI

Norms to declare inventory excess/non-moving	Nos. of planning iterations
Greater than 60 days old	20 to 40
Greater than 90 days old	10 to 18
Greater than 120 days old	6 to10

There has been observed, an estimated lower inventory carried by solar company, with more number of iterations as shown in an estimation based on respondent's views.

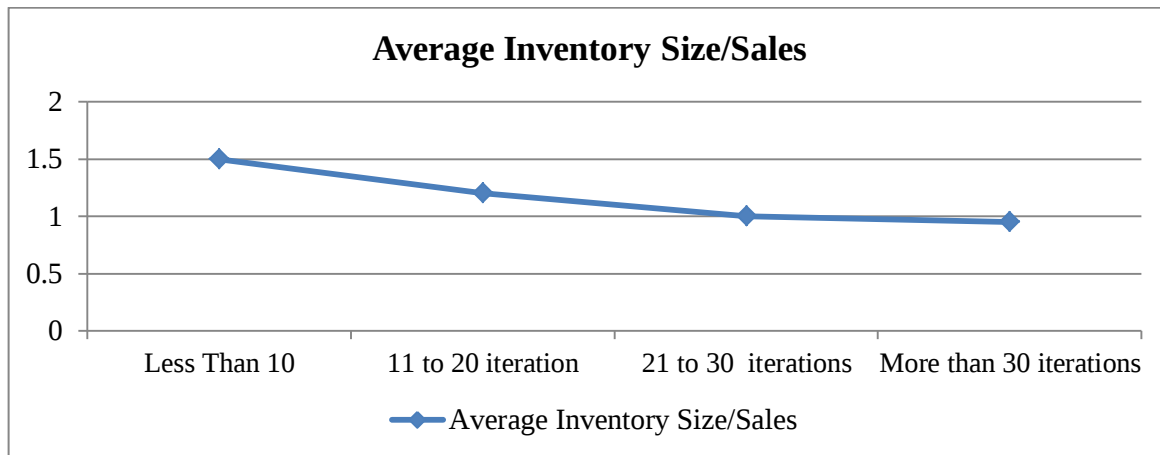


Fig (II)

The figure below shows that solar planners opine that more number of days is provided to declare excess or non-moving stock; less number of planning iterations is expected.

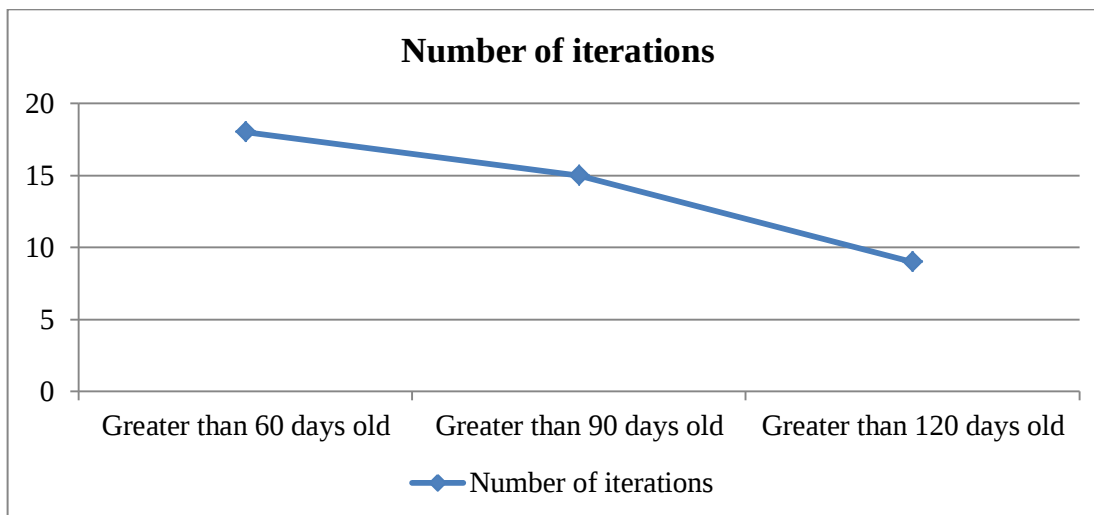


Fig (III)

HA 07: Supplier's credit period affects number of planning iterations.

Procurement in solar industry is being encouraged on a longest possible credit period from suppliers. This is on account of cash crunch situation in the industry. During our interview, it has been found that

one of the important supplier's qualification criteria considered is a long credit period. This affinity towards long credit period of solar contractors pushes them to trade-off on delivery performance and quality of material. A limited number of such suppliers, who has capability to offer longer credit period, make contractor highly dependent on them. A contractor loses ability to switch to alternate source in event of any supply, quality or delivery constraints, during the project execution stages. Respondents explained us that though credit term with longer credit period are pushing planners to have limited source, but at the same time it minimizes number of planning iterations, as alternate sources or material is not explored and supplies continues, irrespective of some delivery glitches.

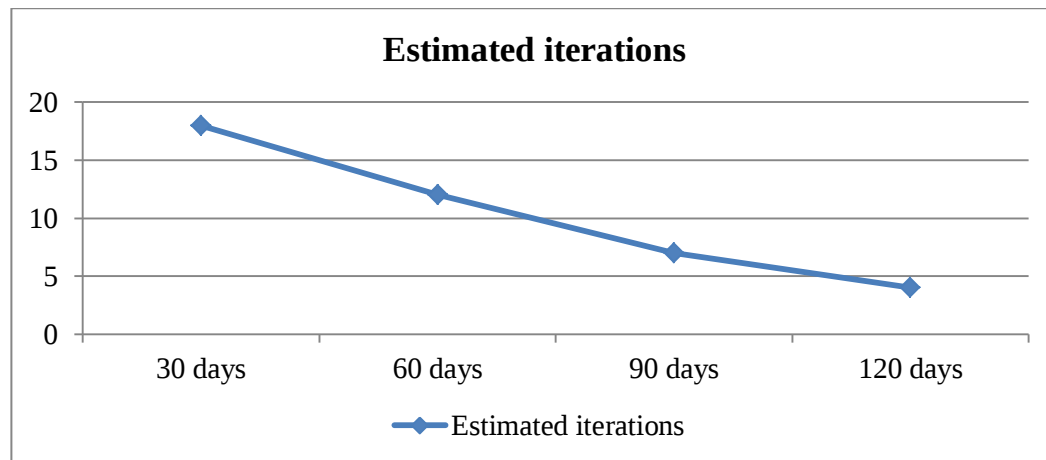


Fig (IV)

Hypothesis stated is substantiated with the above estimated numbers of average iterations to show how less number of credit days, causes more iterations during the planning and revision process.

HA 08: Difference exists between in-house and contract manufacturing of solar modules, cell or solar products in planning iterations.

Solar modules carry about 50% value of solar installations in any solar project or products. In case, module manufacturing by a contractor is in-house, it has about 50% independence in planning by value. In other word half of the value of revenue is under the influence of in-house planners. A planner who has to plan modules from a source other than in-house manufacturing, from domestic or global sources, has to carry out more number of iterations to match prices, availability and quality aspects. A Chi-Square table below shows that in-house and contract manufacturing has relationship with the number of planning iterations.

Table VII

		Increases Iterations	Does not increases iterations
Module Manufacturing source	In-house	130	167
	Outsourced	186	111

A larger proportion of material by value manufactured in-house reduces dependence on outside source and thus number of planning iterations. Same may not be true for planning iteration of other raw material used for solar module or cell manufacturing as revealed by respondents. Effects on material planning iterations are always lesser, in case of finished goods than planning iteration for raw material for producing cells or modules. Our interview respondents indicated that even if in-house modules manufacturing may cause lesser number of iterations for finished goods, but at a child level raw material planning iteration may remain unchanged. At the level of raw material, module procurement is independent of a particular module specification. To some extent, there is de-coupling between number of planning iteration in raw material and finished solar modules. For an in-house planner number of iterations for finished modules are minimal than raw material to produce solar cells and modules.

Table below estimates range of planning iterations if contractor has capability to produce about 50% of material used in solar projects, in house.

Table VIII

	Number of Iterations
Greater than 50% value in-house	8-15
Greater than 50% value procured or contracted	10-30

HA 03:09: Number of planning iterations is dependent on solar business segments.

Planning complexities varies from solar business segment to segment and thus affects planning iterations. Solar customer base can be broadly divided into three business segments - small solar projects (less than 1 MW), large projects (more than 1 MW) and solar product segment. The number of iterations is highly dependent on these segments. Our interview respondents estimated following number of iteration in different solar business segments.

Table IX

Solar Segment	Number of Estimated Iterations
Small Projects	2 to 5
Large Projects	6 to 50
Solar Products	2 to 3

A large solar project involve variables like topography of land to be used for solar project installations, state government regulations, size and complexities of equipments, grid compatible etc. These complexities are much lesser in smaller projects, especially roof top installations, wherein the roof topography and other project design aspects are more predictable. Further solar products are standard product or solution designed to suit universal customer requirement.

A level of customization in solar product is almost inexistent. This is the primary reason to have a more predictable material requirement. It allows planners to have safety stocks and interchangeable usage of components which helps in reducing number of planning iterations.

During our objective discussions with interview respondents, they revealed that planners consider number of planning iteration increases more rapidly for every addition of 5 MW of solar project. Larger the size of solar project, more number of iterations are expected by planners. Beyond a bench marked project size of 5 MW, planners have to look out for alternate material source as a back.

Conclusion:

Number of planning iteration is more in solar industry in comparison to a fast moving product. The reasons for such additional iterations are on account of following factors –

1. Changes in project design on customer request or project site change.
2. Modification in Quality Assurance Plan.
3. Non-availability of correct material stock at the time of requirement at project site.
4. Changes in material to meet or leverage cost in a given project.
5. Poor project cash inflow and availability of funds with a solar firm.
6. Deviation from ideal sequence of material supplies. Majority of projects are facing deviation is sequence of material supplies.
7. Dilemma to judge the time to start planning of material, for a solar project under discussion. This dilemma prevails from a stage of order discussion till a firm order is signed or cash advance is received from customer.
8. Multiple solar project execution at the same time during second half of the year.
9. Strict solar industry norms of inventory obsolescence and excess, causes constraints planning.
10. Longer supplier credit period inversely affect supply chain planning iterations.
11. Dependence on large volume of out-sourced material for projects.
12. Solar business segments – specially related to size and variety of material drives iterations.

Number of planning iterations in solar projects is related to size of solar products. In general, with every addition of 5 MW size of project, number of iterations significantly increases.

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