Abstract

"An analytical study of supply chain planning process for solar renewable energy suppliers in Bangalore during year 201-15"

An evolved understanding in supply chain planning literature is to ensure that required material reaches to customers on time at a most optimum cost, in order to enhance supply chain surplus. Supplies chain "planning variables" are required to be considered depending solar industry sector. The study presented here hypothesising "planning variables" which are not covered specifically by literature for solar industry.

Following four umbrella hypotheses are concluded.

First hypothesis The research brings out an analysis on "planning" process from global supplies, as a means of optimization of cost and primary decision makers for "planning" across industry. Hypothesis discussion also brings out a specific role of planners, played by "state" to serve broader sustainability objectives, beyond just supply chain optimization.

Second hypothesis brings out prime factor for solar demand as a dependent variable, as a function of state support or a comparative support status of two or more than two states.

Third hypothesis describe, number of planning iteration carried out in a solar supply chain. Optimum iterations is dependents on degree of demand and supply visibility and variations in it. The research highlights some of such factors causing extra planning iterations in solar industry, directly affects demand and supply, unlike a matured supply chain planning.

Fourth hypothesis analyses the skills and competencies required to manage solar supply chain planning "width" factors. It is hypothesised that the generic planning skills and competencies alone are not sufficient to build a strong supply chain planning for solar industry.

Chapter -1: Introduction

Chapter covers the details of solar industry development, its value chain, challenges, trends and complexities imperative to supply chain planning.

Chapter-2: Literature Review

Solar supply chain planning variables, to improve supply chain efficiency, is not covered in available literature. Closest available general supply chain literature covers a number of supply chain studies on “coordination, “Collaboration” and “integration”. These generic supply chain literatures, not specific to solar industry is considered as closest to build further solar supply chain planning framework.

Chapter 3: Objective Scope & Hypothesis

Chapter covers **objective** of this research work is to first start mapping global and Indian evolving trend (width variable) in solar industry supply chain planning. Research tries to learn width variables along with planning practices evolving among solar players in the country.

Three business segments respondents are - solar manufacturing, solar EPC contract or developer of solar projects and solar products.

There are four hypothesis further divided into sub-hypothesis to substantiate the main hypothesis discussed in chapter-5

Chapter - 4: Research Methodology

A small case study was undertaken in one of the solar company operating in all the three segments, to put forward research question and hypothesis. 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. The objective is to substantiate the hypothesis formulated based on case study. Two of the solar companies allowed observing their planning session to better comprehend their planning practices.

Interview is followed by an objective survey. A different questionnaire is prepared, based on significant occurring images in interviews.

To include “state” view on supply chain planning, we took help of published reports by central and state government (MNRE).

Chapter -5: Analysis & Interpretation

A detailing of four hypotheses from HA 01 to HA 04 goes as follows

HA 01: Supply chain planning process for solar manufacturer/supplier need a wider view of global & domestic supplies, as critical inputs for effective planning.

First analysis, Procurement factors are Availability, Price and Quality & Technology in solar industry as independent variables, whereas planning decision is a dependent variable. Alternate hypothesis for this part is "HA 01: 01: Planning source of solar material is dependent on attributes of procurement - Availability, Price and Quality & Technology in solar industry". Acceptance of this hypothesis indicates that, in solar industry, source of supply planning in dependent on procurement factors, as a primary decision driver.

Second analysis in the research, correlate "global supply" as another "width" of supply chain, increases the supply chain planning complexities. The hypothesis tested for this purpose is "HA 01: 02: Wider global supply view requirement increases the domestic planning process complexities".

The planning decision pattern indicates that most influential decision of planning and buying solar cells and modules is of "state" followed by senior management in a solar organization.

Third Analysis in research thesis is to assess and establish planning objective by three categories of planners. There seems to be a significant difference between objective of industry level planners and state planner acting as a planner. An alternate hypothesis "HA01: 03: Planning objectives of State is sustainability of supply chain, whereas planning objective for material planners is short term cost and availability leverage".

"Planning" by objective has different goals for state and by material planners. The hypothesis tests sustainability of solar supply chain as an objective of state, whereas cost and short term availability leveraged, as a goal of material planner, to meet short term solar project requirements.

Fourth analysis, material stocking is a cost to company, not only a function of local demand but depends on global availability. Domestic solar industries tend to avoid stocking as against easy availability from global stock maintained by global (Chinese) players. The following stated hypothesis provides the relationship between domestic stocking and global availability. "HA 01: 04: Domestic material stocking in the form of raw material or finished goods depends on global availability". Acceptance of this hypothesis shows that planners foresee more confidence in terms of availability from global stock, as compare to manufacturing capacity or stock in domestic country.

Fifth Analysis is around small solar products, been sold in Indian market to be used primary in rural geographies. Solar products are sold off-the-shelf. Solar products being sold in retail market follow a local market level planning, to meet the requirements of a given geographical region. Research hypothesis is posed as "HA 01: 05: Off the shelf solar product planning is more effective at local place of demand, than at national aggregated demand".

HA 02: National and state level policy support to solar energy, to grow the sector, is a major width variable in supply chain planning.

First analysis of hypothesis is formulated to establish the fact that state support is a primary driver for solar energy deployment in India. "HA 01: Solar demand is a function of "state regulations and support", thus an input to supply chain planning".

Second analysis of alternate hypothesis (HA 02:02) is a support hypothesis to HA02, which establishes the fact that natural drivers are almost inexistent during the period of study. "HA 02: 02: Natural demand factors are less significant than a state support derived demand in solar industry".

HA 03: Existing practices of supply chain planning need more number of iterations to protect interest of buyers and sellers (Stakeholders) than existing in practice.

Following nine sub-hypotheses, from HA 03: 01 to HA 03: 09 are formulated to compare number of iteration is solar industry than in practice referred to FMCG companies.

HA 03: 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. 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

There is no relationship between the reasons of iteration and type or size of solar project. 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.

HA 03: 02: Deviation in sequence of material procurement and dispatch, from a planned sequence, for project installation, increases number of iterations.

It is observed that most of the solar 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 interruption at project site.

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. This uncertainty in clarity is because of the stage, when an order is considered as “firmed” from customer.

HA03 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. Expediting and de-expediting to meet projects requirement leads to extra iterations per project.

HA03 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. Non-availability or delayed availability of funds with contractor leads to more number of planning iterations to satisfy customer requirements.

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

There have been restrain exercised among respondent to promote ex-stock sale in solar industry. Strict norms are followed to declare an inventory as non-moving or excess stock. There has been observed, an estimated lower inventory carried by solar company, with more number of iterations. Solar planners opine that more number of days is provided to declare excess or non-moving stock; less number of planning iterations is expected.

HA 03:07: Supplier's credit period affects number of planning iterations.

Planning and procurement in solar industry is being encouraged on a longest possible credit period from suppliers. An important supplier's qualification criteria considered is as a long credit period. 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.

HA03:08: 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.

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. For an in-house planner number of iterations for finished modules are minimal than raw material to produce solar cells and modules.

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

Number of iterations increases with the size of project. Planning iteration increases more rapidly for every addition of 5 MW of solar project.

Fourth Hypothesis is detailed out as below

A requirement to study skills and competencies was felt, given a particular "width" of solar supply chain variables. The following hypothesis is stated to regarding strengthening of planning skills in solar industry.

HA 04: Roles of supply chain planners need to be strengthened with specialized skill mapping for effectiveness of solar energy companies.

The thesis compares the skills and competencies of generic supply chain planners. While asking a question from respondents about skill sets required for a planner in solar

industry, we received an enlarged planning role for solar projects. Role of supply chain planners and project planners has major overlap in solar industry. Material planning and project planning role is hard to distinguish for solar industry.

Additional skills and competencies requirement of planners are grouped as below

a) Forecasting of central and state government solar regulatory environment.
b) Government tendering processes and its length to decide an order winner.
c) Understanding of specifications of solar products to have an efficient expediting.
d) Understanding on alternate usage of material based on best match of specifications, in case of an order cancellation or alterations.
e) Special state taxation structures on solar products.
f) Ability to connect to top most management for wider planning inputs.
g) An understanding of solar order to cash cycle, to manage healthy material supplies to fulfil on time customer demand and optimizing cost of fulfilment
h) Capability of judgment on probability of winning an order, in addition to view represented by sales staff.
i) Knowledge on solar project quality expectations and certifications requirement, as laid by state for solar projects and products.
j) Knowledge on financing schemes and their impact on solar projects and product demand.
k) A hang on project documentation with government agencies and customers.

At lower hierarchical level in a solar organization, all required skills sets had a weak match without a senior manager's representation in planning.

Chapter -6: Limitations of Study and Future Scope

Thesis presented, has tried to generalize some practices based on a set of solar players, primarily located in and around city of Bangalore. Chapters includes a number of probable future scope of research experienced by researcher during the study

Chapter – 7: Conclusion

In solar industry - price, ease of availability, competitive quality and technology available globally are powerful driving forces for planning and procurement decisions, in favour

high volume producing countries. In absence of state support natural source of buying of solar equipment is from Chinese countries, an important planning width variable.

Complexities of solar supply chain, shifting planning role to higher hierarchical planners in the organization to take most optimal decision.

Planners foresee more confidence in terms of availability from global stock, as compare to manufacturing capacity or inventory stock in domestic country. Solar products being sold in retail market follow a very local level planning, to meet the requirements of a given geographical region depending on local state support and customer requirements. Solar product planning is indifferent of source of procurement either domestically or by import.

Solar project deployment in the country is strongly related to state support programs.

Number of planning iteration is more in solar industry in comparison to a fast moving product. The reasons for such additional iterations are on accounted in the third hypothesis

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.

Solar supply chain planner's skills are wider than a material planner. This role of material planner is closer to project planner. Such planners should have additional skills and competencies in addition to supply chain planning highlighted in fourth hypothesis.

Chapter -8: Suggestions & Recommendations

Solar project execution capability is yet to reach at its highest level of excellence. Reducing cost of solar project execution and delay is causing value deterioration. An excellence program across solar industry, to reduce cost and increase efficiency can help companies in long run.

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