# THE RESEARCH ON CONCEPTUAL MODEL OF LNG PLANT PROJECT PLANNING EXPERT SYSTEM

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**ABSTRACT:** The purpose of this research is to propose the conceptual model of Scenario-based Project Planning Expert System which has not been used in domestic LNG plant industry. This research examines data on the plant project planning expert system of domestic and oversea, analyzes the components of project planning expert systems and benchmark excellent cases. The conceptual model of LNG plant project planning expert system is established through the procedure as has been noted above. The results of this research are as follows: First, this research draws out such components of LNG plant project planning expert system as feasibility, cost control, contract management and risk management. Second, this research proposes the conceptual model of LNG plant project planning expert system which core module is consist of feasibility evaluation, life cycle cost evaluation and decision making. Finally, each module of LNG plant project planning expert system would be integrated into the Scenario-based Project Planning Expert System.

*Keywords: Plant, Expert System, Feasibility, Life Cycle Cost, Decision Making*

## 1. INTRODUCTION

### 1.1 Study Background and Purpose

International Energy Agency (IEA) looks out that the demand of natural gas worldwide will be doubled in quantity by 2030 as compared with that of 2003. And it also estimates investment into the sector of gas over the period from 2003 to 2030 will be 2,700 billion dollars. As the middle and long-term demand of natural gas increases, LNG plant industry attracts business in overseas construction markets as a highly value-added growth industry. The market of LNG plant industry seems to be huge and the continuity of the market is also promising.

Although the development of LNG plant industry has been centered only on engineering and construction, now it gradually expand its business scope to EPC (Engineering, Procurement, Construction). However, the technologic level of present domestic LNG plant industry is not high in general due to the formation of technologic cartel by advanced countries (JGC, Chiyoda, Bechtel and so on). And not many projects have been domestically carried out so far. So, domestic business in LNG plant projects has been limited in the sector of peripheral device design and simple construction. In this vein, domestic technology's making inroads into overseas markets seems to need not only constructional technology but also such business capacities as design, research, business management, project financing and so on in the step of constructional planning. Therefore, it is urgent to ensure the technology in the planning step of LNG plant project and the system which can play the role of a bridgehead for domestic business into foreign markets. In this regard, this study examined Scenario-based Project Planning Expert System, which has not been introduced in domestic LNG plant industry for the present, in order to conceptually design an LNG plant project planning expert system as a comprehensive system which integrates feasibility evaluation, life cycle cost evaluation and decision making.

The purpose of this study can be summarized as follows:

1) Draw out necessary components by analyzing the components of Project Planning Expert Systems and benchmarking excellent cases domestic and overseas.
2) On the basis of the above examination, conceptually design an LNG plant project planning expert system.

### 1.2 Study Procedure and Method

This study is carried out by following procedures and methods figure 1.

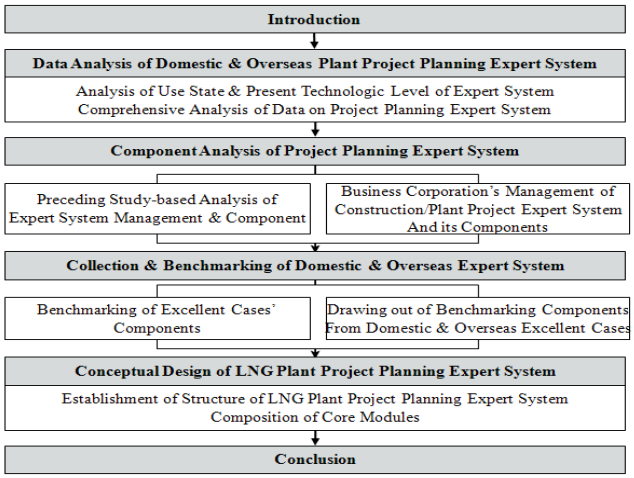


**Fig 1.** Study Procedure and Method

## 2. DATA ANALYSIS OF DOMESTIC & OVERSEAS PLANT PROJECT PLANNING EXPERT SYSTEM

### 2.1 Analysis of Use State & Present Technologic Level of Expert System

#### 2.1.2 Analysis of Use State

As for the general system developed so far, there are MYCIN, XCON/XSEL, DENDRAL, PROSPECTOR, YESMVS and so on. And As for Construction Project Planning Expert System, there are ERP (Enterprise Resource Planning), CIC (Computer-Integrated Construction), and PMIS (Project Management Information System). In case of Plant Project Planning Expert System, JGC Corporation in Japan realized partial systemization of EPCM (Engineering, Procurement, Construction & Management). In case of FIATECH, a stepwise process was established through SbPP (Scenario-based Project Planning).

#### 2.1.2 Analysis of Present Technologic Level

As for the general expert system developed so far, there are nuclear power generation secondary-channel hydrochemistry abnormality checking expert system (KEPCO), equipment checking expert system (POSCO), and SS Fashion production scheduling system (Samsung). As for the expert system in construction industry, there are S Construction Corporation's PMS system, H Construction Corporation's ERP R/3, and G Construction Corporation's TPMS. However, there is no expert system for the planning step of plant project EPC.

### 2.2 Comprehensive Analysis of Data on Project Planning Expert System

Many general expert systems are used in a variety of fields, such as medicine, chemistry and computer for the present. The expert system in construction industry is yet partial and there are such partial project management systems as ERP, CIC and PMIS. But there is nearly no expert system for the planning step of domestic plant industry. The use state of expert system can be summarized as table 1.

**Table 1.** Use State of Expert System

| Division | Content |
|---|---|
| General expert system | MYCIN (medicine), XCON/XSEL (computer), DELTA (equipment), DENDRAL (chemistry), PROSPECTOR (geology), YESMVS (computer) etc. |
| Construction Industry expert system | ERP, CIC, PMIS, EVMS etc. |
| Plant industry expert system | EPCM System (Japan), SbPP System (U.S.A.) |

## 3. COMPONENT ANALYSIS OF PROJECT PLANNING EXPERT SYSTEM

In this study, the business scope of project planning comprises tender, quotation, contract, feasibility and financing, and based on this business scope the component of expert system is analyzed.

### 3.1 Preceding Studies on and Components of Business Corporations' Construction/Plant Expert Systems

#### 3.1.1 Preceding Study-based Analysis of Expert System Management & Component

Based on 'Study on Construction Project Management'[1], 'Study on Plant Project Management Procedure'[2], and 'Study on Overseas Construction Risks'[3], components and management businesses related to the step of plant project planning are summarized as follows table 2:

**Table 2.** Preceding Studies' Expert System Component

| Management | Component | |
|---|---|---|
| Project | ▪Feasibility analysis<br>▪Project information exchange system establishment | ▪Establishing a plan of getting permission & authorization and execution management<br>▪Management of project risks |
| Expenses | ▪Examination of validity of expenses<br>▪Estimation and assessment of expenses | ▪Compilation of pre-working budget<br>▪Compilation of working budget |

[1] The Procedure of Construction Project Management, Hyeon C. T., University of Seoul, 2003.

[2] Development of BPM Model According to the Steps of EPC Execution for the Improvement of Procedure of Plant Project Planning Management, Park B. J., Chungnam National University, 2008.

[3] Risk Management of International Construction Joint Ventures, Bing, L., Tiong, ASCE, 125(4), 277-284, 1999

| | | |
|---|---|---|
| | ▪Prime cost management<br>▪Management of expenditure and quotation<br>▪Accumulation of expenses & construction cost<br>▪Estimation of construction cost and compilation of budget | ▪Management of working budget<br>▪Project quotation<br>▪Establishing an execution plan of project |
| Contract | ▪Deciding contract method<br>▪Establishing a plan of quotation and contract<br>▪Public notice of tender and on-site explanation | ▪Contract management<br>▪Contract alteration |
| Risk | ▪Fluctuation of exchange rate<br>▪Change of laws and norms<br>▪Economical situation<br>▪Political influence | ▪Safety control of construction site<br>▪Consideration of cultural difference<br>▪Tie with partners<br>▪Change of requirements |

### 3.1.2 Business Corporations' Management of Construction/Plant Project Expert Systems and its Components

The examination of construction/plant project expert systems show that in construction industry G Corporation uses PMIS and TPMS; H Corporation, CIC and EVMS; K Corporation, BIM; and S Corporation, ERP respectively.

Based on the above findings, the management and component of plant project planning businesses can be summarized as follows table 3:

**Table 3.** Components of Business Corporations' Construction/Plant Project Expert Systems

| Management | Component | |
|---|---|---|
| Prime cost /quotation | ▪Estimation & working out of working budget<br>▪Management of actual expenditure<br>▪Calculation of quantity of materials and checking prime cost | ▪Prediction of expenditure by periods<br>▪Execution of construction cost<br>▪Estimation of preliminary construction cost |
| Contract | ▪Management of present state of contract<br>▪Management of public notice of tender and present state of successful tender | ▪Management of present state of customers<br>▪Management of present state of contract by subcontractors |

### 3.2 Drawing out of Components of Project Planning Expert System

Based on the examination of preceding studies on and business corporations' present use of construction/plant project planning expert systems, its components consist of feasibility, cost control, contract management and risk management. And these findings can be summarized as follows table 4:

**Table 4.** Drawing out of Components of Project Planning Expert System

| Management | Component | |
|---|---|---|
| Feasibility | ▪Examination of validity of expenses<br>▪Estimation & checking of expenses<br>▪Establishing a project information exchange system | ▪Establishing an execution plan of project<br>▪Establishing a plan of getting permission & authorization and execution management<br>▪Procurement & management of materials & manpower |
| Cost /quotation | ▪Cost control<br>▪Management of expenditure and quotation<br>▪Accumulation of expenses & construction cost<br>▪Estimation of construction cost and compilation of budget<br>▪Estimation of preliminary construction cost<br>▪Prediction of expenditure by periods & business management | ▪Compilation of pre-working budget<br>▪Compilation of working budget<br>▪Management of working budget<br>▪Project quotation<br>▪Management of construction cost execution<br>▪Calculation of quantity of materials and checking of prime cost |
| Contract | ▪Deciding contract method<br>▪Establishing a plan of quotation and contract<br>▪Public notice of tender and on-site explanation<br>▪Management of public notice of tender and present state of successful tender<br>▪Management of present state of customers | ▪Contract management<br>▪Contract alteration<br>▪Management of present state of contract<br>▪Management of present state of contract by subcontractors |
| Risk | ▪Fluctuation of exchange rate<br>▪Change of laws and norms<br>▪Economical situation<br>▪Political influence | ▪Safety control of construction site<br>▪Consideration of cultural difference<br>▪Tie with partners<br>▪Change of requirements |

## 4. COIIECTION & BENCHMARKING OF DOMESTIC & OVERSEAS EXCELLENT CASES

### 4.1 Benchmarking of Excellent Cases' Components

### 4.1.1 Benchmarking of Korea Institute of Plant Engineering and Construction's Components[4]

To construct a plant, it is necessary to establish a plan of product kind and quantity, selling & marketing, market cost and profits, raw material procurement, manpower for operation and maintenance, construction and financing at the step of project planning, and then examine its economical efficiency comprehensively. The common components of analysis of project planning and economical efficiency can be summarized as follows table 5:

**Table 5.** Components of Analysis of Project planning & Economical Efficiency

| | |
|---|---|
| Necessity of project participation | - |
| Current state of product demand & supply and prospect | ▪Trend of demand & supply and prospect in the global market<br>▪Trend of demand & supply and prospect in the domestic market |
| Strategy of project participation | ▪Plan of selling & marketing (plan of securing fixed customers)<br>▪Plan of securing financial investment resources<br>▪Plan of securing economical efficiency<br>▪Profitability of investment<br>▪Potential of growth<br>▪Governmental policy |

[4] Korea Institute of Plant Engineering and Construction

| | |
|---|---|
| | ▪Market competitiveness<br>▪Related laws & systems<br>▪Plan of physical distribution & transportation<br>▪Strategy of facility operation (organization, manpower, production & operation) |
| Effect of project participation | ▪Effect on national economy<br>▪Effect on community<br>▪Effect on employment<br>▪Effect on related industry<br>▪Contribution to technologic development<br>▪Substituting effect of export & import |
| Consideration of economical validity | ▪Revenue requirement method<br>▪Payback period method<br>▪Internal rate of return<br>IRR on investment, IRR on equity<br>▪Sensitivity analysis according to the change of prime cost elements |

### 4.1.2 Benchmarking of JGC Corporation's Project Planning Components

In case of JGC Corporation, its project planning provides market analysis, applied technology checking, joint R&D, equipment composition, capacity checking, cost analysis, financial mediation, procurement from public agencies, and establishment of the whole project plan. Its components can be summarized as follows table 6:

**Table 6.** JGC Corporation's Project Planning Components

| Division | Content |
|---|---|
| Market analysis | ▪Necessity of project participation<br>▪Current state of product demand & supply and prospect<br>▪Effect of project participation. |
| Applied technology checking | ▪Comparative analysis of actually achieved data in the past and applied technology data<br>▪Examination & application of results of quantitative experiment for the introduction of advanced technology |
| Joint R&D | ▪R&D through forming a cooperative system between an ordering nation and an EPC business entity<br>▪R&D of systematic construction by EPC business entities at the time of ordering by working sections or by partitions |
| Equipment composition | ▪Plan of appropriate proportion between pre-processing facilities' pipeline & storage and a superintendent´s office<br>▪Checking the connectivity between the moving line of business & movement and the space of LNG's coming & going |
| Capacity checking | ▪Checking the capacity of project execution through EPC business entities' existing cases<br>▪Checking manpower, schedule and technological capability by business spheres |
| Cost analysis | ▪Checking economical efficiency including the calculation of internal rate of return<br>▪Working out a comparative table of expenses versus returns<br>▪Checking the plan of administrative expenditure occurred in the initial construction and operation |
| Project financing | ▪Planning & setting up a share contribution structure & a share structure among constructors<br>▪Establishing an annual plan of expenses repayment & resources export earnings |
| Procurement from public agencies | ▪Establishing a system of business efficiency among an ordering governmental agency, financiers and EPC business entities<br>▪Establishing a schedule of material procurement and a plan of appropriate material quantity for the construction of facilities (establishing the plan & strategy of securing material quantity by self-supply & import) |
| Procurement from public agencies | ▪Establishing a system of business efficiency among an ordering governmental agency, financiers and EPC business entities<br>▪Establishing a schedule of material procurement and a plan of appropriate material quantity for the construction of facilities (establishing the plan & strategy of securing material quantity by self-supply & import) |
| Establishment of the whole project plan | ▪Adjustment of contract relationship & appropriate expenses among an ordering party (ordering government, financiers) and EPC business entities<br>▪Establishing a management plan of working process and a plan of material procurement schedule according to the whole period of project<br>▪Establishing a plan for the risky accident, occurred during the period of construction<br>▪Establishing a plan for the item and expenditure of maintenance occurred after completion and during post-operation.<br>▪Establishing a plan for the partition of expenditure according to exporting LNG to long-term buyers and for the repayment of expenses |

### 4.1.3 Benchmarking of Components of FIATECH SbPP[5]

In case of FIATECH SbPP, its project planning provides a mutually complementary written assessment about project planning which satisfies all the investors maximally and this planning procedure provides all the factors which have influence upon the life cycle decision making of price, schedule and performing tasks. In addition, Scenario-based Project Planning comprises the repetition of numerous variables under the complex relations. FIATECH SbPP Project Planning components can be summarized as follows table 7:

**Table 7.** FIATECH SbPP Project Planning Components

| Variable | Content |
|---|---|
| 1) Site Selection | ▪Market location<br>▪Raw material location<br>▪Mathematical possibility-revenue & expenditure<br>▪Political & societal climate<br>▪Environmental influence - waste water, air pollution, social elements<br>▪personal risk-explosiveness, exposure to toxic chemicals<br>▪Tax reduction & exemption<br>▪Governmental authorization-international, domestic, building, pipeline, expressway, railroad, flight, airway, airplane, environment<br>▪Manpower-labor union, technological level<br>▪Regional nature of the soil, underground water, geological characteristics<br>▪Infrastructure-available services (electric, telephone, water, railroad, expressway)<br>▪Expenditure-energy, personnel expenditure for construction & operation |
| 2) Facility technology | ▪Technological level<br>▪Competition-global level manufacturing industry<br>▪Alternatives-disposal of wasted materials, sale condition, energy consumption |
| 3) Project Strategy | ▪Pre & post shipping<br>▪Product design<br>▪Construction-assembling every partial materials versus module construction<br>▪Contract-lump-sum payment, accurate calculation of actual cost and adding recompense, additional revenue<br>▪Project information strategy (cooperation, work flow, document management) |
| 4) Resources /obtaining | ▪Processed equipments<br>▪Site materials |

[5] Element 1 Tactical Plan, Scenario-based Project Planning. FIATECH.2004

| | |
|---|---|
| | ▪Necessary manpower<br>▪Raw materials<br>▪Comparison of domestic and overseas materials<br>▪Contract service |
| 5) Schedule | ▪Starting time<br>▪Rate of reaching capacity |
| 6) Project budget | ▪Capital<br>▪Requirement and restraint of fund flow |
| 7) Risk analysis, continuous plan, escaping strategy | ▪Process/structural technology<br>▪Mathematical calculation-method of transferring products<br>▪Economical risks (economical state of project, continuity of assumed state of market)<br>▪Environmental risks<br>▪Contractual risks |
| 8) Information asset | ▪Requirement of contents of transferred information<br>▪Requirement of forms (document, database, letters and so on) of transferred information<br>▪Availability of information & timing of use during the period of information |
| 9) flexibility of project requirements | ▪Flexibility of capacity<br>▪Flexibility of product<br>▪Flexibility of quality |

### 4.2 Drawing out of Benchmarking Components from Domestic & Overseas Excellent Cases

When the components of project planning expert system are drawn on the basis of feasibility, cost control, contract management and risk management deduced in the third chapter, information management is added to it. Benchmarking components of excellent cases can be summarized as follows table 8:

**Table 8.** Benchmarking components of excellent cases

| Components | Contents |
|---|---|
| Feasibility | ▪Market location & raw material location<br>▪Trend of demand & supply and prospect of domestic & overseas plant market<br>▪Validity of materials, manpower, infrastructure and expenditure<br>▪Influence upon national & local economy<br>▪Validity of technological capacity and term of works for the execution of project |
| Cost control (prime cost /quotation management) | ▪Requirement and restraint of fund flow<br>▪Analysis of investment payback period & internal rate of return<br>▪Plan for the payment of accomplished work according to the method of contract<br>▪Validity of facilities versus expenses<br>▪Ordering nation's economical situation & risks |
| Contract management | ▪Contract service & risks<br>▪Present state of contract among EPC business entities<br>▪Method of contract according to the constructional materials of facilities & the schedule of its procurement |
| Risk management | ▪Risk of schedule for materials & construction progress<br>▪Technological risks for project execution capacity<br>▪Economical, political & societal risks<br>▪Risks of investment versus earnings<br>▪Risks of governmental policy change<br>▪Management of risky factors for the plan of facility operation |
| Information management | ▪Collection of the projects & processes from the circle of plant industry<br>▪Establishment of requirements for referential data<br>▪Establishment of information model<br>▪Collection of scenario requirements<br>▪Support of decision making |

## 5. CONCEPTUAL DESIGN OF LNG PLANT PROJECT PLANNING EXPERT SYSTEM

### 5.1 Establishment of Structure of LNG Plant Project Planning Expert System

A project planning expert system is applied to the step of planning. The structure of the system consists of feasibility evaluation, life cycle cost evaluation and decision making. And each evaluation module will be integrated into the Scenario-based Project Planning which will be developed in the future. Following figure 2 is the conceptual design of project planning expert system and presents the connectivity among compositional modules:

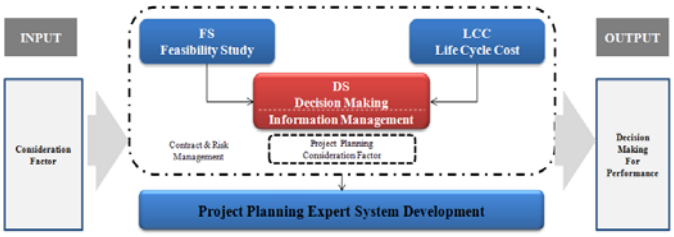


**Fig 2.** Conceptual Design of LNG Plant Project Planning Expert System

### 5.2 Composition of Core Modules

#### 5.2.1 Evaluation of Feasibility

In this study, the evaluation of feasibility centers on financial and economical factors. That is, financial and economical factors, which have great influence upon the evaluation of feasibility, are selected. The detailed items of these financial and economical consideration factors can be summarized as figure 3:

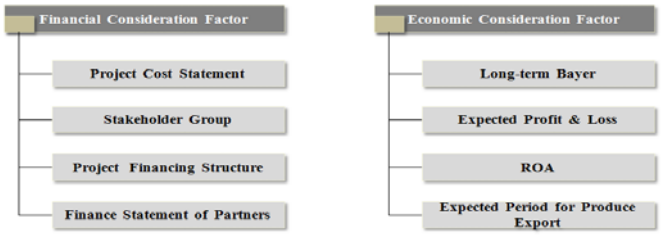


**Fig 3.** Financial & Economical Consideration Factors

#### 5.2.2 Evaluation of Life Cycle Cost

The evaluation of life cycle cost in this study is to estimate expenditure which is generated from plant facilities during its life cycle. Therefore, it covers all the expenditure generated over the period from the planning step to the disuse step, and is reflected on the plan of afterward expenditure. Following figure 4 presents an analysis of life cycle cost:

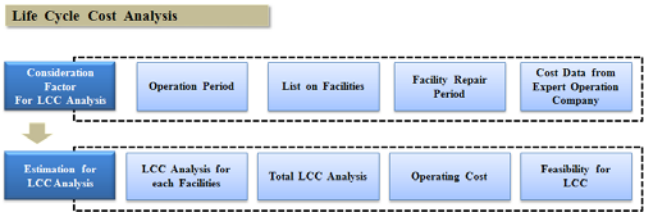


**Fig 4.** Analytic Process of Life Cycle Cost

### 5.2.3 Decision Making Modeling

Decision making for the execution of project in this study varies depending on the characteristic, location and ordering party of the project. And in case of plant, it considers economical, societal, physical, political and financial factors, materials, and transportation distance basically. In addition, it takes into account ordering party's requirements, long-term customers, the composition of EPC business entities, and business proprietor's share rates. Following figure 5 presents the process of decision making:

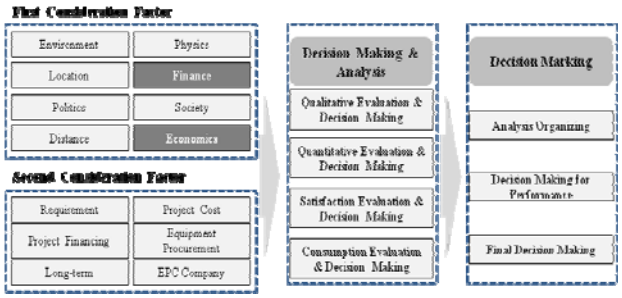


**Fig 5.** Analytic Process of Decision Making

## 6. Conclusion

The purpose of this study was to conceptually design Scenario-based Project Planning Expert System, which has not been introduced in domestic LNG plant industry for the present. For this, the investigators examined domestic and overseas data on the plant project planning expert system. And based on the data examination the investigators analyzed the components of project planning expert systems and the benchmarking of excellent cases. Through these processes, the conceptual design of LNG plant project planning expert system was established. Study findings are as follows:

First, by means of examining preceding studies, some expert systems which are now used in the construction/plant industry, and domestic and overseas excellent cases, the investigators draw out its components which are based on the classification of feasibility, cost control, contract management and risk management.

Second, if an LNG plant project planning expert system is conceptually designed on the basis of above study findings, its core module can consist of feasibility evaluation, life cycle cost evaluation and decision making modeling. And each module will be integrated into the Scenario-based Project Planning Expert System which will be developed in the future.

## ACKNOWLEDGEMENT

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