INDONESIAN JOURNAL OF MULTIDISCIPLINARY SCIENCE

P-ISSN: 2808-5957
E-ISSN: 2808-6724
ijoms.internationaljournallabs.com

ANALYTICAL HIERARCHY PROCESS FOR OPTIMIZING ENGINES OPERATION BY PROCUREMENT STRATEGIES: A CASE STUDY

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ARTICLE INFO

Published: May 26th, 2023

Keywords: *contract types, analytical hierarchy process, critical engines*

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ABSTRACT

This research aims to examine of finding best choice type of contract for supporting critical engines operation and performance (including for maintenance and repairment). The researchers used Multi Criterion Decision-Making method with tool of Analytical Hierarchy Process, which data gather from survey and sampling from practitioners. They also used simplification of contract types from critical variable of contract such as price, quality, and delivery criterion. Criterion acquired from Forum Group Discussion with Subject Matter Expert. The research discovered that existing contracts vary and still many cases of unplanned shutdown lack of support from spare parts and other supports as a product form existing contracts.

INTRODUCTION

Indonesia nowadays still depends on fossil fuels as the main energy supplies. According to Outlook Energi Indonesia 2021, published by *Badan Pengkajian dan Penerapan Teknologi* (BPPT), around 74% of energy consumption in Indonesia (until 2020) based of fossil fuel such as (petroleum oil – gas and coal). Especially from petroleum, Indonesia depends on its fuel around 59% as primary energy, so petroleum business is highly crucial for Indonesia.

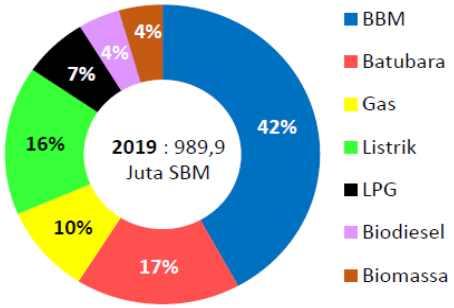


Figure 1. Indonesia's Energy Consumption
Source: BPPT (2021)

For the oil consumption Indonesia had been net oil importer since 2004 while in petroleum gas still in net gas exporter. Based on that fact, for more upcoming years ahead effective and aggressive in oil producing business or upstream have to be implemented by all oil and gas company in Indonesia. For the aggressive implementation will be by surveying for new reservoir

and drilling the reservoir, and the effective one will be optimizing the lifting process for reservoir to surface until transporting it to end customer for refining crude oil and petroleum gas while minimizing the potential loss of oil and gas production during production phase process.

Business Process in South Sumatera Oil & Gas company can be shortly described as exploration and exploitation oil & gas. Oil and gas extracted from the subsurface and purified in surface in the production facility before monetized or traded to customers (Asenso et al., 2023; Inkpen & Ramaswamy, 2017; Mokhatab et al., 2013). The phase of transfer oil & gas from wells to the facilities and also customer can be called "transportation." The engines involved is the main critical components for transportation oil & gas. South Sumatera Oil & Gas by the time passes and also form government request to increase oil & gas production, makes some improvements for increasing the production and also hold from production natural decline which is common in oil & gas upstream business.

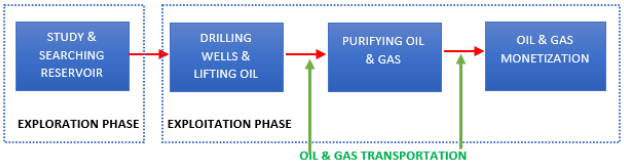


Figure 2. Business Process in South Sumatera Oil & Gas

As the CEO of South Sumatera Oil & Gas company concerned about the high loss opportunity because of unplanned shutdown of oil & gas transportation system, CEO wanted some improvements especially in contract type for supporting critical engine operations and with the contract that can minimize number unplanned shutdown that make company suffering revenue losses as shown in table below.

Table 1. Losses Caused by Unplanned Shutdown

Year	Unplanned		
	0 Loss	With Losses	Losses
	(Cases)	*(Cases)*	*(Barels Oil)*
2020	1408	14085	116,690.29
2021	4708	8730	109,479.63
2022	1423	5960	74,945.04

One of the method in Multi Criterion Decision Making is Analytic Hierarchy Process or so called AHP (Rouyendegh & Erkan, 2012; Shahroodi et al., 2012). The Analytical Hierarchy Process had been commonly used for decision making because of the simple method by comparing all factors/criterion and also alternatives/scenarios for grading the alternatives (Brunelli, 2014; Roy, 2004). By comparing and later on grading the alternatives, AHP can give better quantitative typed method for decision that data collected for this method almost in qualitative type (Saaty, 2004; Saleh et al., 2020).

According to Saaty and Vargas (2012), at least AHP has 3-level hierarchy of Goal, Criterion, Alternatives. Because of AHP is one of MCDM tools, so the phase of AHP will be the same of MCDM. The most challenging phase of AHP will be "Create all criterion related to upcoming goal." The criterion formed have to measuring the internal and external factor leading to the goal. More criterion can be interpreted of more aspect and exposure explored thoroughly for making better goal or decision.

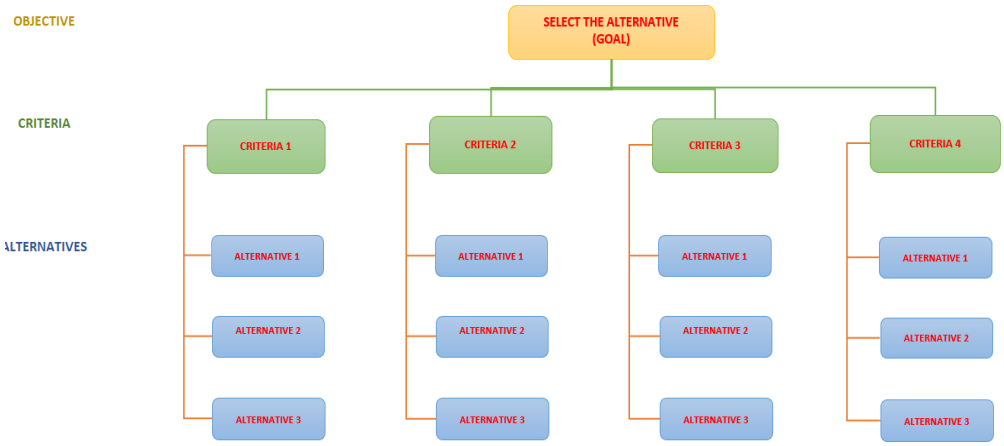


Figure 3. AHP with Three Level Hierarchy

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity *i* has one of the above nonzero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

Figure 4. Fundamental Scales of AHP based on Saaty and Vargas

Cited from Saaty and Vargas (2012), there are seven pillars of AHP:

1) Ratio scales, proportionality and normalised ratio scales;
2) Reciprocal paired comparisons;
3) The sensitivity of the principal right eigen vector;
4) Clustering and using pivots to extend the scale;

5) Synthesis to create a one-dimensional ratio scale for representing the overall outcome;
6) Rank preservation and reversal; and
7) Integrating group judgements

Contract type available for alternatives based on the criterion stated as the parameter of contract (Faraji et al., 2021; Watt et al., 2010). Selecting best contract may not applicable for other industries, and even in same industry with different case and situation will not applicable of strategy by selecting contract type (Kerzner, 2017; Safa et al., 2015). Contract with many perspective concerned of Supply Chain aspect such as Price (Cheaper price/economic), Quality (The higher will be a better), Quantity (The exact amount of needed), Delivery Time (Faster delivery will be more favorable), and Place of Delivery (The place of delivery) will determine the price and time.

The study sought to assess the best contract type for sustaining the operation and performance of vital engines (Including for maintenance and repairment). The research hopefully contributes to wider knowledge of analytical hierarchy process for optimizing engines operation by procurement strategies, especially in Indonesia.

METHOD

A Partners or can also called Suppliers or Second Party will supply to First party by signing contracts first as the result of suppliers selection process or can be called as "TENDER". Tender itself has been regulated by Indonesia government (represented by SKK Migas) as the only way for upstream Oil & Gas Companies in Indonesia for fulfilling demands of goods and services.



Figure 5. Procurement Regulation on Indonesia Upstream Oil & Gas

For upstream Oil & Gas Companies which operates under SKK Migas, the tender regulation is known as "Pedoman Tata Kerja no 007 Revisi 4 tahun 2017" and "Petunjuk Pelaksanaan Tender EDR-0167". Both of them in combination popularly called "PTK 007 SKK Migas."

Tender process can be simply summarized into process from Prequalification - Bidder Invitation – Bidder Submission – Bid Evaluation – Winner Announcement – Tender Award. Full steps of tender can be viewed in Figure 6 below.

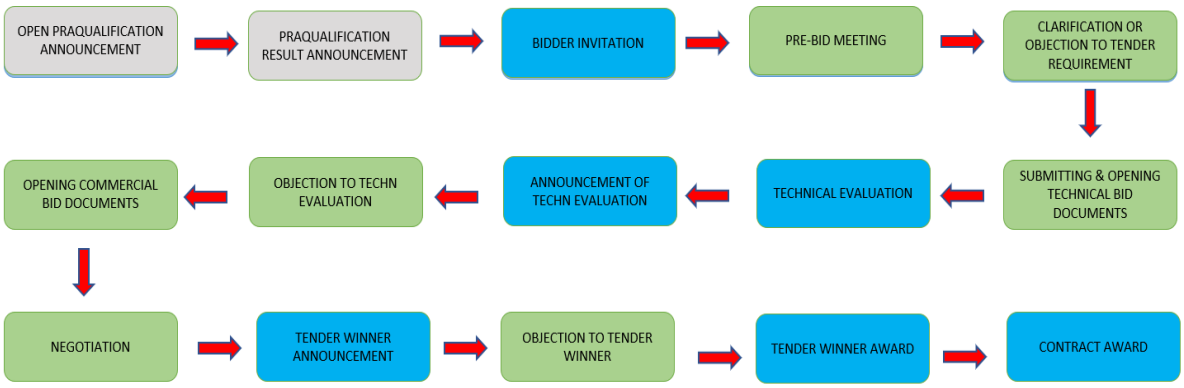


Figure 6. Procurement (Tender) Process on Indonesia Upstream Oil & Gas

For data collection, the researchers used 2 approaches of data collection, by using Forum Group Discussion to Subject Matter Experts (SME) and Survey to Competent respondents. Forum Group Discussion performed by author by inviting expertise in SCM Division who has experiences and competencies in Supply Chain especially in Procurement and Contracting. The FGD attendants are:

1) SCM Manager: 30 years experienced, Procurement certified;
2) Assistant Manager: 15 years experienced, Procurement certified and also competency certification of CSCA (Certified Supply Chain Analysist) or CSCM (Certified Supply Chain Manager), including the researchers themselves;
3) Internal Support: 13 years experienced, Procurement certified with CSCA (Certified Supply Chain Analysist); and
4) Procurement Analysts: 10 – 13 years experienced, Procurement certified.

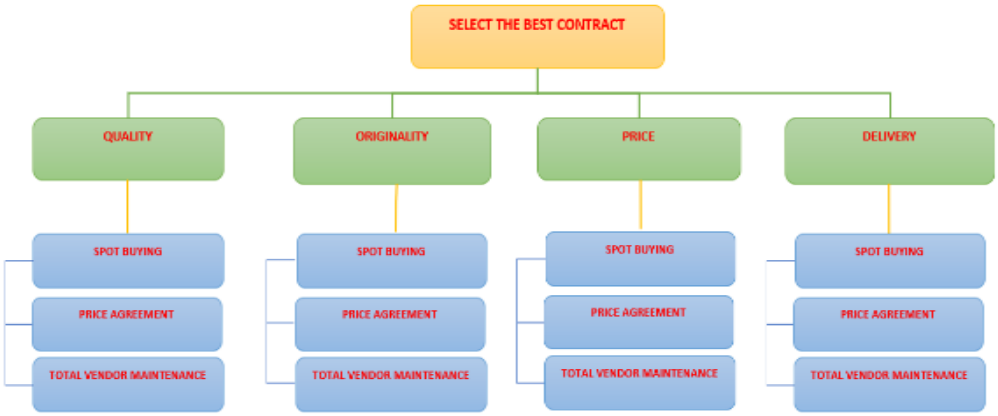


Figure 7. AHP Hierarchy – Decision Structure Based on FGD

FGD itself is discussing of the criterion and also alternatives for improving contract type suitable for optimizing engine (compressors and pumps) performances. Based on those FGD and plotting in figure 7.

After criterion and alternatives based on previous FGD, for next data collection by surveys to competent respondents. Respondents given by some question regarding of criterion and alternatives and they will give number based on table :

Table 2. Parameter of Survey

1	Not Any Concern	In Pair
3	A Little Concern	A Little Bit Sensitive
5	Major Concern	Sensitive
7	Priority	High Sensitive
9	Top Priority	Crucial

The survey matrix based on this research will be :

Figure 8. Rating of Surveys

PAIRWISE COMPARISON	RESP 1	RESP 2	RESP 3	RESP - N	MEAN	
QUALITY						
1-TIME PURCHASE ORDER						PRICE AGREEMENT
1-TIME PURCHASE ORDER						TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT						TOTAL VENDOR MAINTENANCE
ORIGINALITY						
1-TIME PURCHASE ORDER						PRICE AGREEMENT
1-TIME PURCHASE ORDER						TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT						TOTAL VENDOR MAINTENANCE
PRICE						
1-TIME PURCHASE ORDER						PRICE AGREEMENT
1-TIME PURCHASE ORDER						TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT						TOTAL VENDOR MAINTENANCE
DELIVERY						
1-TIME PURCHASE ORDER						PRICE AGREEMENT
1-TIME PURCHASE ORDER						TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT						TOTAL VENDOR MAINTENANCE
OTHER PAIRWISE COMPARISON						
QUALITY						ORIGINALITY
QUALITY						PRICE
QUALITY						DELIVERY
ORIGINALITY						PRICE
ORIGINALITY						DELIVERY
PRICE						DELIVERY

After survey result then the next step will be makng pairwise comparisons as table 2.2. Then author will rate the relative importance between each pair of decision alternatives and criterion. Consistency Check will be simulated before doing synthesize the results to determine the best alternative.

RESULT AND DISCUSSION

Criterion and Alternatives

From GD author seek from 4 types of Subject Matter Expert as described earlier. From FGD, can be form 4 criteria and 3 alternatives. The criteria are:

1) Quality: The first concern of criteria because as unplanned shutdown happen as the result of inadequate quality of contract existed for supporting engine operation. Quality of the contract consists of material (Spare parts) from the supplier (Or manufacturer) as the second party and also services provided.
2) Originality: The concern of source or the second party in the contract that supplying terms in contract. For fulfilling of legalism as authorized party of the engine (brand) and competency issue for delivering terms in contract. Originality means also selection for second party that has authorization from manufacturer as manufacturer agents or distributors.
3) Price: Usually the most concern of all procurement that all contracts have to be on budget, and even gain more cost saving from initial budget. Price in a contract should be inline and not exceeding the budget allocated by higher management.
4) Delivery: Specifically delivery in this research or project concerning for time response between job order from first party to second party, to job delivered by second party, can also be called delivery time. Usually Delivery (time) valued high if fast in amount of time or even faster than initial agreement. Delivery (time) in reverse form price. Faster Delivery or less time for delivery will be followed by the higher price for that order or contract.

The alternatives, based on the discussion, are:

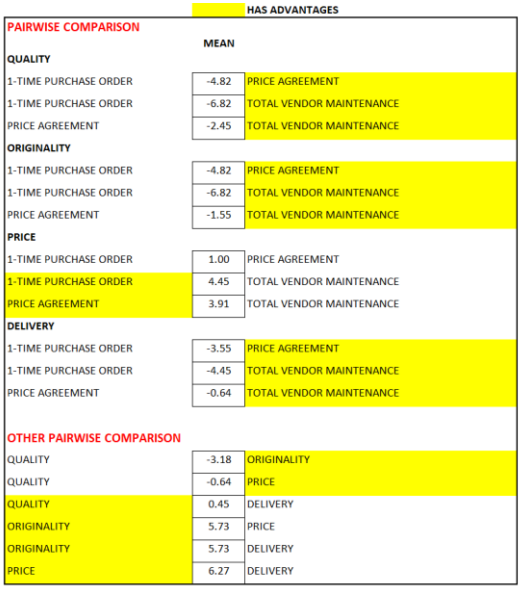
1) Spot Buying: Only buy or make contract in term of part actually needed, in certain short period of contract and delivery term.
2) Price Agreement: Contract in certain period, usually 2 (two) years at max for delivering partial job order issued. Price will be fixed for duration of the contract.
3) Total Vendor Maintenance (TVM): Contract in certain period, usually 3 (three) years at max for second party totally in monitoring, making advices to first party and delivering maintenance.

Selection of Contract Type by AHP

This AHP begins with pairwise comparison conducted by result of weighted average from survey result of criterion and alternatives as shown previously. From that result, can be formed the first level of pairwise comparison of the criterion as shown previously.

The next step will be calculating for the priority of the alternatives from each criterion as shown below. Also in this step will calculate consistency check by finding consistency index (CI) and consistency ratio (CR).

Figure 9. Weighed Average Calculation Based on Survey Result on Respondents



HAS ADVANTAGES

PAIRWISE COMPARISON	MEAN	
QUALITY		
1-TIME PURCHASE ORDER	-4.82	PRICE AGREEMENT
1-TIME PURCHASE ORDER	-6.82	TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT	-2.45	TOTAL VENDOR MAINTENANCE
ORIGINALITY		
1-TIME PURCHASE ORDER	-4.82	PRICE AGREEMENT
1-TIME PURCHASE ORDER	-6.82	TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT	-1.55	TOTAL VENDOR MAINTENANCE
PRICE		
1-TIME PURCHASE ORDER	1.00	PRICE AGREEMENT
1-TIME PURCHASE ORDER	4.45	TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT	3.91	TOTAL VENDOR MAINTENANCE
DELIVERY		
1-TIME PURCHASE ORDER	-3.55	PRICE AGREEMENT
1-TIME PURCHASE ORDER	-4.45	TOTAL VENDOR MAINTENANCE
PRICE AGREEMENT	-0.64	TOTAL VENDOR MAINTENANCE
OTHER PAIRWISE COMPARISON		
QUALITY	-3.18	ORIGINALITY
QUALITY	-0.64	PRICE
QUALITY	0.45	DELIVERY
ORIGINALITY	5.73	PRICE
ORIGINALITY	5.73	DELIVERY
PRICE	6.27	DELIVERY

Table 3. First Level Pairwise Comparison on Criteria

Criteria	Quality	Originality	Price	Delivery
Quality	1.000	0.314	1.571	0.455
Originality	3.182	1.000	5.727	5.727
Price	0.636	0.175	1.000	6.273
Delivery	2.200	0.175	0.159	1.000

Figure 10. Pairwise Comparison Alternatives to All Criteria

QUALITY	SPOT BUYING	PRICE AGMT	TVM	PRIORITY
SPOT BUYING	1.000	0.208	0.147	0.077
PRICE AGMT	4.818	1.000	0.407	0.306
TVM	6.818	2.455	1.000	0.618

ORIGINALITY	SPOT BUYING	PRICE AGMT	TVM	PRIORITY
SPOT BUYING	1.000	0.208	0.147	0.079
PRICE AGMT	4.818	1.000	0.647	0.368
TVM	6.818	1.545	1.000	0.553

PRICE	SPOT BUYING	PRICE AGMT	TVM	PRIORITY
SPOT BUYING	1.000	1.000	4.455	0.456
PRICE AGMT	1.000	1.000	3.909	0.437
TVM	0.224	0.256	1.000	0.107

DELIVERY	SPOT BUYING	PRICE AGMT	TVM	PRIORITY
SPOT BUYING	1.000	0.282	0.224	0.113
PRICE AGMT	3.545	1.000	1.571	0.492
TVM	4.455	0.636	1.000	0.395

For consistency check is by applying formulas of :

$$CI = \frac{\lambda_{max} - n}{n - 1}$$ and $$CR = \frac{CI}{RI}$$, in which RI :

Table 4. Random Index (RI) table based on N Alternative

N	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Table 5. Consistency Check to All Criteria

N = 3 **RI = 0.58**	**Quality**	**Originality**	**Price**	**Delivery**
$\frac{\lambda max - n}{n - 1}$	0.017	0.000	0.001	0.026
$CR = \frac{CI}{RI}$	0.029	0.001	0.002	0.045
Conclusion **(If CR ≤ 0.1 then acceptable)**	Acceptable	Acceptable	Acceptable	Acceptable

Based on the calculation of the consistency check of all criteria and its elements are ACCEPTABLE or CONSISTENT because Consistency Ratio (CR) value of all criteria less than 10% (Saaty, 1977). So the criteria (and also elements or variables) can be calculated into performing next step of AHP process : Synthesize the results to determine the best alternative. The result as shown in the table below.

Table 6. Priority Ranking Calculation

	Quality	**Originality**	**Price**	**Delivery**	**Ranking by Multiplication**
	0.138	0.314	1.571	0.455	
From Consitency Check	Acceptable	Acceptable	Acceptable	Acceptable	
Spot Buying	0.636	0.175	1.000	6.273	0.156
Price AGMT	2.200	0.175	0.159	1.000	0.389
TVM	0.6178	0.5528	0.1070	0.3948	0.455

Implementation Plan

Based on the calculation, then proposal will be proposed to the CEO and related Divisions solution of contract for supporting Critical Engine Operation (especially for maintenance and repairment). The proposal will be likely:

1) Priority 01 : Total Vendor Maintenance (TVM) contract
2) Priority 02 : Price Agreement contract
3) Priority 03 : Spot Buying contract

The implementation plan will be:

1) Establishing project plan, with details of step, timeline, PIC;
2) Coordinating with Key Persons and Stakeholders for implementation;
3) Implementing Procurement Process for Total Vendor Maintenance contract;
4) Contract Execution;
5) Confirming the success rate of project implementation; and
6) Keeping monitoring & evaluating

CONCLUSION

For data collection by using combination of Qualitative and Quantitative data collection method. Qualitative collection by performing Focus Group Discussion to Subject Matter Expert (SME), quantitative collection by performing survey to competent responders for gaining variables or elements for criterion and alternatives. Analytical Hierarchy Process (AHP) can be used for synthetizing final solution from alternatives for supporting critical engine in oil & gas transportation system. For proposed solution, Total Vendor Maintenance (TVM) seems to be best solution for contract type of supporting critical engine in South Sumatera Oil & Gas company, in section oil & gas transportation system, because its quality, originality and also delivery (Response) to job order of critical engine operation.

REFERENCE

Asenso, J. K., Nagudi, B., & Aanyu, K. (2023). 30 Oil and Gas Exploration, Development and Production in Emerging Markets and Developing Economies. *The Economics of the Oil and Gas Industry: Emerging Markets and Developing Economies*, 3.

BPPT. (2021). *Outlook Energi Indonesia 2021: Pespektif Teknologi Energi Indonesia*. BPPT.

Brunelli, M. (2014). *Introduction to the analytic hierarchy process*. Springer.

Faraji, A., Rashidi, M., Khadir, P., & Perera, S. (2021). A risk analysis-best worst method based model for selection of the most appropriate contract strategy for onshore drilling projects in the iranian petroleum industry. *Buildings*, *11*(3). https://doi.org/10.3390/buildings11030097

Inkpen, A., & Ramaswamy, K. (2017). Breaking up global value chains: Evidence from the global oil and gas industry. *Advances in International Management*, *30*. https://doi.org/10.1108/S1571-502720170000030003

Kerzner, H. (2017). *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.

Mokhatab, S., Mak, J. Y., Valappil, J. V, & Wood, D. (2013). *Handbook of liquefied natural gas*. Gulf Professional Publishing.

Rouyendegh, B. D., & Erkan, T. E. (2012). Selecting the best supplier using analytic hierarchy process (AHP) method. *African Journal of Business Management*, *6*(4), 1455.

Roy, R. (2004). *Strategic decision making: applying the analytic hierarchy process*. Springer.

Saaty, T. L. (2004). Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP). *Journal of Systems Science and Systems Engineering*, *13*(1). https://doi.org/10.1007/s11518-006-0151-5

Saaty, T. L., & Vargas, L. G. (2012). Models, methods, concepts & applications of the analytic hierarchy process. In *... -Driven Demand and Operations Management Models*. Springer. https://doi.org/10.1007/978-1-4614-3597-6

Safa, M., Shahi, A., Haas, C. T., Fiander-McCann, D., Safa, M., Hipel, K., & MacGillivray, S. (2015). Competitive intelligence (CI) for evaluation of construction contractors. *Automation in Construction*, *59*. https://doi.org/10.1016/j.autcon.2015.02.009

Saleh, B. I., Anwar, C., Abidin, R. Z., & Radyawanto, A. S. (2020). Analytical Hierarchy Process for Enhancing Procurement Decision-Making in Project Phase: A Case Study in the Gold Mining Project. *ComTech: Computer, Mathematics and Engineering Applications*, *11*(1). https://doi.org/10.21512/comtech.v11i1.6326

Shahroodi, K., Keramatpanah, A., Amini, S., & Sayyad Haghighi, K. (2012). Application of analytical hierarchy process (AHP) technique to evaluate and selecting suppliers in an effective supply chain. *Kuwait Chapter of Arabian Journal of Business Management Review*, *1*(8).

Watt, D. J., Kayis, B., & Willey, K. (2010). The relative importance of tender evaluation and contractor selection criteria. *International Journal of Project Management*, *28*(1). https://doi.org/10.1016/j.ijproman.2009.04.003