Open Journal of Business and Management, 2021, 9, 1619-1630
https://www.scirp.org/journal/ojbm
ISSN Online: 2329-3292
ISSN Print: 2329-3284

Determination of the Risk of Coal Supply Chain for Thermal Power Plants in Vietnam

Quang Tran Van[1], Quoc Hung Vu[2*], Sy Hung Mai[2*]

[1]Internal Control Board, PetroVietnam Power Corporation—Joint Stock Company, Hanoi, Vietnam
[2]Department of Hydraulic Engineering and Construction, National University of Civil Engineering, Hanoi, Vietnam
Email: tranvanquang@pvpower.vn, *hungvq@nuce.edu.vn, *hungms@nuce.edu.vn

How to cite this paper: Van, Q. T., Vu, Q. H., & Mai, S. H. (2021). Determination of the Risk of Coal Supply Chain for Thermal Power Plants in Vietnam. *Open Journal of Business and Management, 9,* 1619-1630.
https://doi.org/10.4236/ojbm.2021.94088

Received: June 11, 2021
Accepted: July 5, 2021
Published: July 8, 2021

Abstract

Currently, electricity is one of the developing fields and plays an important role in the socio-economic life of Vietnam. In which, the power output provided by thermal power plants is very large. In order to ensure stable operation and high productivity of thermal power plants, the Government and people of Vietnam have been making efforts to improve the infrastructure, especially the logistics of shipping by sea to serving the operation of thermal power plants. However, shipping by sea, Vietnam still faces many challenges that need a lot of effort to solve. Currently, shipping by sea is very risky, causing negative impacts on the operation of thermal power plants. In which, the coal supply system plays an important role. Risk assessment has been recognized as a useful tool to identify hazards, analyse weaknesses and risks of shipping by sea, and select appropriate mitigation measures. A questionnaire has been compiled that includes 38 factors that create possible risk events during shipping by sea. The risk matrix is used as the basis for quantitative risk analysis to identify the most important risks that greatly affect the operation of thermal power plants and indicate solutions to control risks. Research analysis and risk assessment based on the survey questionnaire, achieved the following results: 1) Recognizing that, there are 27 major risks affecting the transport of coal by sea; 2) Scientific rating of the effect of all risks to sea transport of coal; 3) Make recommendations that can reduce or eliminate influencing factors. This study provides a valuable reference to help the investor and the contractor complete the plan, ensuring the benefits for the parties involved in the contract to perform the operation of the thermal power plant.

Keywords

Risk Management, Risk Assessment, Transport of Coal by Sea

1. Introduction

Transport of coal by waterway will be critical for increased coal used. The capacity supplying coal for thermal power plants, depend largely on the supply and demand for waterway transportation, as well as on prevailing business practices, the investment climate, and the nature of regulatory oversight of the waterway road industry.

Coal is the second largest dry bulk commodity in terms of trade volume (behind iron ore) that transported by sea, accounting for about the 25% of the world dry bulk trade. Coal is a mineralized fossil fuel, mined extensively throughout the world and widely utilized as a source of domestic and industrial power. Coal which is used for power generation accounts for more than 75% of the total coal transported by sea. Coal is linked to the energy market and its transport is affected by seasonal demand fluctuations of the total annual volume of coal. The increase in seaborne transportation of coking coal has been primarily driven by an increase in thermal power plants (Popek, 2019).

As a seaborne commodity, it is nearly always carried in bulk and is of considerable importance, being shipped in large quantities from Malaysia, Indonesia, China… Almost the seaborne trade of coal is confined to large bulk carriers hence the industry is relying on economies of scale on certain well-established trade routes. Coal markets today are very dynamic and large variety of qualities are traded. Higher import demand in China and number of South-East Asian countries contributed to the volume increase (Benyahia, 2012).

A study into the risks facing the bulk coal export logistics chain is therefore of great importance. Any risk to this logistics chain will directly affect its efficiency and contribution to foreign exchange. The nature of a logistics supply chain is such that risks to one stakeholder (partner or node) affect not only that stakeholder's own operations but also those of the other partners and the whole supply chain's efficiency and sustainability (Botha & Badenhorst-Weiss, 2019).

Currently, there have been a number of studies on risks in coal transportation, such as: Benyahia (2012), "A comparative study of the resilience of coal logistics chains in Australia, South Africa and Canada", the research has pointed out the perspectives of the parties involved in the coal supply chain, thereby finding ways to control risks to increase efficiency at work (Benyahia, 2012).

An Investigation into the Logistical and Economical Benefits of using Offshore Thermal Power in a Future CCS Scheme. This paper presents a study on a possible future way of solving CO_2 transportation issues associated with the use of CCS of thermal power plants. For comparison, the alternative of transporting by ship or using a pipeline-ship combination will also be presented briefly. Initial studies show that the reduction in transportation costs compared to all conventional methods would more than offset the increased costs of operating a power plant offshore (Windén et al., 2013).

Breuer et al. (2013) addressed the Risks of cooperation between logistics related parties, paying special attention to sensitive issues and how to solve them.

The issues associated with the transport of coal and coal-derived products are related primarily to the regulatory and business environments, and with the exception of an improved understanding of complex networks.

Pantaleo and Shah (2013) researched about the Logistics of Bioenergy Routes for Heat and Power; additionally, Nguyen and Do (2021) studied about Vietnam's Logistics Industry: How Vietnam's Expanding Economy is Boosting Growth. The government is proactively taking steps to foster manufacturing investments, which is another reason why Vietnam's logistics industry has strong potential.

The greater coal use projected in some of the scenarios discussed, will be possible only if sufficient transport capacity is available to reliably deliver the increased amounts of coal at reasonable prices.

The capacity, reliability and price of waterway transportation of coal depend to a far degree on research and development. Reliable and sufficient waterborne transportation—depends on the construction and maintenance of waterway infrastructures, especially lock-and-dam infrastructure and port capacity.

Many risks were identified in the bulk coal export logistics chain, and of these risks, it was found that the most important ones were infrastructure, the macro-economy and people-related risks. The findings revealed evidence of underlying tensions between different stakeholders with regard to investment to mitigate infrastructure risks. The findings suggest that there is a lack of communication and an aligned vision among the stakeholders in the logistics chain and that they strategies for their risks separately.

From the above analysis, the "Determine the risk of coal supply chain for thermal power plants in Vietnam" is really necessary, which is also the content of this article.

2. Method Using in the Study

In this study, a checklist method was used to survey participants who have experiences in this study, a checklist method was used to survey participants who have experiences of sea transport logistics in order to assess risks as well as impact level of them on sea transport logistics.

The method using in the study is based on the questionnaire including risk elements impact on sea transport logistics of thermal power plants in Vietnam.

In order to achieve main objective of this paper a review of the literature was conducted to investigate risk and identify the risk factors and sources in sea transport logistics. Risk assessed by qualitative risk management (RM) and one method of qualitative (RM) is questionnaires. The questionnaire used as a simple and effective way for purpose of data collection, it was consisted of two sections, risks factors associated to construction of sea transport logistics and asked respondents to indicate occurrences of these risk factors and impact on construction of sea transport logistics. These risk factors were sourced from a wide range of literature including journal paper and books worldwide as well as those specially focused on sea transport logistics.

The risks factors were categorized into groups of risk factors. The likert scale used for assessing probability and impact were from 1 to 5 where: 1 = very low, 2 = low, 3 =moderate, 4 = high, 5 = very high. Forms of questionnaires created and distributed in sea transport logistics in Vietnam. The survey data were statistically used for calculation of estimation parameters to analyse and assess the risk factors. The weak impact of risk elements will be eliminated if the estimated parameters do not satisfy required standard, and find the main risk have bad affect to construction process of sea transport logistics.

More specifically, questionnaires were delivered to the participants who must have relevant work experience. To analyse and assess the risk elements, we establish the matrix from collected data of the questionnaires through a translation. From the questionnaires delivered by the surveyed members, we built a matrix with the size of $m \times n$ where m is number of the surveyed members and n is number of risk elements as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{2.1}$$

In the established matrix, the impact levels, i.e., low; quite low; medium; high; and very high, are translated to corresponding numbers, i.e., 1, 2, 3, 4, and 5, respectively. We therefore obtained a commented matrix $X = x_{ij}$. Wherein, x_{ij} stands for important meaning of comments given by the i^{th} surveyed member on the j^{th} risk element ($i = 1, 2, \cdots, m$ and $j = 1, 2, \cdots, n$). Secondly, in the second step, i.e., analysis and assessment of the risks, we use the matrix that is established as described above to verify the accuracy of the risk variables model hypothesis based on necessary evaluation criteria using SPSS and AMOS commercial software, i.e., 1) Cronbach's Alpha coefficient to determine the reliability of the question; 2) Calculation and analysis discovery factors based on pattern matrix; 3) Analysis and verifying the combination of factors based on coefficients of loading factor (Mai et al., 2019).

3. Results of Assessments

3.1. Identification of the Risks

The design of the questionnaire is based on previous studies and the actual situation of risks that have happened to the fuel supply chain by sea for coal-fired power plants in Vietnam.

Inherit previous studies, the author therefore summarizes and initially establish a questionnaire including initial risk elements grouped into 7 main factors.

After obtaining an initial surveyed questionnaire with initial risk elements, in order to get a wide context and support for our arguments, the author used the table questionnaire interviews to experts who have a lot of experiences in the field related to sea transport logistics.

The author set up the questionnaire as follows. The author set up the questionnaire as follows:

In the questionnaire, as shown in **Table 1**, the risk delay elements are divided into five levels, such as very low, low, medium, high and very high based on the risk impact. Besides, these levels were translated to the numbers corresponding to 1, 2, 3, 4 and 5, respectively.

The questionnaires were delivered to the participants who must have relevant work experience to the construction of water supply projects, about 350. The participants required have relevant experience working. To ensure all questionnaires using in the study are accuracy, the author verify and just use the questionnaire if all questions in which are answered correctly. Consequently, 261 surveyed questionnaires reach the requirement and they are used in the study, the aggregate number of respondent groups is described below (**Table 2**, **Table 3**).

There were 261 respondents, including (**Table 2**, **Table 3**).

3.2. Analysis and Assessment the Risks

In this part, we used surveyed data to statistically estimate parameters to analyse and assess risks. Obtained results are taken into comparison with the standard then causal factors with weak impact are eliminated. Thus, we find high impact causal factors.

3.2.1. Calculation the Cronbach's Alpha

Cronbach's alpha coefficient is used to determine the reliability of the question. It is well known that the Cronbach's alpha coefficient value (α) is always in the interval from zero to 1. In addition, in case of $\alpha < 0.6$ the hypothesis relating to the risk is unreliability, when $0.6 < \alpha < 0.8$ the former is reliability, while in the case of $0.8 < \alpha < 1$ the hypothesis is high reliability. For the surveyed data in this study, we use a condition of $\alpha > 0.6$ to verify if the hypotheses corresponding to the risks are reliability (Nguyen et al., 2021). We can neglect the variables with $\mu < 0.3$, i.e., corrected item minus total correlation, which indicates those risks have a low impact level.

*Calculate Cronbach's Alpha coefficient to determine the risk factor reliability R*1:

From the result table in **Table 4**, there are a number of causal factors having "Corrected Item-Total Correlation = $\mu < 0.3$", including: r1.5. Corrected item minus total correlation, which indicates those risks have a low impact level.

In **Table 5**, the Cronbach Alpha result when removing the risks with little effect The Cronbach Alpha of the R1 group was: 0.805. Thus, $0.8 < \alpha < 0.1$ is highly reliable (Mai et al., 2019; Nguyen et al., 2021).

Risks that have a major impact on this group include: r1.1, r1.2, r1.3, r1.4, r1.6.

Table 1. Questionnaire using in the study.

Risk groups	Risk elements	Expansions of risks	Impact level bad to construction process of water supply system				
			Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Risk management of owner (R1)	Risks of production not fulfilling the assigned plan	r1.1					
	Risks of change in business administration of owner	r1.2					
	Risk of planning and controlling schedule	r1.3					
	Risk of no having a backup plan for coal supply chain disruptions.	r1.4					
	Risks due to scale adjustment of project, changes in type of coal raw material or technology of thermal power	r1.5					
	The risk of concealing or delaying negative information resulting in a slow response when impacted by unexpected events.	r1.6					
Risk of policies and society (R2)	Risks due to unstable macroeconomic management policies	r2.1					
	Risks due to the relationship between the owners/investors, contractors and the authorities	r2.2					
	Risk due to change in owner or supplier	r2.3					
	Risks due to unexpected events, force majeure events	r2.4					
	Risks due to labor safety	r2.5					
Legal risk (Bidding for coal supply) (R3)	Risks due to non-transparency in coal supplier selection	r3.1					
	Miners and coal suppliers refuse directly bidding due to CIF (the delivery conditions at seaport) is complicated and risky	r3.2					
	Low quality of coal due to suppliers	r3.3					
	Lack of experience in coal logistics transport by domestic suppliers	r3.4					
	Payment conditions in suppling coal bidding are not suitable	r3.5					
Trade risk (R4)	Risks due to unclear contract terms	r4.1					
	Risks due to changes or additions to the terms of the contract	r4.2					
	Risks of fluctuating price due to agreement between coal supply contract and Power purchase	r4.3					
	Risks due to contract disputes	r4.4					
	Financial risks of the owner/investors	r4.5					
	Risks due to coal supplier's financial capacity	r4.6					
Cost risk (R5)	Risks of inflation	r5.1					
	Risks of interest rate	r5.2					
	Risks due to shipping fees	r5.3					
	Risks of cargo insurance fees	r5.4					
	Risks of coal loss during inland transport and transit	r5.5					

Continued

Risks due to partners and coal suppliers (R6)	Risks due to insufficient production capacity	r6.1
	Risks due to poor management	r6.2
	Risks due to not enough information of both internal and external among supply chain partners	r6.3
	Risks due to selection inappropriate modes of transportation	r6.4
	Risks due to low quality of coal	r6.5
Risk of transport (R7)	Risks due to no fulfillment of transported demand	r7.1
	Risks due to not enough berthing to loading/unloading demand	r7.2
	Risks due to channel into thermal factory	r7.3
	Risks caused by severe weather	r7.4
	Risks of fire and explosion prevention and coal crushing system	r7.5
	Risks due to coal mill damage	r7.6
Consequences of risk (R8)	Disruption of operations, production	(r8.1)
	Revenue, profit decrease, loss	(r8.2)

Table 2. About sex, years old and experience at work.

Sex		years old				Experience at work	
Male No (%)	Female No (%)	<25 No (%)	25 - 35 No (%)	36 - 50 No (%)	>50 No (%)	3 - 10 years No (%)	>10 years No (%)
203 (77.8%)	58 (22.2%)	5 (1.9%)	93 (35.6%)	114 (55.2%)	19 (7.3%)	83 (31.80%)	178 (68.2%)

Table 3. About the degree, about the job role and about job position.

About the degree			About the job role			About job position	
Master degree No (%)	Bachelors No (%)	Other qualification No (%)	operational technicians No (%)	office work No (%)	Managers No (%)	Contractors No (%)	Investor No (%)
48 (18.4%)	185 (70.9%)	28 (10.7%)	92 35%	116 45%	53 (20%)	35 13.4%	226 86.6%

Table 4. Results of Cronbach Alpha without removing causes had little effect.

Risk	Scale Mean if Item delected	Scale variance if Itemp delected	Corrected Item-Total correlation	Cronback's Alpha if Item delected
r1.1	12.84	11.641	0.558	0.681
r1.2	13.13	10.714	0.518	0.690
r1.3	13.52	11.296	0.626	0.663
r1.4	12.73	10.391	0.739	0.625
r1.5	14.25	15.797	0.053	0.805
r1.6	13.18	10.423	0.492	0.703

Cronbach Alpha without removing causes had little effect: 0.739.

Table 5. Cronbach Alpha results when eliminating 1 risk had little effect.

Risk	Scale Mean if Item delected	Scale variance if Itemp delected	Corrected Item-Total correlation	Cronback's Alpha if Item delected
r1.1	11.16	11.377	0.570	0.775
r1.2	11.45	10.441	0.530	0.789
r1.3	11.85	10.969	0.652	0.753
r1.4	11.05	10.109	0.758	0.719
r1.6	11.50	10.120	0.508	0.802

Cronbach Alpha results when eliminating 1 risks had little effect: 0.805.

In the same way for other groups of risks, we find high impact causal factors:

As we can see in Table 6, all of the Cronbach's alpha coefficients are larger than 0.6 ($\alpha > 0.6$), indicating all results are reliable.

3.2.2. Calculation and Analysis Discovery Factors Based on Pattern Matrix

To analyze discovery factors based on pattern matrix, we base value indicators: Kaiser-Meyer-Oklin (KMO), Bartlett examination (σ), percentage of variance, coefficients calculated of loading factor to determine the risk factor group. Necessary to calculate and analyse the discovery factors in order to investigate the main factors including the observation variables (survey questions). In the factor analysis of SPSS software, the factor reduction method "principal axis factoring" and the horizontal rotation method "promax" are used. We then obtain results including seven factors from R1 to R7. Surveyed data are suitable to analyse risk factors if KMO ≥ 0.5 and $\sigma \le 0.05$ indicates that surveyed data are statistics significance (Hair et al., 2009; Mai et al., 2019; Nguyen et al., 2021).

Bartlett examination is a statistical value using to verify if variables possessing interaction effect. In case of Bartlett examination, i.e., σ is smaller than 0.05, variables possess interaction effect (Gerbing & Anderson, 1988).

Results of KMO, σ and percentage of variance reached (Table 7).

The KMO test coefficient features the value of 0.879 (>0.5), indicating surveyed data are suitable to analyse factors, and the coefficient of the Bartlett statistical meaning is smaller than 0.00002, i.e., $\sigma < 0.05$, demonstrating variables possessing interaction effect. The data are effective.

3.2.3. Synthesize the Main Causes of Create Risks Factors

Main causes of create risk factors are illustrated in Table 8.

4. Conclusion and Limitations of Paper and Further Research

4.1. Conclusion

Using the survey method, combined with statistical analysis, the study investigates potential risks in the coal supply chain affecting the operation of thermal power plants. Findings in the study include:

Table 6. Calculation summary table Cronbach's Alpha.

Risk groups	Cronbach's alpha Ri	High-impact causes	Cronbach's alpha ri	Causes that have a small impact (eliminated)
(R1)	0.805	r1.1;	0.775	r1.5
		r1.2;	0.789	
		r1.3;	0.753	
		r1.4;	0.719	
		r1.6	0.802	
(R2)	0.802	r2.1;	0.716	r2.2;
		r2.3;	0.888	
		r2.4;	0.748	
		r2.5	0.635	
(R3)	0.775	r3.1;	0.725	r3.5;
		r3.2;	0.733	
		r3.3;	0.707	
		r3.4	0.716	
(R4)	0.936	r4.1;	0.894	r4.2; r4.4
		r4.3;	0.891	
		r4.5;	0.963	
		r4.6	0.911	
(R5)	0.905	r5.1;	0.781	r5.3; r5.5
		r5.2,	0.994	
		r5.4	0.791	
(R6)	0.934	r6.1;	0.891	r6.3
		r6.2;	0.888	
		r6.4;	0.961	
		r6.5	0.910	
(R7)	0.881	r7.1;	0.731	r7.3; r7.5; r7.6
		r7.2;	0.994	
		r7.4	0.727	

Table 7. KMO and Bartlett's test.

Kaiser-Meyer-Oklin Measure of Sampling Adequacy		0.879
Bartlett's Test of Sphericity	Approx. Chi-Square	10,481.203
	df	351
	Sig	0.00002

Table 8. Synthesize the main causes of create risks factors.

Risk groups	High-impact causes	Synthesize the main causes of create risks factors.
Risk management of owner (R1)	r1.1;	Risks of production not fulfilling the assigned plan
	r1.2;	Risks of change in business administration of owner
	r1.3;	Risk of planning and controlling schedule
	r1.4;	Risk of no having a backup plan for coal supply chain disruptions.
	r1.6	The risk of concealing or delaying negative information resulting in a slow response when impacted by unexpected events.
Risk of policies and society (R2)	r2.1;	Risks due to unstable macroeconomic management policies
	r2.3;	Risk due to change in owner or supplier.
	r2.4;	Risks due to unexpected events, force majeure events
	r2.5	Risks due to labor safety
Legal risk (Bidding for coal supply) (R3)	r3.1;	Risks due to non-transparency in coal supplier selection
	r3.2;	Miners and coal suppliers refuse directly bidding due to CIF (the delivery conditions at seaport) is complicated and risky
	r3.3;	Low quality of coal due to suppliers;
	r3.4	Lack of experience in coal logistics transport by domestic suppliers;
Trade risk (R4)	r4.1;	Risks due to unclear contract terms
	r4.3;	Risks of fluctuating price due to agreement between coal supply contract and Power purchase
	r4.5;	Financial risks of the owner/investors
	r4.6	Risks due to coal supplier's financial capacity
Cost risk (R5)	r5.1;	Risks of inflation
	r5.2;	Risks of interest rate
	r5.4	Risks of cargo insurance fees
Risks due to partners and coal suppliers (R6)	r6.1;	Risks due to insufficient production capacity
	r6.2;	Risks due to poor management
	r6.4;	Risks due to selection inappropriate modes of transportation
	r6.5	Risks due to low quality of coal
Risk of transport (R7)	r7.1;	Risks due to no fulfilment of transported demand
	r7.2;	Risks due to not enough berthing to loading/unloading demand
	r7.4	Risks caused by severe weather

1) Identify the main causes in the coal supply chain affecting the operation of thermal power plants-Vietnam.

2) On the basis of those risk models, the study has calculated, analyzed, and

carefully assessed the risks and pointed out 7 groups of risk factors and 27 main causes in the waterway logistics chain that affect come to operate a thermal power plant in Vietnam.

4.2. Limitations of Paper

The limitations of this paper are:

1) Risk study in coal fuel supply chain for thermal power plants in Vietnam. The common ground for plants in the world has not been studied.

2) Experts have not been interviewed to suggest useful solutions to control those risks.

4.3. Further Research

1) Proposal of implications that could reduce/prevent and control those main causes.

2) In the aspect of engineering risk management information system, it is necessary to develop data collection and processing methods and standards, and to establish a risk-related information system

3) It is needed to develop engineering risk management information system software to improve the implementation of project risk information management and to extend the scope of management applications.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Benyahia, S. (2012). *A Comparative Study of the Resilience of Coal Logistics Chains in Australia, South Africa and Canada.* Montreal: Université de Montréal.

Botha, A., & Badenhorst-Weiss, J. (2019). Risk Management in a Bulk coal Export Logistic Chain: A Stakeholder Perspective. *Journal of Transport and Supply Chain Management, 13,* Article No. a424. https://doi.org/10.4102/jtscm.v13i0.424

Breuer, C., Siestrup, G., Haasis, H.-D., & Wildebrand, H. (2013). Collaborative Risk Management in Sensitive Logistics Nodes. *Team Performance Management, 19,* 331-351. https://doi.org/10.1108/TPM-11-2012-0036

Gerbing, D. W., & Anderson, J. C. (1988). An Updated Paradigm for Scale Development Incorporating Unidimensionality and Its Assessment. *Journal of Marketing Research, 25,* 186-192. https://doi.org/10.1177%2F002224378802500207

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2009). *Análise multivariada de dados*. Porto Alegre: Bookman Editora.

Mai, S. H., Siphada, V., Wang, J., Mekthanavanh, V., Hlaing, H. H., & Sokliep, P. (2019). Evaluating and Classifying the Impact of Individual Risk on the Delayed EPC Hydropower Projects in the Developing Countries of Asia. *International Journal of Risk Assessment and Management, 22,* 170-194. https://doi.org/10.1504/IJRAM.2019.101279

Nguyen, D. H., & Do, M. (2021). *Developing Logistics Services of Expeditors—Vietnam*

Joint Stock Company under Integration Condition and EVFTA: EVFTA Opportunities for Enterprises and Economies.

Nguyen, M. T., Mai, S. H., & Vu, Q. H. (2021). Risk Assessments in Construction of Water Supply Projects in Hanoi, Vietnam. *American Journal of Industrial and Business Management, 11,* 232-250. https://doi.org/10.4236/ajibm.2021.112015

Pantaleo, A. M., & Shah, N. (2013). The Logistics of Bioenergy Routes for Heat and Power. In F. Zhang (Ed.), *Biofuels-Economy, Environment and Sustainability* (pp. 217-244). London: IntechOpen.

Popek, M. (2019). Sea Transportation of Coal Liable to Liquefaction. *TransNav: International Journal on Marine Navigation and Safety of Sea Transportation*, *13,* 803-807. https://doi.org/10.12716/1001.13.04.13

Windén, B., Chen, M., Okamoto, N., McCaig, E., Shenoi, A., & Wilson, P. (2013). An Investigation into the Logistical and Economical Benefits of Using Offshore Thermal Power in a Future CCS Scheme. *Energy Procedia, 37,* 2997-3004. https://doi.org/10.1016/j.egypro.2013.06.186