John Biogreen: Supply Chain Improvement

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Received: July 15, 2018 Revised: January 13, 2022 Accepted: January 18, 2022

Abstract

In April 2016, Pratchya Sae-Ngo, director of logistics of NK Energy (NKE), faced a challenge regarding the supply chain of the company's newly acquired biomass power plant, John Biogreen (JB), which was in a dire situation since the total supply chain cost accounted for more than 90% of its revenue, significantly higher compared to their first plant. NKE was a small power producer (SPP) located in Nakhon Pathom province. The company operates an 8MW biomass power plant with rice husks as the main fuel. In 2016, they decided to acquire JB, which is a biomass power plant located in Suphanburi and that has similar technical specifications, yet the performance of JB is relatively lower. They discovered that the failure of JB was a result of its poorly designed supply chain. On average, JB has higher material costs than NKE and lower than average inventory level. Thus, Somchai arranged for Pratchaya to redesign the supply chain of JB. His objective was to reduce the supply chain cost and to ensure continuous feedstock. After analyzing the supply chain of JB, Pratchaya found that the problem lay in its small supplier base, insufficient inventory, and low flexibility in transportation. There were several alternatives in solving those issues and Pratchaya had to analyze and combine them in order to create a new supply chain for JB. He only had 2 months to finalize his new supply chain design before the quarterly meeting of the company, which was to be held on June 1, for approval since the implementation of the redesigned supply chain had to be completed before the next harvesting season.

Keywords: Supply Chain Management, Supply Chain Design, Inventory Management, Logistics, Biomass Power Plant

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จอห์นไบโอกรีน : การพัฒนาห่วงโซ่อุปทาน

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บทคัดย่อ

ในเดือนเมษายน ปี 2016 นายปรัชญา แซ่โง้ว ผู้จัดการโลจิสติกส์ของบริษัทนครปฐมไบโอแมส ได้พบกับความท้าทายใหม่ ห่วงโซ่อุปทานของโรงไฟฟ้าไบโอแมสของบริษัทจอห์นไบโอกรีนที่ทางบริษัทได้ทำการซื้อกิจการมานั้นกำลังอยู่ในสถานการณ์ย่ำแย่ ค่าใช้จ่ายในการจัดการห่วงโซ่อุปทานของจอห์นไบโอกรีนนั้นสูงถึง 90% ของรายได้รวมซึ่งถือว่าสูงมากเมื่อเทียบกับนครปฐมไบโอแมส นครปฐมไบโอแมสเป็นผู้ผลิตกระแสไฟฟ้าเอกชนรายเล็กในจังหวัดนครปฐม โรงไฟฟ้าไบโอแมสของบริษัทใช้แกลบเป็นเชื้อเพลิงหลักโดยมีกำลังผลิตอยู่ที่ 8 เมกะวัตต์ ในปี ค.ศ. 2016 ทางบริษัทได้ตัดสินใจซื้อกิจการของจอห์นไบโอกรีนซึ่งเป็นโรงไฟฟ้าไบโอแมสในจังหวัดสุพรรณบุรี จอห์นไบโอกรีนนั้นมีความคล้ายคลึงกับนครปฐมไบโอแมสในหลายด้านไม่ว่าจะเป็นด้านเครื่องจักร วัตถุดิบ รวมถึงสถานที่ตั้งหากแต่ว่าจอห์นไบโอกรีนกลับมีผลประกอบการที่ย่ำแย่กว่านัก ทางบริษัท พบว่า ปัญหาของจอห์นไบโอกรีนนั้นเกิดจากการจัดการห่วงโซ่อุปทานที่ย่ำแย่ เพื่อเป็นการแก้ปัญหานครปฐมไบโอแมสจึงได้มอบหมายให้นายปรัชญาไปทำการออกแบบห่วงโซ่อุปทานใหม่โดยมีเป้าหมายหลัก คือ ลดต้นทุนและมีวัตถุดิบพร้อมใช้ หลังจากการวิเคราะห์ นายปรัชญาพบว่าปัญหาในห่วงโซ่อุปทานของจอห์นไบโอกรีนนั้นเกิดจากการมีต้นแหล่งน้อย โกดังมีขนาดเล็ก และขาดความยืดหยุ่นในการขนส่ง นายปรัชญามีเวลา 2 เดือนในการออกแบบห่วงโซ่อุปทานใหม่เพื่อแก้ปัญหาเหล่านี้ เพราะเขาจะต้องนำเสนอแผนในการประชุมประจำไตรมาสของบบริษัทในเดือนมิถุนายนไม่เช่นนั้นการดำเนินการตามแผนอาจจะไม่เสร็จทันฤดูเก็บเกี่ยวครั้งหน้า

คำสำคัญ : การจัดการห่วงโซ่อุปทาน การออกแบบห่วงโซ่อุปทาน การจัดการคลังสินค้า โลจิสติกส์ โรงไฟฟ้าชีวมวล

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Introduction

It was April 1, 2016, and Pratchaya Sae-NGO was driving to the company for his team meeting. Pratchaya was the logistics director of Nakhon Pathom Energy Company (NK Energy), a small power producer. Currently, he is responsible for redesigning the supply chain of the company's newly acquired biomass power plant, John Biogreen. In 2015, with the success of their first biomass power plant, NK Energy decided to expand its business. Two alternatives for them were building a new plant or acquiring the existing power plant. After careful consideration, NK Energy decided to acquire John Biogreen. There were several reasons for the acquisition, yet the main points were the similarity between the two plants and the low acquisition cost due to a huge accumulated loss. Before the acquisition, NK Energy executives were certain that the problem lay in the supply chain since their average material cost was 95% of their revenue, almost 30% higher than that of NK Energy. Since material cost was considered to be the most significant cost for biomass power plant, therefore inefficient supply chain of John Biogreen was an urgent issue that requires immediate attention. They believed that this problem could be solve with their experience from their plant. Therefore, Pratchaya, who was considered to be the best in the field, was assigned by the president to solve the problem. He was given two main goals: reducing the procurement cost and ensuring the continuous supply of rice husk. Pratchaya started this supply chain improvement project in January 2016. He and his team began by studying the operation of the plant, the current supply chain design and strategy, the suppliers, the available resources, and many other aspects. It took 3 full months for them to fully understand the entire supply chain structure and the operation of John Biogreen. With sufficient information, he expected to come up with a new supply chain design and strategy, or some feasible ideas at the very least. Pratchaya had to finalize his improvement plan before the quarterly meeting in June 2016, or else they were afraid that there would not be enough time for implementation since the next harvesting season would begin in January. If they could not solve the issue, it was highly possible that John Biogreen would suffer a loss for another year since the company have to relied on the existing inefficient supply chain.

Company and Industry Background

NK Energy company was one of the small power producers (SPPs) in Nakhon Pathom with revenue of over 250 million Baht annually. The company was founded in 2010 by Somchai, who was recognized by many for his accomplishment in the logistics business. He has been in the transportation business for more than 40 years with a fleet of almost one thousand trucks. As his logistics business matured and stabilized, he began to explore new sectors of the business for further expansion and he set his eyes on renewable energy production, which was becoming more attractive to investors in recent years. In 2010, Somchai founded NK Energy, a biomass power plant located in Nakhon Pathom province.

Electricity production in Thailand has been steadily growing over the years. On average, the growth is approximately 5% - 10% annually. (Exhibit 1) The production of electricity can be categorized according to sources, which include natural gas, coal and lignite, oil, hydroelectricity, imported electricity, and renewable energy. Among them, renewable energy was one of the most attractive sources. Its growth rate was, on average, higher compared to total energy production growth. (Exhibit 2) In addition, recently the laws and regulations in Thailand began to promote renewable energy since the country could benefit from the development of sustainable energy systems. Not only would renewable energy help the country meet its growing electricity demand, it would also help to address the soon-coming scarcity of the fossil fuel supply. Examples of renewable energy include solar, wind, and biomass.

Biomass is one of the most utilized sources of renewable energy as it comprised of wide range of material including plant/animal materials, residues from agricultural processes, and organic wastes. There are several benefits in adoption biomass for energy production. Apart from carbon mitigation and energy security, biomass power plant promotes creation of new jobs, increase in farmer's income, cheap heat supply, and reduced waste. There are several methods in converting biomass to electricity such as direct combustion, pyrolysis, fermentation, or gasification. In Thailand, the most common method is the direct combustion. The operation of a biomass power plant is relatively simple. After the biofuel is procured, it is burned to heat the water in a boiler, which will produce steam that will rotate the turbine of a power generator. The electricity produced from the generator in turn will be measured and transferred to a public electricity wire for public usage. The revenue of the plant will be paid based on the amount of electricity produced by the Electricity Generating Authority of Thailand (EGAT), which is the only customer of the plant.

For a biomass power plant, there are many alternatives for fuel. In Thailand, the most common types of biofuels are agricultural waste, such as bagasse, wood chips, or rice husks. The choice of biofuel typically depends on the location of the plant. For example, chipped wood is preferred in the southern part of Thailand since rubber trees are the industrial crop of the region. Because the plant was located in the central region, Somchai chose to build a biomass power plant with rice husks as the main fuel, with the bagasse alternative as the secondary fuel. The reason for this biomass choice is that NK Energy is located in Nakhon Pathom province, where the main agricultural produce is rice, as in neighboring provinces such as Suphanburi or Ratchaburi. In addition, farmers in the central region of Thailand also cultivate rice twice a year, instead of once, meaning that there would be an abundant supply of rice husks for the plant almost all year round. Nevertheless, NK Energy also had to design its supply chain carefully since their profitability largely depended on procurement costs. The key for a biomass power plant is to have low biofuel costs and a continuous supply in order to keep the plant running 24/7. Even if the central region of Thailand has an abundant supply of rice husks, there still are shortages during certain times of the year since rice is a seasonal crop.

Supply Chain Strategy of NK Energy

Realizing that an efficient supply chain is crucial for NK Energy, Somchai assigned Pratchaya Sae-Ngo, who has been working with him for decades since he founded his logistics company, to act as logistics director for the plant. A week after he took the position, Pratchaya realized that there were several characteristics that separate biomass supply chain from a typical one. The first one is seasonal availability of the product as rice husk was a seasonal product that only available in particular time of the year. Another issue was the density of the material.

Rice husk has very low density which resulted in larger space required. It also needed to be kept away from moisture as it could led to inefficient combustion. Knowing such characteristics, Pratchaya designed the supply chain for NK Energy with two main objectives, which were cost minimization and continuous supply. He began by assessing the demands of the plant in order to compute the inventory required by taking the seasonality factor into account. Then he created supplier selection criteria in order to form his supplier pool since only a single supplier would not be capable of satisfying the plant's demands. After that, he decided on a transportation model, whether operating their own trucks or outsourcing to a 3rd party logistics company.

NK Energy Supply Chain

There are several parties involves in the supply chain of NK Energy including the supplier, transportation and distribution parties, energy production facility, the government/utility firms who provide the incentives, and the customer. In general, there are five components in biomass supply chain which are harvesting and collection, pre-treatment, storage, transport, and energy conversion. As a logistics director, Pratchaya only focus on storage and transport components. He also modeled the supply chain of NK Energy as multiple suppliers, a single customer, in-house transportation, and 3rd party contractors. (Exhibit 3) NK Energy procured rice husks from the supplier and then stored them in a warehouse before sending them to the production line. The product, which was electricity, was then sold to EGAT. Due to the geological advantage of the plant, located in a region with abundant suppliers, the most efficient transportation mode was using trucks. NK Energy was using its own trucks and hiring 3rd party logistics providers.

In terms of supplier selection, Pratchaya defined 4 factors as the most crucial: supplier capability, price, supplier location, and quality. According to the specifications of the plant, NK Energy required approximately 200 tons of rice husks per day, depending on their quality. Thus, the company needed to have a large pool of suppliers, and most had to be large-capacity rice mills. (Exhibit 7) As for the price, NK Energy made a contract with its suppliers in the form of quota purchased. This resulted in the company having to renegotiate the price almost every month. The drawback of this was low coordination within the supply chain. However, flexibility in switching suppliers was the reason behind such a contract since there were many substitutes in the region. In terms of location, these contracted rice mills were mostly located in Nakhon Pathom province or a neighboring province in the central region of Thailand, which allowed NK Energy to lower its transportation costs. Not only transportation costs, but also the lead time was shortened due to shorter distances, meaning that the company could achieve more cycles with a small number of trucks. Lastly, the quality of the rice husks was also an important factor, and the quality is determined by the amount of dust mixed in with the husks and their humidity. If there was large amount of dust in the rice husks or a high moisture level, the consumption could have increased by 10%, leading to higher costs for each unit of electricity produced.

Apart from supplier selection, inventory management also needs to be considered in building an efficient biomass supply chain. Due to the fact that rice was a seasonal crop, the price and availability of rice husks could vary throughout the year. In addition to the seasonal factor, the price of rice also has an effect on rice husk prices. The reason is that rice prices could affect the decision of the rice mill; that is, whether to mill or stock unmilled rice. According to historical data, Pratchaya could estimate that rice husks would not be available from July to November. Even if NK Energy could procure them, the cost would be significantly higher, around 15%. (Exhibit 4) Therefore, he believed that NK Energy needed to have a sufficient inventory to cover those months. Choosing location of the warehouse was considered a crucial step that must take into account type/characteristics of material and transportation options. It can be on-field, in-between, on-site, or multiple locations. Pratchaya considered establishing an intermediate warehouse between field and power plant. The problem is that the optimal location of the warehouse for this approach required complex computation. Nevertheless, Pratchaya decided to keep things simple and located the warehouse next to the powerplant and utilized dynamic programming approach to minimize the storage cost to account for the rice husk seasonal availability. As a result, NK Energy built a large warehouse where they could stockpile enough rice husks to for 3 months' usage. In addition, the holding cost for rice husks was relatively low compared to the cost of shortages, which included higher rice husk prices and lost revenue if there was no supply to operate the plant.

With geographical limitations, the most suitable transportation mode for NK Energy was land transport using trucks. Pratchaya decided to use both company-owned trucks and 3rd party logistics providers. NK Energy owned 5 trucks with 50 tons of loading capacity. This was sufficient to satisfy the daily demand with only one cycle for each truck. Normally, each truck would be dispatched 2 cycles per day so that the company could gradually stock the rice husks. However, if the price of rice husks went down significantly, they could utilize up to 3 cycles per day, which would mean 750 tons of rice husks. As for 3rd party logistics, Pratchaya categorized this as a secondary transportation mode, which could be used when the supply of rice husks was scarce, or when there were not enough company-owned trucks to procure the rice husks in time. The reason is that 3rd party logistics providers included transportation costs in the contract price, resulting in higher costs compared to using the company's own trucks. However, when the local supply was scarce and there was a need to go further for rice husks, the total procurement cost of the 3rd party logistics provider became lower. Even though it was difficult to control the quality of rice husks from these companies, NK Energy could still reject the shipment if the quality fell lower than the acceptable standard.

Acquisition of John Biogreen

With a carefully designed supply chain, NK Energy could profit greatly from its first plant. They started to plan on expanding their business. There were two alternatives in Somchai's mind—building a new plant or acquiring the existing one. A careful analysis was performed of those two options. While building the new plant was attractive, Somchai found an interesting candidate for acquisition, John Biogreen. John Biogreen is a biomass power plant located in Suphanburi province. The previous owner was an acquaintance of Somchai's and he wanted to sell his company due to large accumulated loss over the years. After visiting the plant and analyzing their financial statement, Somchai found that this was a good opportunity that he could not miss. First, he could acquire the plant for a relatively lower price than expected since the previous owner strongly desired to sell it while nobody was interested in the plant. Secondly, the plant itself was almost identical to that of NK Energy in Nakhon Pathom. It had a capacity of 7MW, which was similar to 8MW of NK Energy. Moreover, the main fuel for the plant was also rice husks, just like their own plan. Since the plant was in Suphanburi province, this meant it was relatively close to their first plant, and they could even share the supplier pool. With all of these similarities, Somchai strongly believed that he could turns things around after he purchased the plant, despite the fact that its current performance was extremely poor.

Somchai suspect that the problem of John Biogreen lay in its poor supply chain management. Their inefficient supply chain directly resulted in higher fuel costs compared to other plants. According to his experience, Somchai knew that, for biomass power plan, there were 2 major cost that had to be monitored. The first cost is maintenance cost as the plant itself needed to be properly maintained to achieve highest efficiency. Slight mistake in maintenance could led to major breakdown with will cost the company millions to repair and millions of lost revenues during shutdown. The second cost was fuel cost which considered to be largest cost of the plant. In general, the fuel cost ranged between 60% to 80% of the revenue. According to their financial statement, their fuel cost was 30% higher than that of NK Energy, even though both plant specifications were almost identical. In addition, the managerial cost and other costs of John Biogreen were also lower than that of NK Energy. (Exhibit 5) Since fuel cost represent major cost of the company, performance of supply chain could significantly affect the performance of the plant. This was clearly shown as John Biogreen’s revenue was only half of NK Energy. Therefore, Somchai assigned Pratchaya, whom he highly recognized for his knowledge of supply chain management, to redesign the supply chain of John Biogreen.

John Biogreen Supply Chain

In January 2016, Pratchaya began his supply chain improvement project. The first thing he did was to examine the current supply chain of John Biogreen. After months of data gathering, he found that the supply chain of this new plant was similar to that of NK Energy. There were only differences in some areas, yet those differences were major ones that limited the efficiency of the supply chain.

The first point was that the supplier base of John Biogreen was smaller, resulting in the inability to procure rice husks during times of shortage. (Exhibit 6) The company only has three suppliers with combined capacity of 6,100 tons per month, barely enough for its monthly demand of 6,000 tons. In addition, the average price of the rice husk is relatively higher compared to NK Energy despite the fact that there were even more suppliers in the area. (Exhibit 7)

The difference in price may resulted from the company choice in procurement. Unlike NK Energy that relied on both company-own trucks and several 3rd party logistic providers, John Biogreen only relied on single 3rd party logistics providers. This resulted in their low flexibility in reacting to changes. For instance, Pratchaya found out that they had to shut down the operation for several times because their contractor was unable to procure a supply for them, especially during July to November when rice husk was scarce. Even though they charged a penalty fee, it was still lower than their lost revenue. Their contractor also provided John Biogreen with limited supply, only enough for their demand, which caused the company to be unable to stockpile the rice husk.

Finally, the last issue that Pratchaya found out was the capacity of the warehouse. In contrast to that of NK Energy, John Biogreen warehouse was significantly smaller. It could hold only 1,200 tons of rice husks, which could only satisfy 6 days of demand. Even though the company was able to procure enough rice husk, there was no place to store it. This meant that when the supply of rice husks ran into a shortage, John Biogreen would have to procure them at a higher price, or sometimes would have to shut down the plant due to a lack of fuel.

According to his analysis, Pratchaya could summarize that the seasonal availability of rice husks was the main issue that he had to address when redesigning the supply chain for John Biogreen. He had to ensure that the annual procurement cost would be minimized and that the plant would have continuous feedstock.

The Decision

In that day's meeting, after all of the data were gathered, Pratchaya and his team began working on redesigning the new supply chain for the plant. There were several alternatives offered by the team, including: 1) expanding the inventory, 2) expanding the supplier base, 3) modifying the transportation method, 4) renegotiating the contract, and 5) building a central warehouse for both plants.

If they chose to expand the inventory it would take a considerable amount of time and investment, depending on the capacity. The question was, to what extent should they expand so that they would not be overstocked or run into a shortage? Enlarging the supplier base was also an option to be considered, as this would allow them to have higher bargaining power over the rice mill and could affect their transportation costs, which depended on the distance of the supplier. For the transportation model, they were considering investing in new trucks for more flexibility. However, would that be worthwhile, and how many trucks should they have? Renegotiating the terms of the contract with the supplier was also an option. They could make a contract based on the amount procured, have a long-term contract, or other contract types. Finally, the most extreme option, since both plants were close to each other (only 80 kilometers), they considered building a central warehouse that could be used for both plants. Regardless of their choice, they also had to consider the effects of their decision on other aspects as well. First of all, demand of rice husk would increase which could lead to shortage of material or increase in price, depending on degree of change in demand. There were also several potential environmental impacts such as dust and CO_2 emission from transportation. These environmental impacts could also harm the locals. Therefore, it was crucial for Pratchaya's team to consider these impacts and mitigated them as they tried to achieve their objective.

With these improvement options in mind, Pratchaya and his team had to select one, or a combination, in order to formulate the final supply chain redesign plan for John Biogreen. The redesigned supply chain had to satisfy two criteria. First, it had to lower the fuel costs of John Biogreen to the same level as that of NK

Energy. Second, the new supply chain had to allow John Biogreen to have a continuous supply of rice husks. In addition, he also had to create a monthly procurement plan, in terms of the quantity procured for each month, along with the plan. Nevertheless, Pratchaya had to finalize his improvement plan before the quarterly meeting in June 2016, or else there would not be enough time for implementation. Without the redesigned supply chain, John Biogreen would have to relied on the existing inefficient supply chain and suffered a loss for another year.

Exhibit 1: Annual Power Generation in Thailand (In GWh)

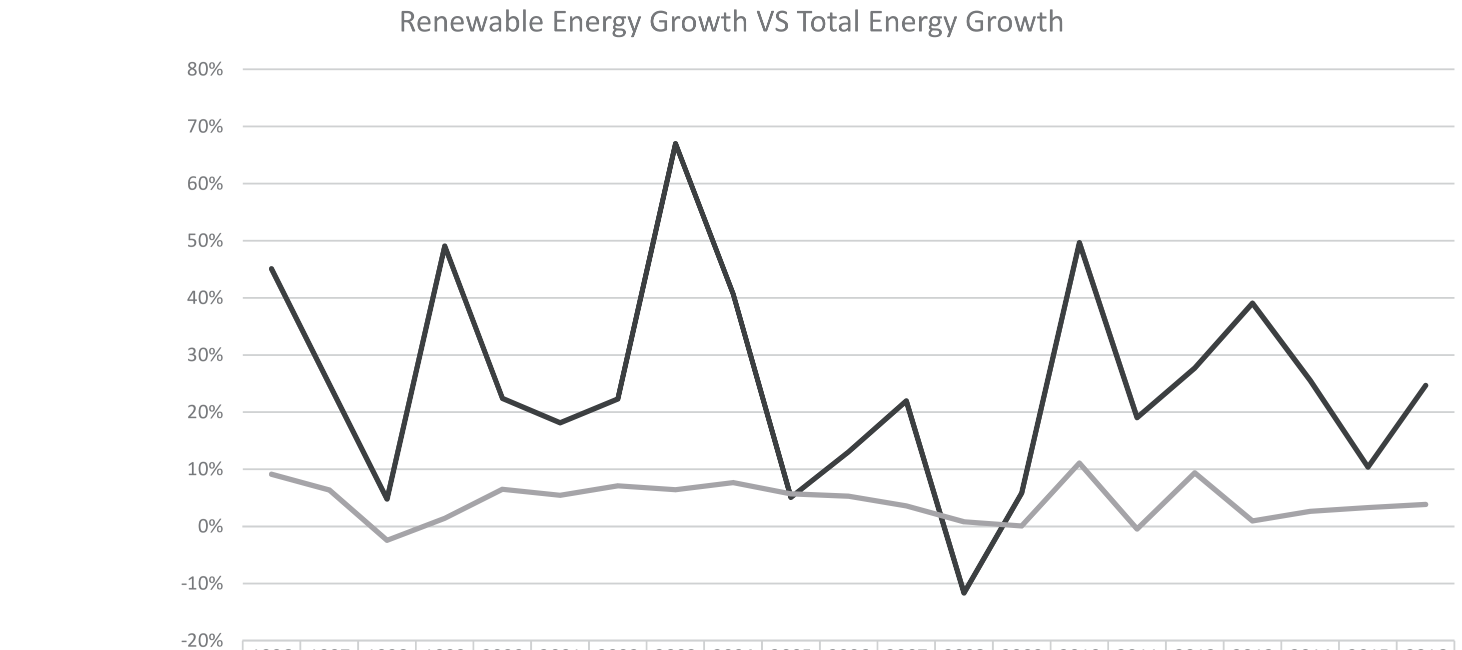
Year	Natural Gas	Coal & Lignite			Oil			Hydro Electricity	Imported	Renewable Energy	Total
		Lignite	Coal	Total	Fuel Oil	Diesel	Total				
1992	22,943.04	14,815.05	0.00	14,815.05	14,928.92	161.34	15,090.26	4,158.94	479.90	20.86	57,508.05
1993	27,953.16	13,503.75	0.00	13,503.75	17,494.52	743.97	18,238.49	3,612.50	644.52	29.43	63,981.85
1994	31,484.80	14,130.91	0.00	14,130.91	19,647.18	1,385.18	21,032.36	4,403.60	870.82	50.76	71,973.25
1995	33,863.26	15,152.25	12.86	15,165.11	21,711.89	2,261.18	23,973.07	6,593.01	699.12	142.75	80,436.33
1996	36,433.34	17,507.17	72.90	17,580.07	20,983.73	4,572.36	25,556.09	7,215.00	805.61	207.12	87,797.24
1997	44,573.67	18,924.58	101.22	19,025.79	19,280.93	2,440.68	21,721.61	7,082.00	745.63	258.68	93,406.91
1998	49,021.13	16,475.24	115.24	16,590.48	17,572.52	988.97	18,561.49	5,088.82	1,622.71	271.09	91,155.72
1999	53,804.43	15,418.91	1,214.29	16,633.20	15,472.54	457.33	15,929.87	3,409.67	2,255.66	404.15	92,470.95
2000	61,094.56	15,852.17	2,345.17	18,197.34	9,643.54	107.95	9,751.49	5,891.44	2,966.25	494.77	98,487.52
2001	71,228.78	17,722.36	2,573.67	20,296.03	2,456.51	248.06	2,704.57	6,174.35	2,881.71	584.54	103,868.90
2002	78,910.24	16,651.86	2,639.64	19,291.51	2,006.75	150.98	2,157.73	7,366.94	2,812.18	715.04	111,253.87
2003	85,687.83	16,856.16	2,445.22	19,301.38	2,471.53	75.30	2,546.83	7,207.76	2,473.41	1,194.24	118,411.44
2004	90,289.05	17,993.55	2,410.93	20,404.48	5,629.85	232.95	5,862.80	5,896.29	3,377.85	1,679.74	127,510.51
2005	94,467.62	18,334.50	2,279.80	20,614.30	7,731.04	176.85	7,907.89	5,671.18	4,371.89	1,765.23	134,798.20
2006	94,438.46	18,027.68	6,440.70	24,468.38	7,836.79	76.92	7,913.71	7,950.05	5,151.85	1,996.12	141,918.57
2007	98,243.47	18,497.68	12,383.43	30,881.11	2,988.65	28.24	3,016.88	7,961.36	4,488.36	2,434.71	147,025.89

Exhibit 1: Annual Power Generation in Thailand (In GWh) (Cont.)

Year	Natural Gas	Coal & Lignite			Oil			Hydro Electricity	Imported	Renewable Energy	Total
		Lignite	Coal	Total	Fuel Oil	Diesel	Total				
2008	104,457.92	18,679.30	12,158.34	30,837.64	1,016.81	23.28	1,040.09	6,950.69	2,783.57	2,151.02	148,220.93
2009	106,343.31	17,922.09	11,875.01	29,797.10	478.81	45.07	523.88	6,965.74	2,451.41	2,276.68	148,358.11
2010	118,438.15	17,987.63	11,776.38	29,764.00	577.37	41.59	618.95	5,346.75	7,253.78	3,407.16	164,828.81
2011	108,261.32	18,835.63	12,876.10	31,711.73	1,315.58	35.98	1,351.56	7,934.92	10,774.41	4,055.98	164,089.92
2012	119,368.45	18,802.01	15,780.60	34,582.61	1,329.92	62.76	1,392.68	8,431.22	10,527.43	5,181.22	179,483.61
2013	119,217.90	19,097.98	16,254.22	35,352.19	1,266.52	179.14	1,445.66	5,412.08	12,571.79	7,205.83	181,205.45
2014	120,314.16	19,370.82	18,201.10	37,571.92	1,606.43	62.60	1,669.03	5,163.57	12,259.71	9,045.51	186,023.89
2015	128,525.00	16,932.30	17,649.81	34,582.11	796.91	125.70	922.61	3,760.73	14,414.49	9,984.55	192,189.48
2016	126,149.59	19,059.43	18,047.73	37,107.16	317.81	173.69	491.50	3,543.08	19,825.36	12,450.16	199,566.83

Source: Energy Policy and Planning Office, 2017

Exhibit 2: Comparing Renewable Energy Growth with Total



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Renewable Energy	45%	25%	5%	49%	22%	18%	22%	67%	41%	5%	13%	22%	-12%	6%	50%	19%	28%	39%	26%	10%	25%
Total	9%	6%	-2%	1%	7%	5%	7%	6%	8%	6%	5%	4%	1%	0%	11%	0%	9%	1%	3%	3%	4%

Source : Energy Policy and Planning Office, 2017

Exhibit 3: NK Energy Supply Chain

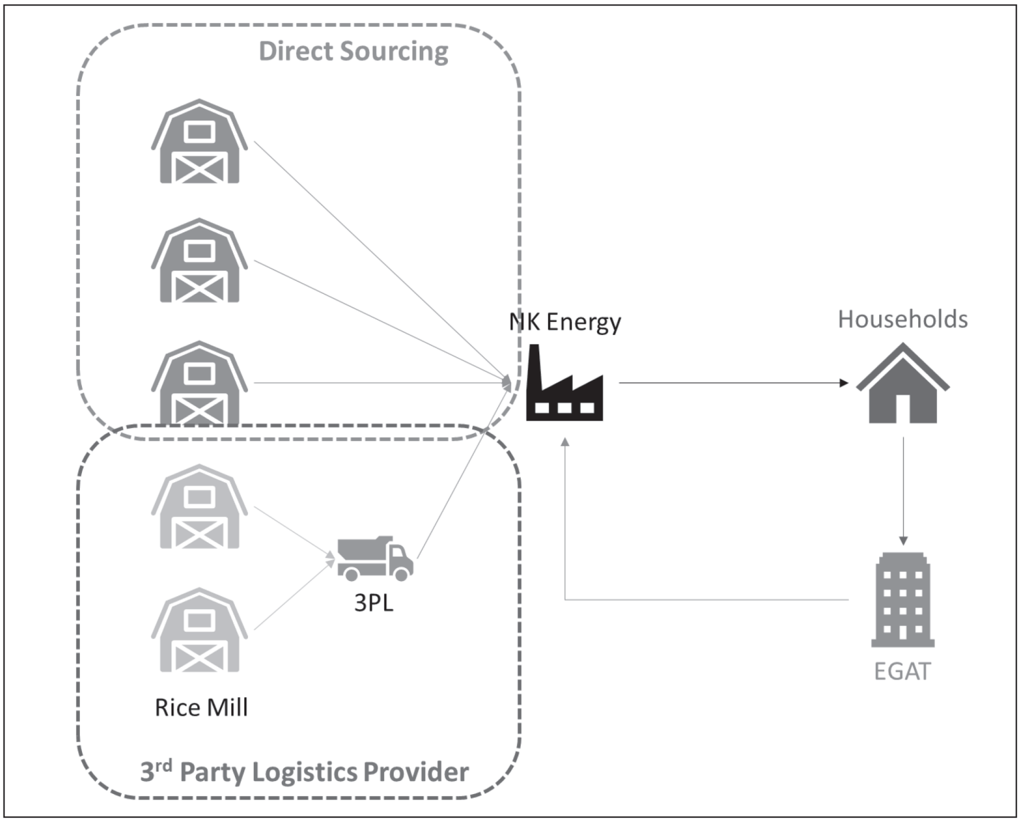
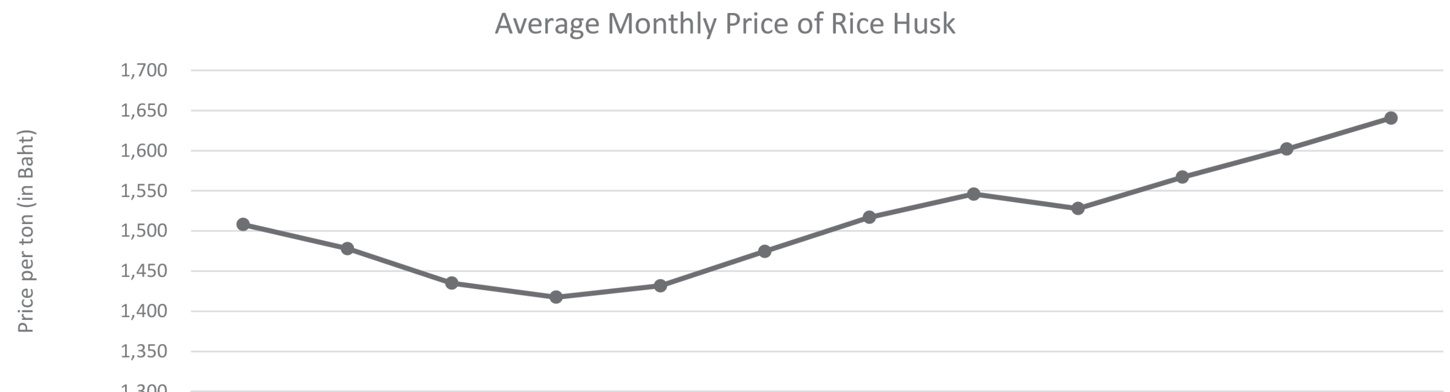


Exhibit 4: Monthly Average Price of Rice Husk (In Thai Baht)



	January	February	March	April	May	June	July	August	September	October	November	December
Price per ton	1,508	1,478	1,435	1,417	1,432	1,475	1,517	1,546	1,528	1,567	1,602	1,641

Source: Historical data of NK Energy in 2013-2014

Remark: Exchange rate: 1 USD ≈ 35 THB

Exhibit 5: Income Statement Comparison of NK Energy and John Biogreen

Income Statement of 2014
John Biogreen and NK Energy

	John Biogreen	NK Energy
Income	121,959	255,199
Material cost	114,077	179,644
Managerial cost	19,275	20,171
Total cost	133,352	199,815
Gross profit	(11,393)	55,384
Other cost	14,577	21,225
Profit before tax	(25,970)	34,159
tax	0	0
Net profit	(25,970)	34,159

Remark: Unit in thousands of Baht (1 USD ≈ 35 THB)

Exhibit 6: John Biogreen Suppliers (Including Potential Supplier and 3PL)

Supplier	Average Monthly Capacity [C]	Price (in Thai Baht) [E]			Estimated Distance [D]
		Average	High	Low	
SP Transport [A B]	2,100	1,935	2,140	1,730	
Suphan Panich [A B]	2,200	2,030	2,190	1,870	
Sang Thong Panich [A B]	1,800	2,005	2,170	1,840	
Nakhon Rice	700	1,500	1,650	1,350	30
Boonchai Rice Mill	600	1,653	1,700	1,607	25
Don Chedi Rice	500	1,645	1,750	1,540	10
Nakhon Chai Mill	1,100	1,700	1,700	1,700	40
Khao Panich	900	1,625	1,750	1,500	20
Lim Charoen Rice Mill	600	1,625	1,750	1,500	35
Lim Rice Mill	1,400	1,488	1,600	1,376	25
AP Rice Mill	700	1,625	1,750	1,500	30
Aek Chai Rice	100	1,375	1,500	1,250	20
Choke Chai Panich	500	1,440	1,530	1,350	15
Banpong Rice Mill	200	1,487	1,575	1,400	20
Sang Jarus [B]	1,500	1,960	2,160	1,760	
Thong Poon Rice	100	1,500	1,600	1,400	20
Tawee Sri Rice Mill	200	1,400	1,400	1,400	25
NPS RICE	600	1,488	1,600	1,377	20
Rung Charoen Panich	200	1,525	1,600	1,450	25
Paisarn Rice Mill	100	1,425	1,500	1,350	30

Remark:

[A] Existing suppliers of John Biogreen

[B] 3^{rd} party logistics providers

[C] Capacity can be varied during the year due to seasonality of rice husk

[D] Estimated distance from John Biogreen (Not provided for 3PL since transportation cost is included)

[E] Exchange rate: 1 USD ≈ 35 THB

Exhibit 7: NK Energy Suppliers (Including 3PL)

Supplier	Average Monthly Capacity [B]	Price (in Thai Baht) [D]			Estimated Distance [C]
		Average	High	Low	
K Mill	200	1,575	1,750	1,400	20
PC Rice	300	1,550	1,800	1,300	30
RT Rice Mill	300	1,550	1,750	1,350	35
Kul Chai Rice Mill	100	1,600	1,800	1,400	25
Boonma Panich [A]	500	1,650	1,900	1,400	
Chun Phen Rice Mill	800	1,500	1,750	1,250	25
Kamon Rice Mill	1,100	1,425	1,650	1,200	30
Teera Rice	300	1,450	1,700	1,200	20
Boonchai Rice Mill	2,600	1,400	1,550	1,250	25
Veera Rice	600	1,550	1,800	1,300	30
Charoen Rice Mill	2,300	1,475	1,750	1,200	35
Yong Suwan Rice Mill	2,200	1,450	1,600	1,300	25
CK Rice Mill	600	1,450	1,650	1,250	40
Choke Panich	1,000	1,350	1,500	1,200	40
Tawee Choke Transport [A]	300	1,750	1,950	1,550	
Dumrong Rice Mill	1,300	1,450	1,700	1,200	35
Thanawong Rice Mill	3,800	1,350	1,500	1,200	40

Remark:

[A] 3rd party logistics provider

[B] Capacity can be varied during the year due to seasonality of rice husk

[C] Estimated distance from NK Energy (Not provided for 3PL since transportation cost is included)

[D] Exchange rate: 1 USD ≈ 35 THB

Exhibit 8: Additional Information

Truck

1. Estimated cost of truck	4 million Baht
2. Fuel consumption	8 kilometers per liter
3. Average diesel price	24 Baht per liter

Warehouse

1. Construction	15 million Baht per 10,000 tons of capacity

Remark: Exchange rate: 1 USD ≈ 35 THB

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