## MS-E2177 Seminar on Case Studies in Operations Research 2019

# Project plan

NESTE's feed stock purchase optimization

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# Background

The petroleum refining process is by far an old method to extract useful, and therefore valuable, products from crude oil. The importance of the oil refining industry measured in its size and strategic role increased exponentially since its use for lamps fuel (i.e. kerosene) production in the 19th century to these days. Some of the most important technical frontiers in the oil refining business stand on Supply Chain Management (SCM) as the services become more globalized, as well described by Jacoby [1]:

> "*The globalization of the industry is forcing suppliers to respond with global service and more robust international logistics capabilities … As suppliers globalize, the cost of shipping internationally is forcing them to reevaluate their supply chains, sometimes replacing their raw material sources and reconfiguring their intermediate processing activities and locations. While this presents opportunities for local suppliers, it can also threaten them.*"

Among the SCM capabilities in an oil refinery, one of the most important is the decision of the amount of raw material (crudes) to be procured to reach multiple objectives such as profit, oil specifications, possible liabilities and so on. Nevertheless, the feedstock procurement is not an activity that can be directly accounted for by cost management, as long as the costs depend on different features, such as quality. This is further explained by Ocic [2] in:

> "*…this is a process industry where a full slate of products, differing in quality and by use value, is obtained from a single feedstock on a single unit. Relating the basic feedstock costs to all products, and observing their individual quality as obtained on a particular processing unit, does not, in fact, present the real causality of costs for a single product. All the products cannot be evenly treated from the aspect of production motive. Namely, within a product slate we can recognize the products, on account of which the production process is organized, as well as by-products, which are inevitable, in a process. These products must not be treated in the same way from the aspect of charging the costs to their carriers.*"

Neste is a Finnish oil refinery and marketing company with a strong focus on renewable energy products. The company was founded in 1948 with the goal of securing Finland's refined fuel demand. Neste has a headquarter in Espoo, more than 5000 employees in over 14 countries, and its largest shareholder is Finnish government which owns over 40% of the company's shares. [3] In 2017, Neste had a 1,1B€ operating profit and a 13,2B€ revenue. From this revenue, oil products generated 8,5B€, marketing & services create 3,9B€, and renewable products 3,2B€ (there were also over 2,6B€ eliminations from the revenue). The company is the world's largest producer of renewable diesel. In 2017, Neste's renewable segment produced approximately the same operating profit as the larger oil products segment. [4]

Neste has two main oil refineries which are located in Porvoo and Naantali and, besides that, it has an additional joint venture for base oil production in Bahrain. The total oil refining capacity is over 15 million tons per year. Neste's renewable diesel production facilities are located in Porvoo, Singapore, and Rotterdam. Their total production capacity is 2,6 million tons per year. Marketing & services unit sells petroleum products and related services directly to end-customers. [4] Porvoo's refinery has four production lines and Naantali's refinery has one. The schematic summary of the company division is presented below.

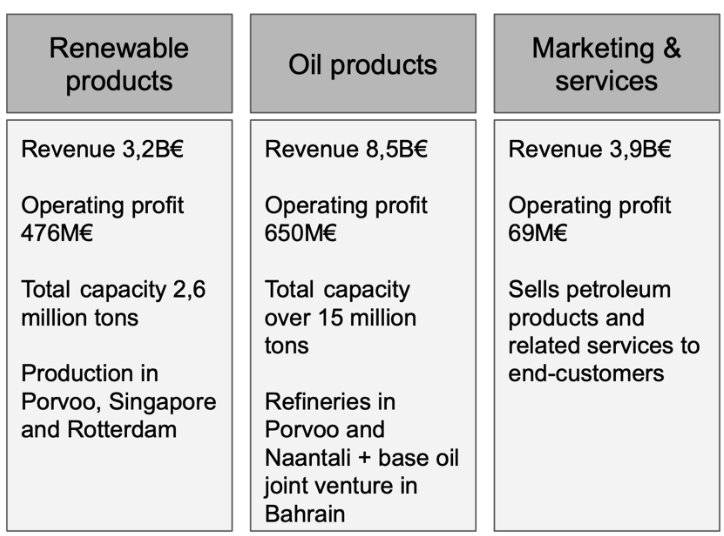


Figure 1, Neste's approximate division

The SCM department aims to maximize the total profit from these refineries by establishing the optimal products mix (i.e. feedstock supply). The optimization is done on a monthly basis based on a 15-month Sales and Operation Plan (SOP). The SOP is based on optimization models of the refineries and their production lines considering the refineries constraints, sales data, and price forecasts. The optimization models are implemented using an AVEVA's Spiral Suite software.

## Objectives

This project aims to further develop the optimization-based tool in order to identify the most profitable refinery feedstock mix for the suppliers. The analysis should consider all the economic aspects along with the changes in the refinery operation caused by the new procurement. Our project will deal with the crude procurement problem in a practical situation using optimization techniques to aid the decision making.

The schematic representation of the Neste's refinery operation system is presented below.

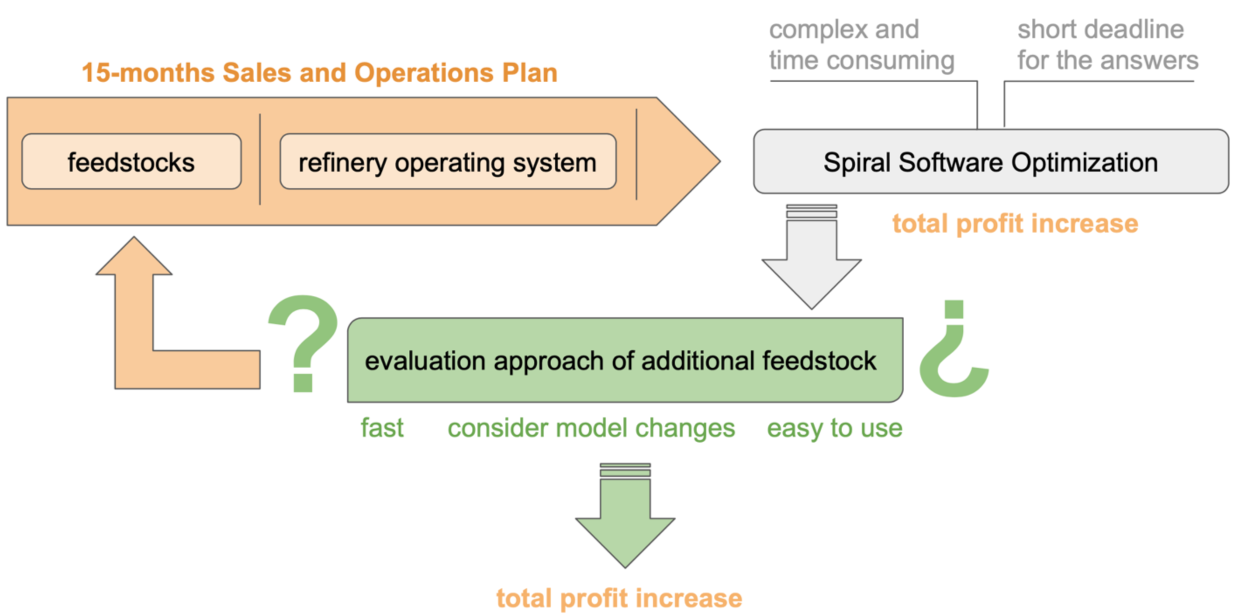


Figure 2. Schematic representation of Neste's refinery operation system

The refinery operation system inputs are usually crude oil and condensates connected by a complex network. The output flows of the purification stage feed the other process units, for instance, fractional distillation units, desulfurization, or cracking units. The maximization of the total profit through the increase of the unit's potential may be gained by the inclusion of the supplementary feedstocks into the system. Monthly, this economic optimization results in a new 15-month SOP. The model considers the possibility of the feedstock set expansion for any operating unit.

However, this target appears to be challenging due to the SOP complexity. Mathematical optimization models supporting the system demand considerable much in computation time while the answer is usually required with a short deadline. Hence, this project seeks to develop an evaluation approach of additional feedstocks in order to increase the total profit with no need of running the entire network optimization. The developed tool should take into consideration the existing constraints and account for possible changes in the base model without requiring complex tuning procedures and run quickly enough.

## Tasks

*1) Searching for useful articles/books and Selecting the material to be used*

An extensive paper search will be held using Scopus journal database and books related to oil refining SCM and to the optimization tools related to feedstock mix. After gathering the most relevant references after screening the literature, a brainstorming along with Neste's collaborators about what are the works to be used will take place.

*2) Learning the feeding processes*

The tool will use data from the simulation of prices and qualities of the feed stocks and the final products coming from the refining process. Therefore, a careful assessment of the software used (i.e. Spiral suite) and the network framing the problem poses as a milestone to the problem modelling.

*3) Mathematical modelling*

The optimization model formulation will count with post-optimality tools. Approaches such as sensitivity and stability analysis will be further studied as well as the usability of these methodologies into their software.

*4) Testing & Adjustments*

Along the Math modelling, toy problems will be proposed by Neste employee to validate results.

*5) Write the code & Debugging / Testing*

A routine will be developed along with the clients' needs, the language to be used is still under decision.

## Schedule

The initial schedule is presented in Appendix 1.

## Resources

The mathematical optimization models underlying the SOP for Porvoo and Naantali refineries are implemented using AVEVA Spiral Software Suite. The models themselves along with the input and output data are the company property that requires the necessity of using company encrypted laptop ensuring the data safety. Hence, all the computations are supposed to be performed on this laptop that restricts the range of possible computational software. In particular, in this task, the team is allowed to use Matlab, Python or R.

Nevertheless, the company policy does not impose many limitations in the methodology and existing approaches utilization. Thus, apart from computational part of the project implying application of Spiral Software, Excel and allowed programming languages, the theoretical substantiation of the experimental part requires a broad literature review.

## Risks

The most relevant risks associated with our project are listed in the table below

| Risk | Probability | Effect | Impact | Plan to mitigate risk |
|---|---|---|---|---|
| Team member inactivity or dropout | Low | Other team members need to cover or the person being absent works remotely | Low to medium | Clear schedules, project manager's authority, and informing possible absences well in advance |
| Too large workload | Medium | Not all objectives will be reached, the results will be inadequate, or work-hours increase drastically | Medium | Frequent communication with Neste and having a clear plan towards the most feasible direction. In case it seems unreachable the willingness to pivot |
| Inability to build a meaningful mathematical model | Low | Need to change the mathematical model used or get additional help from other researchers | Medium | Use pretested mathematical models and consult Neste about their feasibility |
| Inability to program the mathematical model | Low | Find a workaround either with another programming language or by adjusting the mathematical model | High | Use feasible mathematical models and programming languages well known for all team members |
| The final model does not satisfy customer needs | Medium | The final model will not be functional, however, the report and literature review might have produced useful results | Medium | Frequent communication with Neste and ensuring that the model developed is relevant and valuable for Neste |

Figure 3. The table of risks associated with the project

## References

[1] Jacoby, D. (2012). Optimal Supply Chain Management in Oil, Gas, and Power Generation. PennWell Corporation.

[2] Ocic, O. (2005). Oil Refineries in the 21st Century: Energy Efficient, Cost Effective, Environmentally Benign. WILEY-VCH Verlag GmbH & Co. KGaA.

[3] Neste (yritys). (2019). Retrieved from https://fi.wikipedia.org/wiki/Neste_(yritys)

[4] Neste. (2018). Neste Annual Report 2017. Neste. Retrieved from https://www.neste.com/sites/default/files/attachments/corporate/investors/agm/neste_agm_17_eng_netti.pdf

## Literature under revision

Leiras, A., Ribas, G., Hamacher, S., & Elkamel, A. (2011). Literature review of oil refineries planning under uncertainty. International Journal of Oil, Gas and Coal Technology, 4(2), 156-173.

Al-Shammari, A., & Ba-Shammakh, M. S. (2011). Uncertainty analysis for refinery production planning. Industrial & Engineering Chemistry Research, 50(11), 7065-7072.

Chen, R., Deng, T., Huang, S., & Qin, R. (2015). Optimal crude oil procurement under fluctuating price in an oil refinery. European Journal of Operational Research, 245(2), 438-445.

Shah, N. K., Li, Z., & Ierapetritou, M. G. (2010). Petroleum refining operations: key issues, advances, and opportunities. Industrial & Engineering Chemistry Research, 50(3), 1161-1170.

# Appendix 1

| Status | Macro Activity | Task / week | Jan | | | | Feb | | | | Mar | | | | Apr | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | **9** | 10 | 11 | 12 | 13 | **14** | 15 | 16 | 17 | 18 | **19** | 20 |
| done | Course Demands | Introductory Class | ■ | | | | | | | | | | | | | | | | | | | |
| | | Project Plan | | | | | | | | | ■ | | | | | | | | | | | |
| | | Interim report | | | | | | | | | | | | | | ■ | | | | | | |
| | | Final report | | | | | | | | | | | | | | | | | | | ■ | |
| in progress | Literature Review | Searching for useful articles/books | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | |
| in progress | | Selecting the material to be used | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| delayed | Modelling the problem to be optimized | Learning the feeding processes | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| in progress | | Mathematical modelling | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | |
| | | Testing | | | | | | | | | | | ■ | ■ | | | | | | | | |
| | | Adjustments | | | | | | | | | | | | ■ | ■ | | | | | | | |
| in progress | Programming | Write the code | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| | | Debugging / Testing | | | | | | | | | | | | | | | | ■ | ■ | | | |
| | | Build users interface | | | | | | | | | | | | | | | | | ■ | | | |
| | Prepare the deliverables | Finish an ad-hoc tool (*optional*) | | | | | | | | | | | | | | | | | ■ | ■ | | |
| | | Build an analysis file (*optional*) | | | | | | | | | | | | | | | | | ■ | ■ | | |
| | | Write the final report | | | | | | | | | | | | | | | | | ■ | ■ | | |

| | |
|---|---|
| green | done |
| yellow | in progress |
| red | delayed |

Figure 4. Project's schedule