Summary

Due to the growth of the Indian economy the local demand for energy is rising. Therefore the demand for coal is also increasing. Due to unreliable supply of coal on the clogged Indian railway tracks the Indian energy supply is unreliable. To create a trustworthy supply chain from abroad to the power plants in the inland of India, the Indian government has started with a pilot project on the Hugli River. This pilot project explores the possibilities to transport 3,000,000 ton of coal annually over the inland waterways of India. From the Bay of Bengal in the south to a power plant in Farakka, 600 km northwards. Because the Indian government and the Indian commercial parties have no experience with inland waterway transport, the Dutch government provides assistance. On behalf of the Dutch government, Royal Haskoning and Marin advise the Indian parties on the logistics chain, environmental aspects and financial impact.
The logistics chain of coal supply starts at the arrival of a deep-sea vessel at the Bay of Bengal in Eastern India. Due to draft restrictions, large (Panamax size) deep-sea vessels cannot approach the inlet of the Hugli River and have to be unloaded on open sea, 70 km southward. Small, Handymax size, vessels can sail further upstream to the entrance of the river and can be unloaded in calm waters.
Panamax vessels supply cheaper coal due to the economy of scale; however Handymax vessels reduce the number of transshipments and quantity of inland equipment. Also the allowed berthing time differs for both vessel types. In this report it is assumed that, due to higher operational costs, a Panamax vessel shall be unloaded within 48 hours, whereas a Handymax vessel shall be unloaded in three days.
Both modalities have a typical and significant impact on the logistics chain to transport the coal into the hinterland. The deep-sea vessels must be unloaded with floating equipment due to absence of suited harbours in the region. The coal must be transshipped into smaller vessels to be transported upstream on the river. The Hugli River becomes narrower and shallower further upstream and eventually is substituted for the Bhagirathi River with an allowable vessel draft of only 2.3 meter.

The combination of two methods of coal supply and the varying local conditions result in many possible combinations of equipment to transport the coal between the deep-sea vessels and the power plant.
The Indian governments required that the inland waterway transport shall be cheaper than transport by rail; hence the total handling cost of the inland waterway transport must be at most: €7 per ton coal.
The purpose of this assignment is to determine the configuration that can achieve the stated requirements; therefore the problem statement is:

Determine the best performing configuration of equipment and terminals
that fulfils the stated requirements to import coal over inland waterways in Eastern India.

There are several variations for handling coal with floating equipment. The best option in this case in the floating terminal. The storage on a floating terminals facilitates the decoupling of the logistics chains between the supplying deep-sea vessels and the hinterland connection. This creates reduction of the inland vessel fleet and higher efficiency of the inland vessels. On the floating terminals a number of bulk handling cranes will be installed to unload the coal from the deep-sea vessels. A combination of hopper, belt conveyors and ship loaders will load the waiting inland vessels.
Numerous vessel types have been studied. Some of the types are very suited for parts of the local environment. Furthermore, calculations have shown that for transport on open sea the large estuarine vessels with a capacity of

9,280 ton (135m, 4.4m draft) are the cheapest per kilometre. For transport on inland rivers with shallow waters of 2.3m the Class IV vessel (1580 ton, 86m) is best suited, due to low operational cost and high availability in the region. For a solution with a single vessel for both open sea and shallow waters a small estuarine vessel (3,030 ton) appears to be optimal.

Based on efficiency, flexibility and controllability, seven comprehensive configurations are selected. These configurations are used to find the best combination of equipment that fulfils the requirements. After static calculations two configurations prove to be very promising. The first, configuration #6, uses Panamax as supplier and large estuarine vessels until the river becomes too shallow. At that moment the coal is transshipped with a floating terminal into Class IV barges. From here the coal is transported to Farakka. This configuration exploits the economy of scale and uses one extra inland floating terminal.

The second, configuration #7, also used Panamax vessels as supplying modality and transships the coal with a floating terminal into small estuarine vessels. These vessels sail without further transshipment to Farakka. This configuration exploits the controllability of a simple chain without intermediate transshipment.

These two configurations are further researched with a simulation model to gain insight in the variation of the output when stochastic variables are introduced in the model. Parameters are varied to create a broad spectrum of runs. The simulation runs have to fulfil the following requirements:

- Productivity: the run must be able to handle the coal for less than €7 per ton
- Effectivity: the run must be able to unload 75% of the deep-sea vessels within 48h and 99% within 96h.
- Efficiency: the occupancy of the cranes and barges must be at least 80%.
- Control: the terminal storage shall be completely filled at most once every month. If this happens more often the storage is too small and control of the logistics chain is insufficient.

Based on 135 runs with the simulation model, the best performing configuration appears to be configuration #6 with the following equipment: a floating terminal at open sea with 100,000 ton storage and three offshore cranes, 3 large estuarine vessels, an inland floating terminal with 20,000 ton storage and one crane, 14 Class IV vessels and a terminal at Farakka with one fixed crane.

All requirements are satisfied in the simulation of this configuration: the handling costs are €5.95 per ton, 75% of the deep-sea vessels are served within 46 hours and 99% within 86 hours. The crane occupancy is on average 80.5% and occupancy of the barges is above 84%. The terminal has been fully loaded 35 times (when 60 times was allowed).

It is concluded that the requirements of the Indian government can be fulfilled and a suitable configuration to transport the coal from open sea to Farakka has been identified.

To gain more insight in the performance of the chosen configuration, extra simulations were done. It has been simulated that only one large estuarine vessel extra is required when the deep-sea vessels must be unloaded at another location during the monsoon season.

It has furthermore been simulated that to adjust to growing demand in the future the configuration can be ramped up with minor adjustments. This increases the annual throughput to 5,000,000 ton per year. The handling cost decrease to €5.09 due to more efficient use of the existing equipment. A 10,000,000 ton throughput can be achieved by doubling the complete logistics chain.

It is concluded that the pilot project of the Indian government can be implemented successfully and will be more cost efficient than the existing railway solution. And more importantly, the supply of coal will be reliable throughout the whole year, at the current demand and when facing the growing demands of the future.