370.043 VU Selected Topic in Energy Economics and Environment

Assignment 1

Marcus Dahlström (12402525) | Ali Türen ()

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> *a) Draw the supply curve for natural gas imports in Germany (axis labeling!) and determine the most expensive import route.*

Solution: The given data from the assignment is seen in the table below.

Table 1. Market shares and prices as given in the assignment.

Import Route	Share [%]	Price [EUR/MWh]	Total MWh	Total Cost [Million EUR]
Nord Stream	10	7	10^8	700
Poland/Belarus	10	9	10^8	900
Austria/Czech/Slovakia/Ukraine	10	10	10^8^	1000
Nord Sea	30	8	3*10^8	2400
The Netherlands/UK	25	12	2.5*10^8	3000
Belgium	10	13	10^8	1300
Denmark	5	15	0.5*10^8	750

Using the given data the following supply curve can be drawn. The most expensive import route, in total EUR, is the one from The Netherlands/UK. The most expensive import route in EUR/MWh is the one from Denmark.

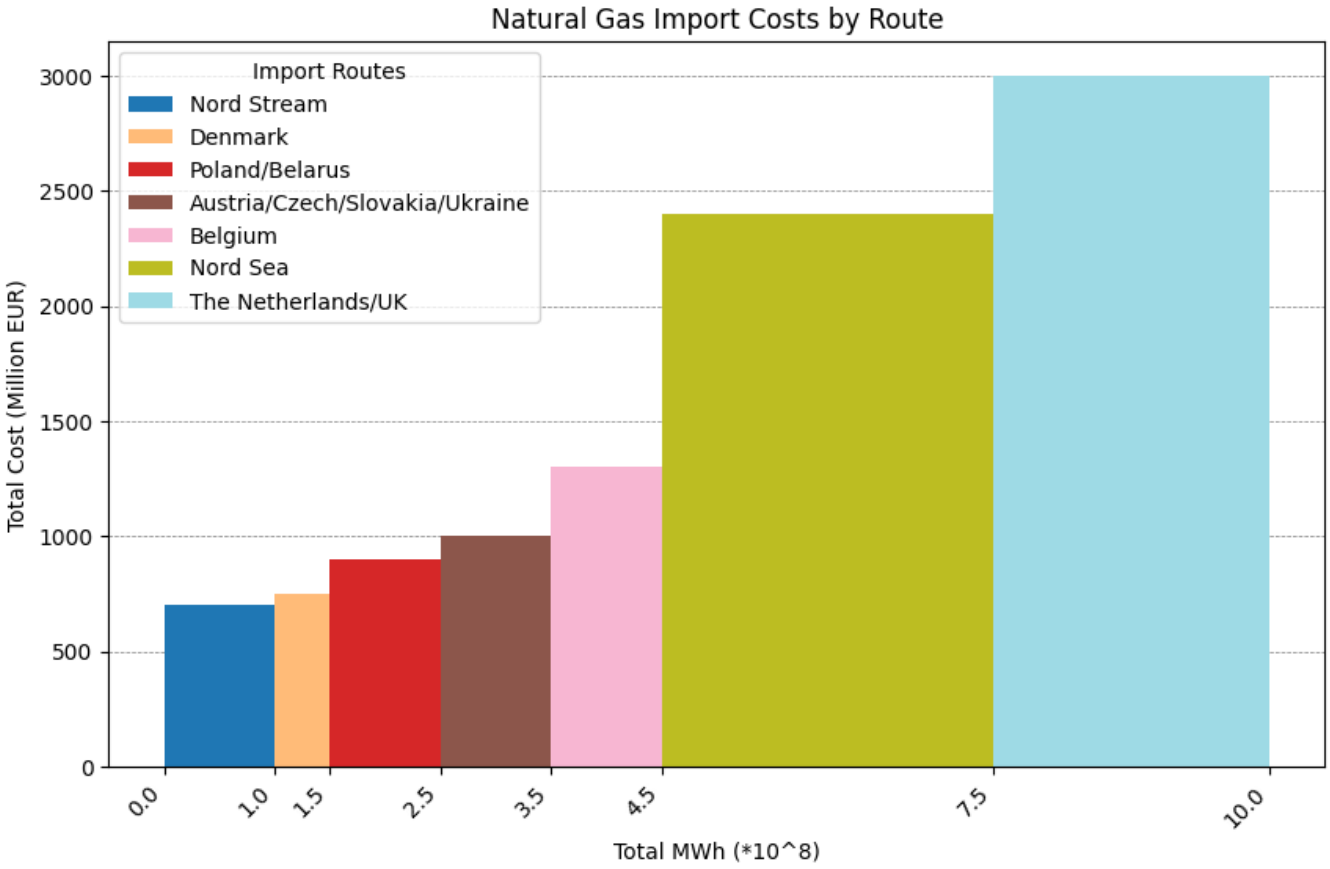

Figure 1. Supply curve for the data in Table 1.

> *b) Based on the above, calculate the so-called IRD factor (Import Route Diversification) for Germany. The IRD factor is defined as follows:*

$$IRD = \sum_{l} \left(IP_{X,\, border,\, l}\right)^2 + \sum_{m} \left(LNG_{terminal,\, m}\right)^2 \tag{1}$$

Solution: As it's not specified if a route is a pipeline or a LNG terminal, it is assumed that all routes are pipelines. Using the data from the table above, the IRD factor can be calculated as follows:

$$IRD = \left(0.1^2 + 0.1^2 + 0.1^2 + 0.3^2 + 0.25^2 + 0.1^2 + 0.05^2\right) = 0.195 \tag{2}$$

As an IRD of 1 means a monopoly, and 0 means infinitely many suppliers, the IRD factor of 0.195 indicates a relatively low level of market concentration.

> *c) It has already been assumed in previous years (i.e. before February 2022) that due to political tensions with both Ukraine and Belarus, there may be supply interruptions at any time and the 2 corresponding gas import routes to Germany are no longer fully available (i.e. it is assumed that the 3rd route (Baltic Sea pipelines) is still fully available). If it is now assumed that a corresponding loss of imports of "Russian gas" via these 2 routes to 80 % is*

> *compensated by newly built LNG terminals on the coast of northern Germany and to 20 % by import capacity expansions from the North Sea (Norwegian waters): What is the new IRD factor for Germany according to this new situation?*

Solution: The two routes that are no longer fully available are Poland/Belarus and Austria/Czech/Slovakia/Ukraine. The losses are covered by $0.2 * 0.8 = 0.16$ from new LNG terminals and $0.2 * 0.2 = 0.04$ from increased imports from Nord Sea. The new IRD factor is calculated as follows:

$$IRD = \left(0.1^2 + (0.3 + 0.04)^2 + 0.25^2 + 0.1^2 + 0.05^2\right) + \left(0.16^2\right) = 0.2262 \quad (3)$$

The increase in IRD is expected, as the diversification of import routes decreased when two routes were lost and replaced by one new route and the expansion of an existing.

> *d) Draw the new supply curve for natural gas imports in Germany assumed under point c) (axis labeling!), if it is assumed that the newly added LNG quantities have 3 times the price level as the most expensive import route to date under point a. The volume expansions from the North Sea will be offered 10% below the price level of the newly added LNG volumes.*

Solution: Using the most expensive import route in terms of *total EUR cost* from task a), which was The Netherlands/UK router, the new LNG terminals will have a price of $3 * 12 = 36$ EUR/MWh. The price of the volume expansions from the Nord Sea will be $0.9 * 36 = 32.4$ EUR/MWh. The updated price table and supply curve can be seen below.

Table 2. Market shares and prices after two closed routes, new LNG terminals, and expanded Nord Sea import.

Import Route	Share [%]	Price [EUR/MWh]	Total MWh	Total Cost [Million EUR]
Nord Stream	10	7	10^8	700
Nord Sea	30	8	3*10^8	2400
The Netherlands/UK	25	12	2.5*10^8	3000
Belgium	10	13	10^8	1300
Denmark	5	15	0.5*10^8	750
New LNG terminals	16	36	1.6*10^8	5760
Nord Sea exp.	4	32.4	0.4*10^8	1296

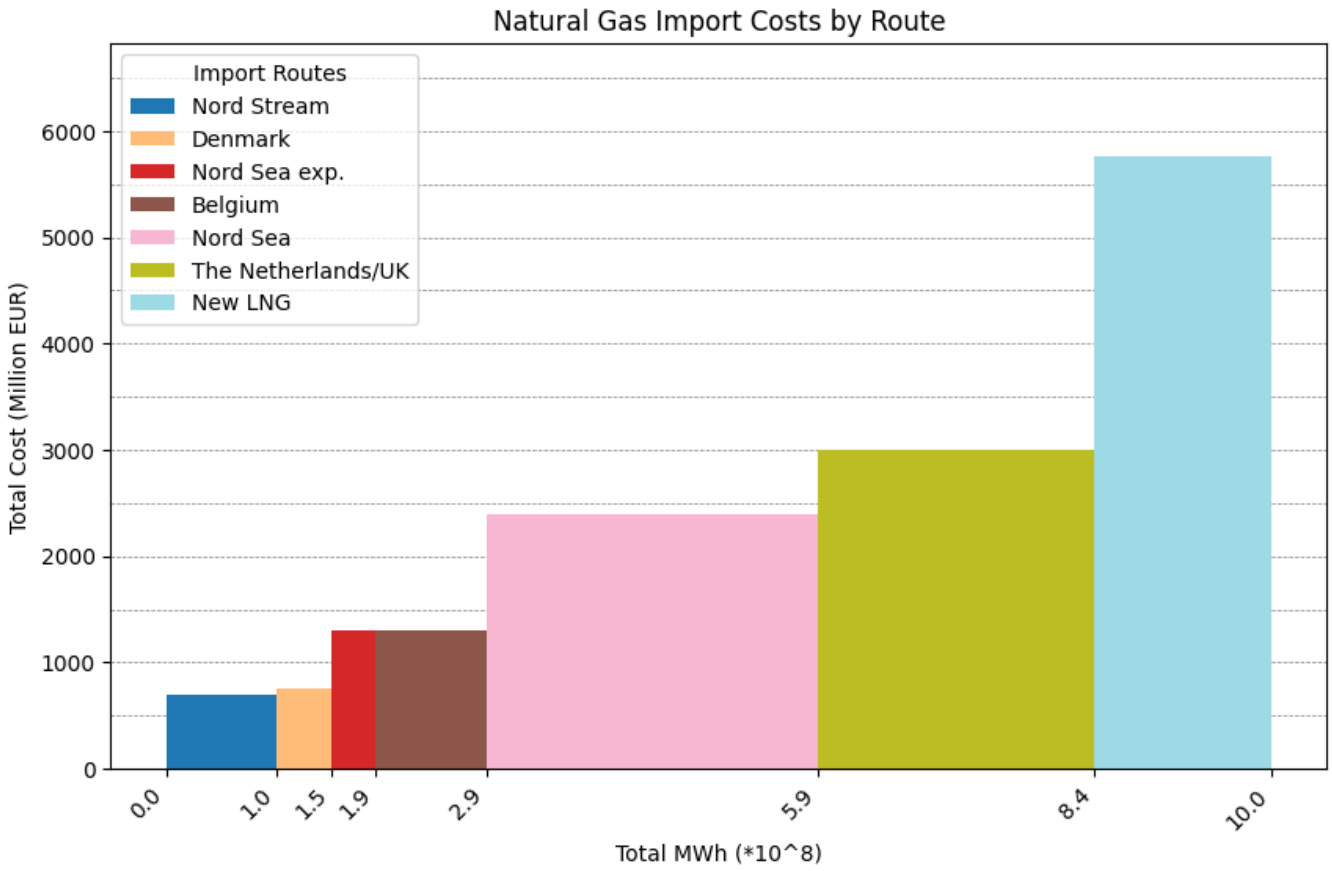

Figure 2. Supply curve with the updated data from Table 2.

> *e) If, on the basis of the situation under Point d) with regard to LNG (for piped North Sea gas (Norwegian waters) use the parameters under Point a): 30% and 8 EUR/MWh)), the following is assumed: Now the German gas market will be "flooded" in the long term up to the fully available LNG capacity of 60 billion m3 at a price of 10 EUR/MWh. Which import routes will be kicked out from the gas supply as a result? Which import route is now the most expensive one? Please draw this new gas import supply curve for Germany below?*

Solution: The residual demand after including the full LNG capacity is $100 - 60 = 40$ billion m3 (or 400 billion kWh = 4*10^8 MWh). From task d) the routes from Poland/Belarus and Austria/Czech/Slovakia/Ukraine were lost. It is assumed based on the instructions to refer to the Nord Sea parameters from task a), that the expanded route from Nord Sea as well as the new LNG terminals are not to be inluded in this task. This means that the available total supply can be seen in the following table.

Table 3. Import shares and prices after market flooding.

Import Route	Share [%]	Price [EUR/MWh]	Total MWh	Total Cost [Million EUR]
Nord Stream	10	7	10^8	700
Belgium	10	13	10^8	1300

Import Route	Share [%]	Price [EUR/MWh]	Total MWh	Total Cost [Million EUR]
Denmark	5	15	0.5*10^8	750
Nord Sea	30	8	3*10^8	2400
The Netherlands/UK	25	12	2.5*10^8	3000
Stored LNG	60	10	6*10^8	6000

Here it can be seen that the total required supply can be met with the Nord Stream, Nord Sea, and stored LNG. This means that the routes from Belgium, Denmark, and The Netherlands/UK won't be needed, which is well as they are the most expensive ones in terms of EUR/MWh. The new supply curve can be seen below.

The new IRD factor can be calculated as follows:

$$IRD = \left(0.1^2 + 0.3^2 + 0.6^2\right) = 0.46 \tag{4}$$

Where it can be seen that the IRD factor has more than doubled compare to before. This is due to the fact that the diversification of import routes has decreased significantly, as there are only three routes left.

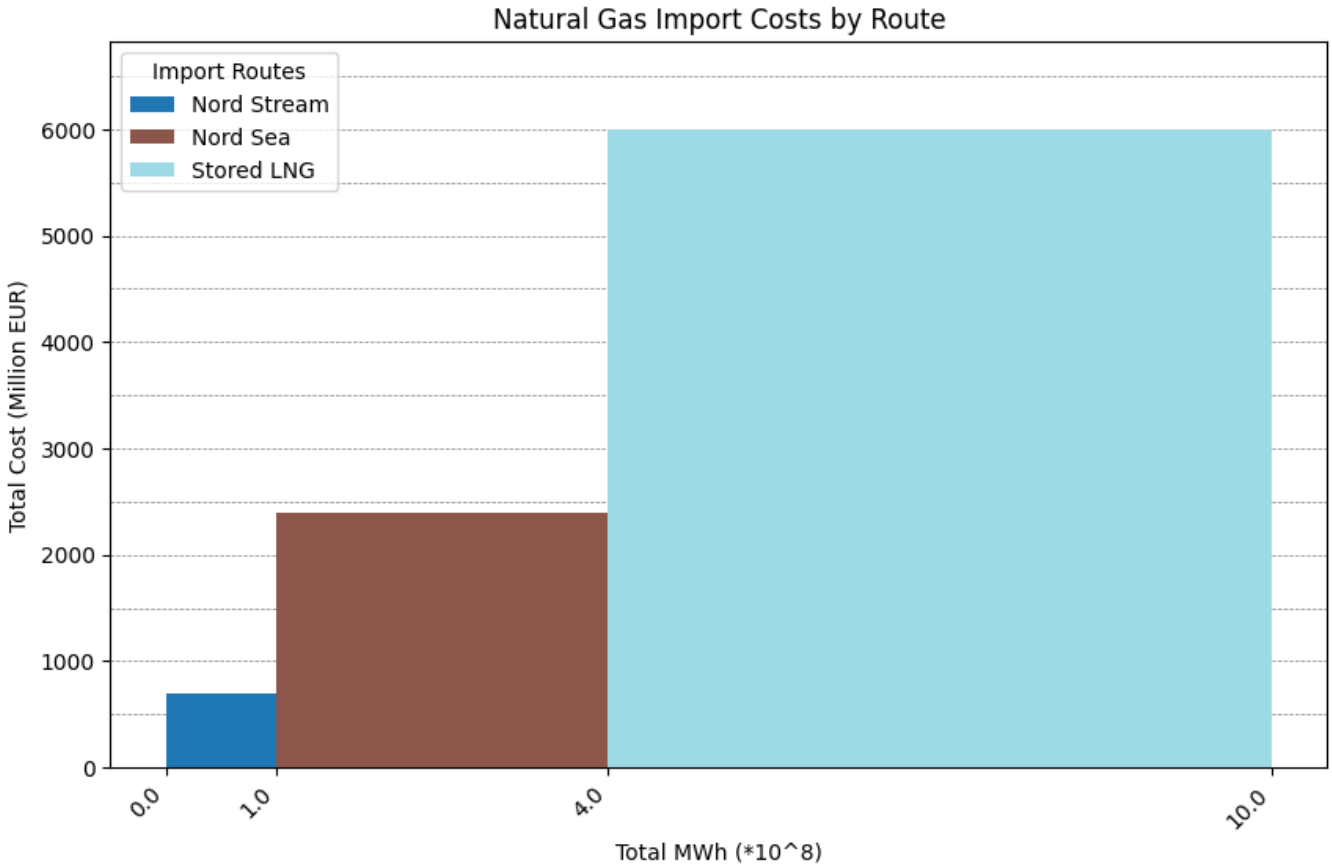

Figure 3. Supply curve after kicking out two routes after flooding.