FORECAST OF ECONOMIC EFFECTS OF A GOOGLE DATA CENTRE IN DENMARK

Client: Google

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EXECUTIVE SUMMARY

Google is establishing a large-scale data centre in Fredericia (Denmark). Google already operates four data centres in Europe in St. Ghislain (Belgium), Hamina (Finland), Dublin (Ireland), and Eemshaven (the Netherlands). Large-scale data centres, such as Google's, represent very large investments, proven to have positive effects on the country and local economy. Google has announced to invest in Denmark DKK 4.5 billion (EUR 600 million).

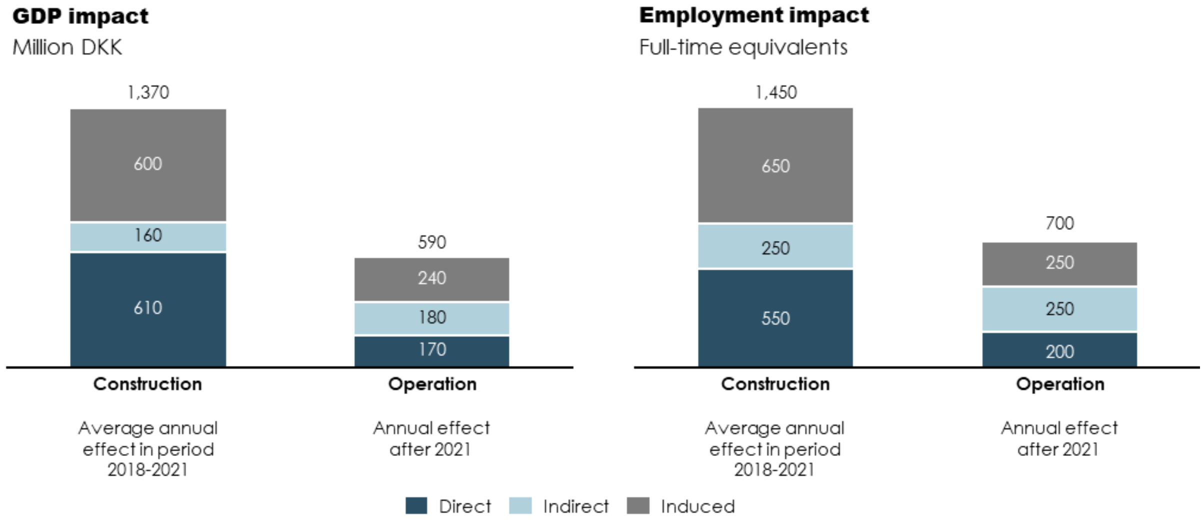
This note forecasts the economic effects of the Google data centre in Denmark. Our forecast is based on Google's planned investment for this data centre and past experiences from Google's other data centres in Europe (see more details in the Fact box in appendix).

We find that:

- The investment will contribute to the Danish gross domestic product and create jobs both in the construction and operation phase.
- Construction is forecasted to support GDP of DKK 1.4 billion per year (EUR 190 million) and will support 1,450 jobs per year (direct, indirect and induced) over the 2018-2021 period.
- Operation is forecasted to support GDP of DKK 590 million per year (EUR 80 million) and will support 700 jobs per year (direct, indirect and induced) from 2021 and onwards.
- Multiple channels of *spillover effects* in the value chain in the data centre industry are expected, e.g. knowledge gains amongst suppliers, local training activities and the international signalling of a good investment attractiveness for Fredericia and Denmark.
- In addition, Google is investing in better fibre networks, the so-called *Havfrue* subsea cable, which will improve Denmark's internet connectivity to North America.
- Data centres are not only good for jobs and growth. Large-scale data centres are also energy efficient and use less energy to deliver a given level of computing power compared to dispersed computing.
- Finally, the data centre will use green energy as Google matches its worldwide electricity use with 100% procurement of renewable energy via PPAs.

We forecast until year 2024. Our forecast of economic effects in Denmark relates to the investment announced so far for Denmark; however, if the data centre is expanded in the future, further economic benefits would follow – as we have seen at Google's other data centres in Europe.

Figure 1 Expected supported gross domestic product and jobs per year from the Google Fredericia data centre



Note: operation employment impact depends on speed of ramping up of the data centre. In the figure we report the bottom of the forecast range of 300-350 direct jobs associated with the currently planned facility at full operation.
Source: Copenhagen Economics based on Danmark Statistik, Google and Copenhagen Economics (2018) study.

BACKGROUND – How did we calculate the expected contribution to GDP and job creation?

We calculate the economic contribution of a data centre in terms of contribution to GDP and job creation via three separate effects: 1) the *direct* effect, 2) the *indirect* effect and 3) the *induced* effect.

The *direct* effect includes the economic impact supported directly by the data centre key construction contractors. It also comprises the directly supported jobs in operations, including positions in management, mechanical and electrical maintenance and repair, IT and systems technicians.

The *indirect* effect reflects how the data centre expenditure on domestic goods and services supports increased industrial and commercial activity up the value chain. Thus, demand from the data centre supports indirect GDP and jobs, including in wholesale trading, engineering, architecture, logistics (for construction) and security, catering, and cleaning (for operations).

The *induced* effect includes the supported economic impact when salaries paid to employees at the data centre and its suppliers are spent throughout the economy. Induced jobs are primarily service-related, in for example retail trade, transport, accommodation, restaurants, housing and finance.

These three elements of Google's economic impact have been calculated using a well-established economic input/output model, calibrated based on the latest available sectoral accounts from Danmarks Statistik.[1]

Figure 1 provides a breakdown by type of economic effect on a per-year basis.

[1] Danmarks Statistik, table NIO1F.

Contribution from construction activity

Data centres are digital infrastructure assets. It is thus unsurprising that – alike investments in roads, bridges and railway tracks – the construction phase is the most intense period of economic activity.

We forecast Google's construction investment to support economic activity in Denmark (direct, indirect, induced) of **DKK 1.4 billion per year** (EUR 190 million) in GDP terms – for **a total of DKK 5.5 billion** (EUR 740 million) over the four years considered.

The construction investment is forecast to support **1,450 jobs per year** on average (full-time equivalents), including direct, indirect and induced jobs throughout the economy (thus not just at the data centre site but also beyond).

Contribution from operation activity.

Once the data centre is built and running at full speed, we forecast that the ongoing operations will support economic activity in Denmark (direct, indirect, induced) of **DKK 590 million per year** (EUR 80 million) in GDP terms – for a **total of DKK 2.4 billion** (EUR 320 million) over the five years considered.

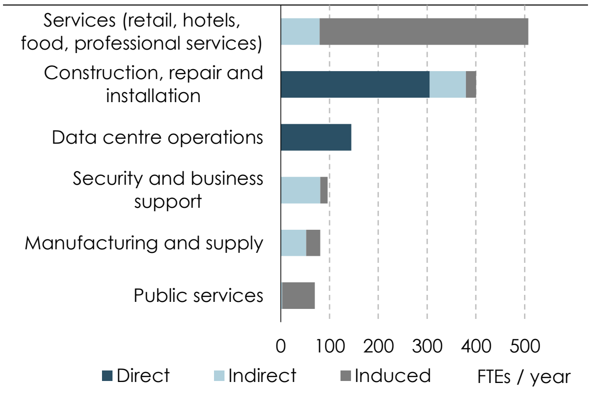
As to direct jobs, once the data centre is operational, between 150-250 people are expected to be employed at the Fredericia site in a range of roles, including computer technicians, electrical and mechanical engineers, catering and security staff.

Considering direct, indirect and induced jobs throughout the economy (thus not just at the data centre site but also beyond), the data centre operation is forecasted to support **700 jobs per year**, on average (full-time equivalents).

After a ramp-up phase (as operations usually scale up during the construction phase of a data centre), employment in operations may increase further. However, to be conservative in our estimates, we have not accounted for this in our forecast.

Based on the results from the detailed input-output model (calibrated on the features of the Danish economy), we have analysed how the forecasted jobs supported by the data centre investment (over 2018-2024) would spread out throughout other sectors of the economy. While direct jobs are predicted in construction and operation of the data centre, many indirect jobs are predicted in security and business support sectors during the operations phase. Induced jobs are estimated to span a broad range of private service sectors of which retail is the main component (see Figure 2).

Figure 2 Type of employment supported by Google's data centre: 2018-2024 prediction



Note: The period covers construction jobs in the period 2018-2021 and operation jobs from 2020-2024.
Source: Copenhagen Economics based on Danmarks Statistik, Google and the Copenhagen Economics (2018) study.

Experience from Google's other European data centres shows that as demand for data keeps growing, data centres get expanded. In 2018, Google announced data centres expansions via further investments of DKK 1.9 billion (EUR 250 million) in Belgium, DKK 780 million (EUR 105 million) in Ireland and DKK 3.7 billion (EUR 500 million) in the Netherlands. Such extra investments drive further economic benefits and support more jobs.

Spill-over effects in the data centre industry

Data centres provide benefits beyond those reported above because they bring international knowhow and skills which gradually create spill-over (ripple) effects for the local communities and industries.

In a recent report reviewing Google's four European data centres we find confirmation of the following effects:[2]

- Data centres create jobs in remote areas, including IT technicians, electrical and mechanical engineers, catering, facilities and security staff. A large-scale investment can yield a sizable increase in demand for local labour to construct and operate the data centre, which would benefit local communities.
- Large multinational companies' hold technical, operational and managerial knowhow that can improve the productivity of local suppliers through knowledge spill-overs and market-size effects.
- Google supports the local data centre community, for instance, through grants. An example of this is the support to communities via teaching collaborations in local colleges, building the local skills base.
- The signalling of a large, well-known company investing in a region can influence others to invest there too, by confirming the presence of skills, suppliers and resources that other investors are also looking for.

For instance, we have interviewed regional development companies in Finland and the Netherlands who confirm that Google's presence in their region is helping them attract further investments in the regions.

Further, interviews with Google's suppliers highlight how the interaction with Google has helped them gain new skills and learn to work with international product and service standards.

Moreover, Google is actively involved in education programs in Belgium (HELHa), Finland (Ekami), Ireland (IT Sligo) and the Netherlands (Hanzehogeschool), which Google supports with data centre training and grants donations.

Thus, it is key to monitor over the next few years how the Danish data centre industry (supply chain) and local markets and policies can best tap into the above channels of spill-over effects.

Enhanced internet connectivity and attractiveness for data centres' investments in Denmark

Google's activities in Europe related to data centres has led to significant investments in internet fibre cables. Data centres host files to serve millions of user requests from all over the Europe and the world. To reach users, a high capacity network is needed.

Therefore, Google is also investing in improving the core networks between European countries and across the Atlantic via intercontinental subsea cables. This will improve connectivity for all internet users, first and foremost Danish citizens.

Google and its consortium partners are building a direct subsea cable system called *Havfrue* (Danish for mermaid) connecting the United States with Denmark and Ireland (see Figure 3), expected to be completed by end of 2019.[3]

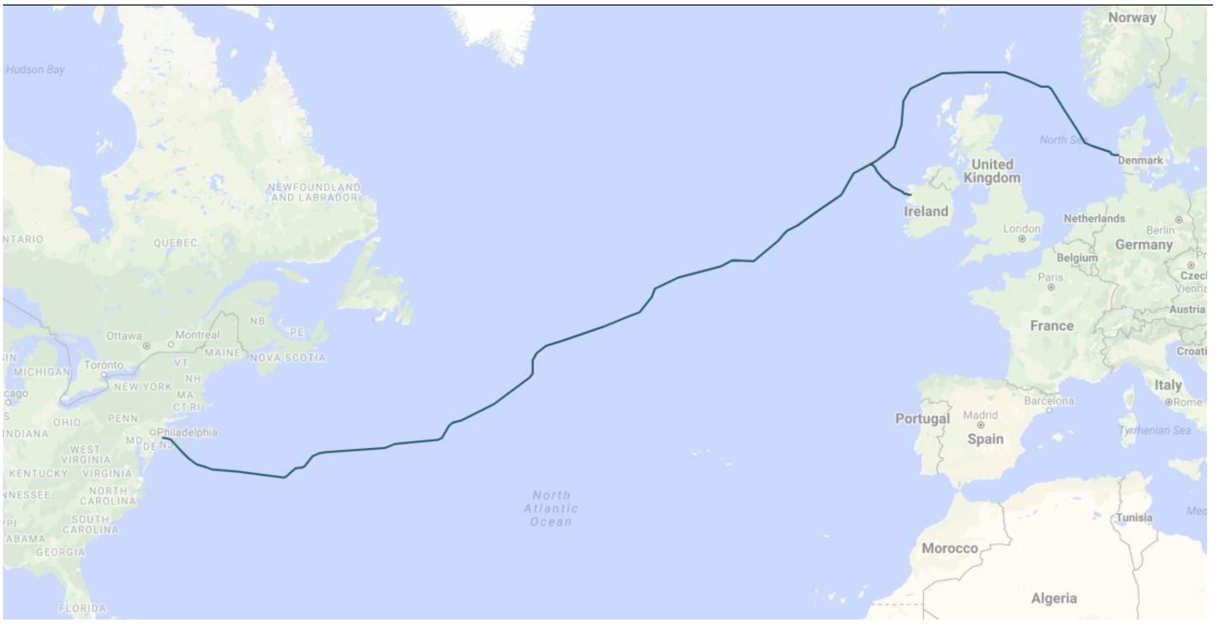
This high capacity cable will improve the internet connectivity between Denmark (and the rest of Europe) with North America.

Such major infrastructure projects can lead to **increasing Denmark's attractiveness for future data centres and tech firms,** creating a virtuous investment circle.

[2] See Copenhagen Economics (2018) *European data centres - How Google's digital infrastructure investment is supporting sustainable growth in Europe.*

[3] Consortium partners include Aqua Comms, Bulk Infrastructure, Facebook and Google. https://www.siliconrepublic.com/comms/havfrue-subsea-cable-google-aquacomms; https://www.blog.google/products/google-cloud/expanding-our-global-infrastructure-new-regions-and-subsea-cables/

Figure 3 The Havfrue route interconnecting Denmark with the US via Ireland



Source: Google. The overall length of the route reaches over 7,000 km.

Data-centre, cloud-based computing is more energy efficient

The digitalisation of our economies implies a greater use of data storage and computer processing power. Each of us as consumer or as part of a business is choosing to move more and more activities to digital services. Because of new ways of living and doing business, use of data is exploding; for instance, cross-border data flows have grown by 45 times since 2005.[4]

Storing and processing this data requires energy. This is a derived demand from the end users' choice to go more and more digital. This energy consumption replaces the energy previously used for alternative ways of obtaining services (e.g. paper-based processes, driving to several stores etc.).

Compared to traditional in-house servers (e.g. office basements) large data centres such as Google's is much more energy efficient for the same computing power, when data is accessed and processed via cloud computing. Data centres can maximise server utilisation, and use virtualisation and scalable computing, thereby reducing the total computing power needed.

An example of energy efficiency gains via cloud computing is e-mail, for which an in-house e-mail server uses up to 175 kWh annually per user, compared to only 3.3 kWh in an average European data centre and 2.2 kWh in a Google data centre.[5]

Only 52% of Danish employees using e-mails have company solutions based on cloud e-mail (Eurostat 2017 data). Thus, there is an energy efficiency gain available to be reaped if all Danish companies were to adopt cloud-based e-mail storage in data centres with state-of-the-art energy efficiency (such as Google's). We estimate that, if the remaining amount of current e-mail activity in Denmark were to be moved to cloud solutions overnight, we would need 70 GWh less to ensure the

[4] McKinsey Global Institute (2016) Digital Globalization: the New Era of Global Flows, p.4.

[5] Google (2011) *Google's Green Computing: Efficiency at Scale*.

same yearly level of e-mail activity.[6] This is roughly equivalent to the yearly electricity use in 17,000 homes.

Purchasing 100% renewable energy to match consumption for global operations

Since 2010, Google has signed long-term contracts that have enabled almost DKK 22.4 billion (EUR 3 billion) investments in renewable energy projects across the globe, of which nearly DKK 7.5 billion (EUR 1 billion) is in Europe.[7] At the time of writing, Google has signed 14 so-called power purchase agreements (PPA) in Europe, by which Google has made a long-term commitment to purchase electricity production from nearly 900 MW of wind and solar energy capacity. Worldwide, Google has committed to more than 20 PPAs, representing over 3 GW of renewable energy capacity; Google is currently the world's largest corporate buyer of renewable energy.[8]

Long-term commitments such as Google's can help Europe reach its renewable energy targets for 2020 and 2030 as they ensure stability and reduce risk for developers and financing parties. Corporate PPAs such as those signed by Google enable greater investment in renewable energy and have the added benefit of reducing the renewable energy project developers' reliance on public subsidy schemes

Thus in 2017, across the globe, for every kilowatt hour of electricity Google consumed, Google purchased a kilowatt hour of renewable energy from a wind or solar farm that was built specifically for Google.[9] The company holds a commitment to purchase enough renewable energy to cover the electricity consumed at its data centres and operations which will extend to its new facility in Fredericia.

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[6] Own calculation based on data from Eurostat (sbs_sc_sca_r2, isoc_cicce_use, isoc_ci_cm_pn2 and isoc_ci_in_en2).

[7] Interview with Marc Oman, EU Energy Lead, Global Infrastructure at Google on 5 December 2017.

[8] See Bloomberg https://www.bloomberg.com/news/articles/2017-11-30/google-biggest-corporate-buyer-of-clean-power-is-buying-more and ZME Science, https://www.zmescience.com/ecology/renewable-energy-ecology/google-renewable-energy-04122017/.

[9] See Google (2018) *Meeting our match: Buying 100 percent renewable energy* (blog post), Google (2016) *Environmental Report* and Google (2017) *Environmental Report – 2017 progress update*.

Fact box: Our methodology for calculating the economic impact forecast

Upon assessing the forecast, we divide the economic effect into three separate effects: the *direct* effect, the *indirect* effect and the *induced* effect. We estimate their magnitude in two steps.

First, the direct effects are calculated as the sum of estimated wage expenditures at the data centre and the estimated number of employees working there. For an ex-post analysis of the impact of an existing data centre, this would be the data on realised expenditures. In our forecasting exercise, we have estimated them for the Danish data centre based on the average across the Google's four built European data centres (as previously reported to us by Google). The planned construction investment of DKK 4.5 billion (EUR 600 million) is as published by Google. We assume that this investment is to be distributed across the years 2018-2021, based on an expenditure time-profile and an operations' start matching the latest built Google European data centre (Eemshaven); on this basis, operations are assumed to start in 2020. The (i) relative size of operational activity compared to construction activity and (ii) the ratio of direct jobs to expenditure are assumed to match prior evidence from Google's four built European data centres. Additionally, since labour conditions in Denmark may be different from the other four EU countries in which Google data centres are located, we have cross-checked these ratios to fit with information from Danmarks Statistik on the Danish construction industry and official forecasts for the Fehmarn Belt fixed link construction project.

Second, we estimate the indirect and induced effects using an input-output model. This is a standard class of models that is compatible with the national statistics and provides a consistent and intuitive way of measuring the economic effects of an activity in any given industry or company. The model uses input-output tables, which reflect how national statistical agencies track the interdependency between all the sectors of the economy. We use Denmark Statistics' input-output tables from 2016 with 69 industrial sectors. This table shows how each of 69 industrial sectors: i) relies on the other 68 sectors for inputs to their production; and ii) supplies its products and services to each of the remaining 68 sectors. We use the input-output tables to estimate economic multiplier, which are multiplied with the appropriate expenditures to give the economic effects.

Because of the underlying features of this class of models, the results calculated by this method have known limitations. Some of the assumptions are most likely to hold in the short run, and others are more appropriate for the long run. The results should thus be interpreted in the light of the following remarks:

- We do not observe data on gross surplus (which under national counting rules is counted as part of GDP). In order to provide a conservative estimate, we do not include gross surplus in the operations when calculating the GDP contribution; including this would produce larger impacts.
- We assume that the technology and resource mix (ratios for inputs and production) is the same for all firms in each industry (each of 69 industrial sectors). As such, our analysis describes average effects.
- We assume fixed production and input ratios of companies and fixed consumption shares of households. We do not include extra effects from investments or government spending.
- We assume that firms can increase their use of labour and capital as needed to meet the additional demand for their products from Google and their suppliers. Further, we assume that extra output can be produced in one area without taking resources away from other activities. This approach to considering no supply-side constraints is equivalent to an assumption of fixed prices and wages; indeed input-output models are referred to as *fixed-price models*. We thus refer to our estimated impact as supported effects, because they indicate the potential effects if the resources are readily available in the economy.
- We assume that the structure of the Danish economy remains unchanged, looking as in 2016 (the year of the latest available input-output table). Any structural changes in the Danish economy since 2016 would lead to changes to the multipliers.

About Copenhagen Economics

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- includes economists from various nationalities / languages (among which Danish, Dutch, English, Finnish, French, German, Hungarian, Icelandic, Irish, Italian, Lithuanian, Norwegian, Portuguese, Romanian, Spanish, Swedish)
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