A photograph of a rural landscape under a clear blue sky. Several power lines stretch across the frame from the top left towards the right. In the foreground, there is a field of golden-brown crops. In the middle ground, a small white building with a dark roof is visible. On the right side, a utility pole with cross-arms and insulators is partially visible.

## Electrical and fiber networks for household FTTH access

A summary of Swedish experiences

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*Orbion Consulting is a technical consultancy company targeting networked infrastructure and users thereof, with an array of services and capabilities addressing all phases in a networked infrastructure lifecycle i.e. from planning and engineering to operations and end-of-life*



## EXECUTIVE SUMMARY

The population of Sweden is almost 10 million and there are 4,6 million households in the country evenly distributed between single dwelling units (SDU) and multi dwelling units (MDU). 85% of the Swedish population lives in urban areas, while 12% of the population lives in sparsely populated rural areas (less than 50 people and/or more than 150 m between houses). **Swedish municipalities have a responsibility to provide basic infrastructure and services** such as roads, water and electricity to all its inhabitants.

Since the deregulation of the Swedish telecom market in 1993, the municipalities have been very active in building their own broadband infrastructure. **Governmental support programs have been launched and are still in use, but these have in fact only had a marginal effect on broadband development.** However, it is clear that the financial incentives functioned as a catalyst for the development of broadband rural networks in Sweden.

Today, there are municipal broadband networks in more than 200 of Sweden's 290 municipalities. **According to the Swedish association of city networks (Stadsnättsföreningen), only about 7% of these networks have been built using any form of public funding.** The main driving force behind the development of the rural broadband network in Sweden is commercial market forces, i.e. the demand for broadband access from the private and public sector and the need for the **municipality to increase its attractiveness.**

According to Swedish legislation, revenue from fiber optic networks must be separated from the revenue from electric networks. Thus, **there is no way for the electrical grid owners to include FTTH investments in their capital base**, which is a regulatory tool used to determine how much each power company can charge their customers.

## Executive Summary

4

On municipal level there is often a close relationship between the electrical grid owner and the broadband network owner. Often municipal fiber companies are municipality owned daughters of the power grid companies. A recent trend is that 3rd parties like IP Only are consolidating these fiber companies. None of the main owners of the regional power grid are directly involved in FTTH projects other than in so called co-location projects where e.g. fiber optic cables are placed in the same trench as the electric cables. This reduces the cost of excavation by approx. 30% for the electrical grid owner.

Since there is an external pressure both from EU and the Swedish government to increase the speed of broadband development it can be assumed that co-location will be used more frequently in the near future. However, the timing of projects is crucial and often the limiting factor for co-location to be feasible.

Of the studied large electric grid owners, Vattenfall and E.ON seem to be the most active companies in seeking opportunities for co-location. Vattenfall has a separate unit for businesses outside the regulated electricity distribution business and handles their broadband initiatives within the framework of that unit.

Although E.ON does not have a separate unit for broadband initiatives they are quite active in seeking co-location partners in order to lower investment costs. All companies look at co-location as a way of increasing the margin in the electricity distribution business. In line with Swedish legislation, all companies keep separate accounting for their broadband business.

The so called capital base is used by the regulatory agency to determine what fee the electricity distributor can charge its customers. According to the legislation the amount an electricity grid owner charges a customer category must reflect the costs the network company has for this particular category. So far, the total value of the co-location projects is so small in relation to the total investment volume that it is not likely to effect the capital base over the next four year period. In time, reduced investment cost should be reflected in the standard price list which could force the electricity distributors to lower their fees.



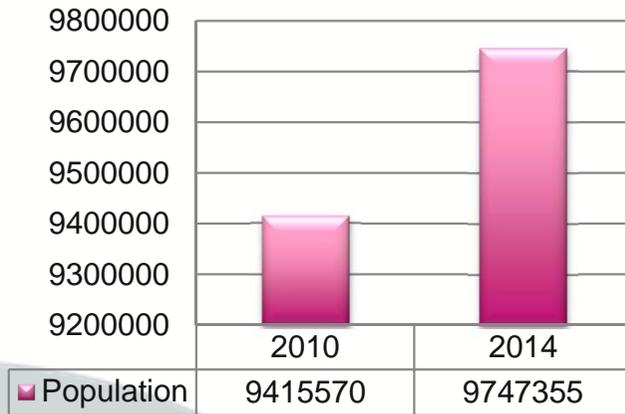
**Marcus Bergman**



**SWEDISH DEMOGRAPHY**

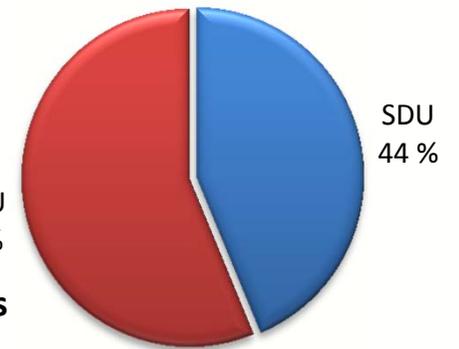
The population of Sweden is roughly 9,7M people

The number of households is almost 4,6M with an average 2,3 persons per household

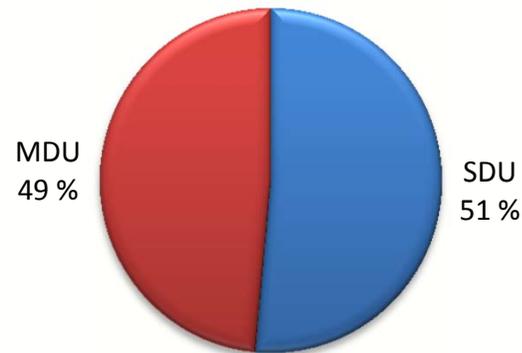


In the country as a whole there are 44% single dwelling units (SDU) and 56% multiple dwelling units (MDU). Excluding the three biggest cities the ratio is almost 50/50

**Sweden**



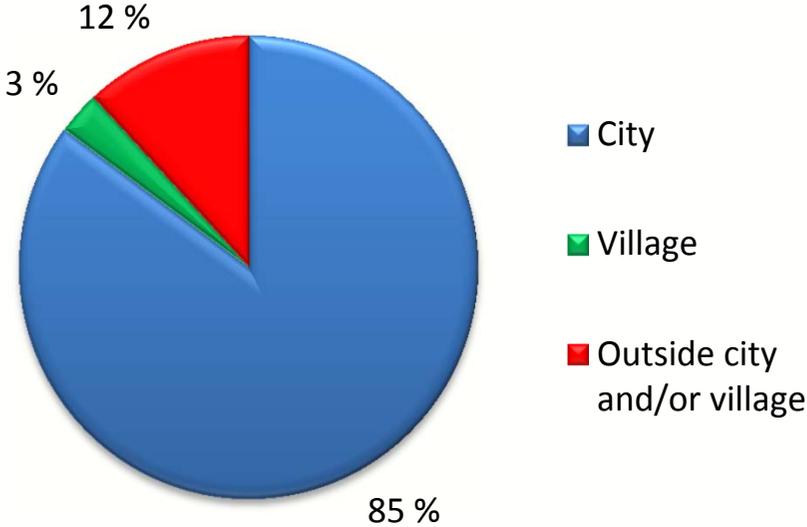
**Sweden excluding three biggest cities**



# 1 Background

According to the latest available statistics (2010) 85 % of the Swedish population lives in cities, and 3% of the population lives in villages (i.e. 50-199 inhabitants and no more than 150 m between houses)

Consequently 12% of the Swedish population lives outside cities and/or villages.



**THE SWEDISH POWER GRID**

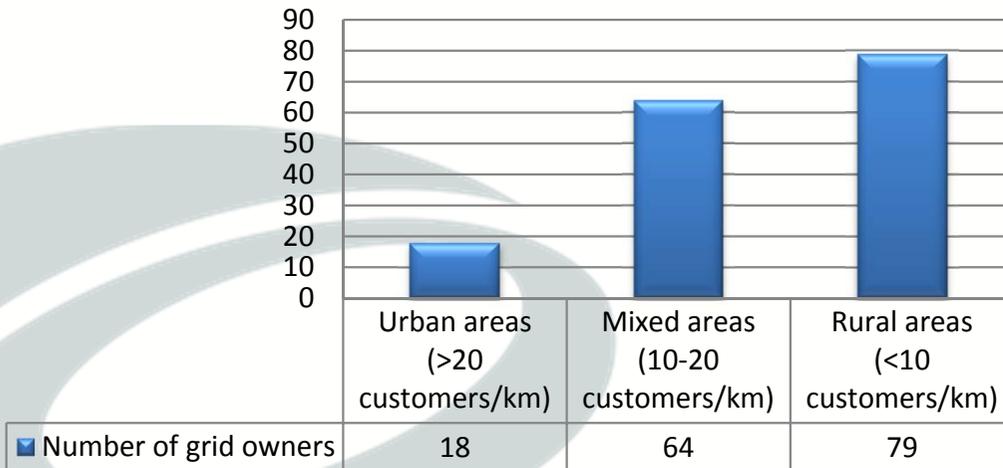
The Swedish power grid is approximately 555 000 km. 360 000 km is underground cables and 195 000 km is overhead power lines

The national power grid (400 kV) is 100% state owned by Swedish Grid (Svenska Kraftnät)

The main part (>95%) of the regional power grid (20-130 kv) is owned by E.ON, Vattenfall and Ellevio (Fortum)

There are approx. 160 local power grid (0,4-20 kV) owners in Sweden (mostly municipality owned).

**Local power grids, 0,4-20 kV**



Power company	Number of customers	% of cust.	Length of power grid (km)
E. ON	1 000 000	19%	120 000
Ellevio (Fortum)	890 000	17%	60 000
Vattenfall	860 000	16%	110 000
Others (158)	2 600 000	49%	210 000
<b>Total</b>	<b>5 300 000</b>		<b>500 000</b>

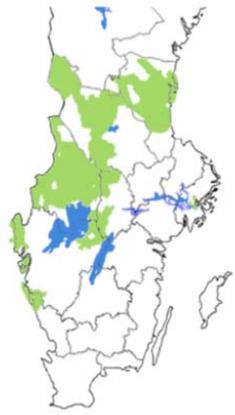
1 Background

# Geographical distribution of main electrical grid owners

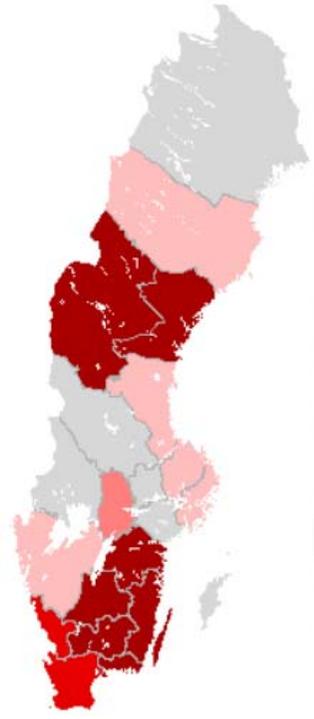
Svenska Kraftnät



Fortum



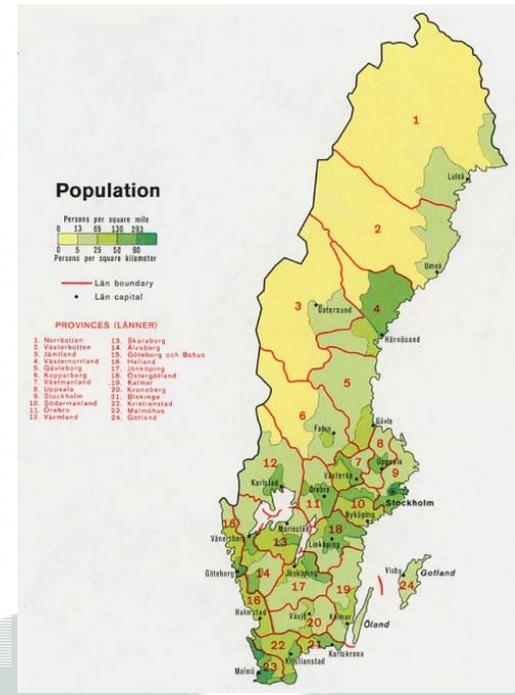
E.ON



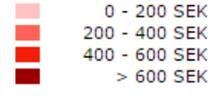
Vattenfall



Population density



Regional investments per citizen



**SECURING POWER SUPPLY**

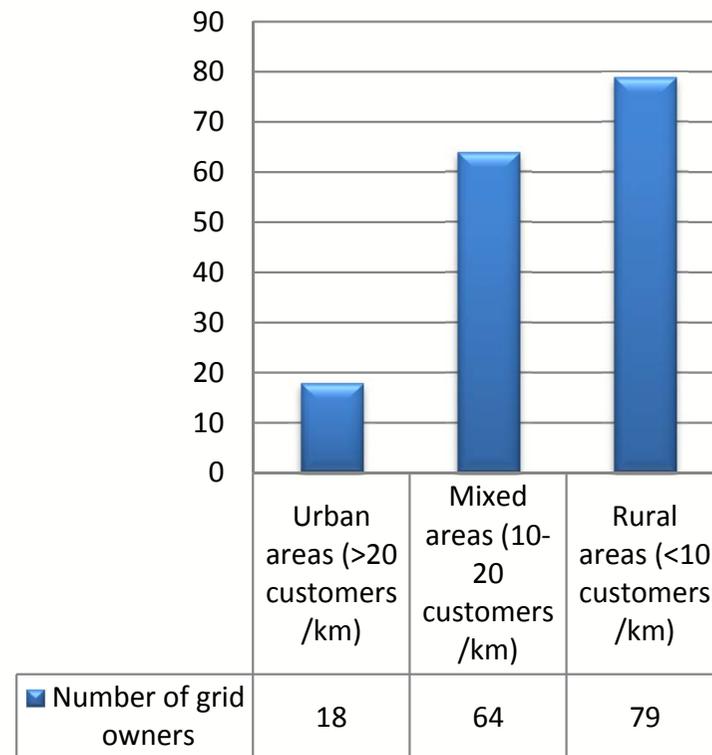
Since 2001 the Swedish power companies have invested SEK 50 billion to weather proof the power grid, primarily by replacing uninsulated overhead power lines with underground cables.

The work, which started by the industry's voluntary agreement with the Government, was accelerated by the storm Gudrun in 2005 and the storm Per two years later. Some 57000 km would totally be addressed according to the original plan.

Economic instruments have been introduced in Sweden in order to provide an incentive for power companies to increase security of supply and continuously maintain and invest in their electricity grids

A legal obligation for power grid owners to compensate their clients in case of power failure longer than 12 hours was introduced in 2006

**Local power grids, 0,4-20 kV**



### LEGAL FRAMEWORK

## Electricity Act (1997:857), Including amendments up to 1 January 2012

### Chapter 3

2§. *Financial accounts related to a network operation shall be kept separately from those of other operations. (SFS 2008:265).*

### Chapter 4

1§. *Network tariffs shall be objective and non-discriminatory. Chapter 5 contains provisions on the establishment of revenue frames. (SFS 2009:892).*

### Chapter 5

1§. *A revenue frame shall be established in advance for each supervisory period.*

2§. *A network concessionaire shall submit a proposal for a revenue frame to the network authority together with the information required for consideration of the proposal. (SFS 2009:892).*

6§. *The revenue frame shall cover reasonable costs in order to conduct network operations during the supervisory period and provide a reasonable return on the capital required in order to conduct the operations (capital base). (SFS 2009:892).*

9§. *The capital base shall be calculated based on the assets which the network concessionaire uses in order to conduct the network operations. In addition, consideration shall be given to investments and depreciations during the supervisory .*

**Fiber optic networks for FTTH access is not part of the capital base. However, co-location of cables with fiber optic network owners reduces the cost of investment for the electricity network owner and contributes to increased margins.**



### SWEDISH ENERGY MARKETS INSPECTORATE (EI)

## EI regulates electricity network fees

There is only **one electricity grid operator within each geographical area** and the electricity consumer have no possibility of changing company. The reason for this is that it would be too expensive to build and run parallel grids.

Since there is **no competition** in the electricity network market, the **market must be regulated**. This is done by the Swedish Energy Markets Inspectorate (EI). One of its tasks is to **monitor that the electricity network fees are reasonable**, objective and non-discriminatory. To monitor this EI inspects the total revenue of every electricity grid operator, i.e. the maximum charge of customers for each company.

Ex ante regulation of electricity network fees was introduced in 2012. This means that every **electricity grid operator has been given a revenue cap for the total amount that they may charge their customers during the years 2012-2015**.

The purpose of the revenue caps is that companies shall obtain reasonable coverage for their costs and reasonable return on the capital that is required to run the operation. At the same time, the regulation is designed to ensure that the electricity customers shall have sustainable and stable fees.

**The amount an electricity grid owner charges a customer category must reflect the costs the network company has for this particular category.**



### EU LEGISLATION

## DIRECTIVE 2014/61/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 May 2014

on measures to reduce the cost of deploying high-speed electronic communications networks

The Digital Agenda for Europe aims to bring basic broadband to all Europeans by 2013, and to ensure that, by 2020, **all Europeans have access to much higher internet speeds of above 30 Mbps and 50 % or more of Union households subscribe to internet connections above 100 Mbps.**

This Directive aims to **facilitate and incentivize the roll-out of high speed electronic communications networks** by promoting the joint use of existing physical infrastructure and by enabling a more efficient deployment of new physical infrastructure so that such networks can be rolled out at lower cost.

Member States shall ensure that, upon written request of an undertaking providing or authorised to provide public communications networks, any network operator has the obligation to **meet all reasonable requests for access to its physical infrastructure** under fair and reasonable terms and conditions, including price, with a view to deploying elements of high-speed electronic communications networks. Such written request shall specify the elements of the project for which the access is requested, including a specific time frame.

Member States shall, by **1 January 2016** adopt and publish the laws, regulations and administrative provisions necessary to comply with the directive, which is a minimum directive.

Member States shall apply the provisions of the directive as of **2016-07-01**



#### GOVERNMENT POLICIES

Parliament has decided that the IT objective is that Sweden as the first country shall become an information society for all (Govt. Bill 1999/2000: 86, the so-called IT Bill, bet. 1999/2000: TU9, Riksdag Communication 1999/2000: 256).

In the IT Bill, the Government said that households and businesses in all parts of Sweden in the next few years should have access to IT infrastructure. Based on the IT bill and parliamentary decision **support programs** have been designed, primarily oriented to areas outside urban centers and sparsely populated areas in general (*Law 2000: 1335 on credit on the tax account for support to municipalities for the construction of local telecom networks, Regulation 2000: 1469 on support to municipalities for the construction of local networks and Regulation 2001: 350 on aid to municipalities for the construction of interurban telecom networks, etc.*). **The reason for the aid is that market forces was not deemed to be sufficiently strong to provide expansion in all parts of the country.**

For the support efforts to have the desired effect, the parties in the network market must be able to rely on that there will be good opportunities to connect a local network to a national backbone network. On 17 August 2000, the Government instructed the public enterprise Swedish Grid (Svenska Kraftnät) to build a backbone network with high transmission capacity (ref 1999 / 11617).

On June 30, 2001, 61 municipalities was connected to the backbone network via the agency's own fiber optic cable. On the same date a further 49 municipalities was connected to the **Triangle Company AB's** core network, jointly owned by Birka Energi (currently Ellevio), Swedish Grid, Sydkraft (currently E.ON) and Vattenfall. Furthermore, 48 municipalities was connected to a national backbone network mainly through networks owned by the Birka Energy (Ellevio), Vattenfall and Sydkraft (E.ON). Thus, a total of 158 municipalities, i.e. 55% of all municipalities, was connected to the core dark fiber network.

**The Swedish Governmental Broadband Strategy states that by 2020, 90 percent of all households and businesses shall have access to broadband of at least 100 Mbit/s.**

3 Swedish Broadband (FTTH)

REGIONAL BACKBONE FIBER NETWORK

Triangelbolaget

Triangelbolaget is a company jointly owned by Vattenfall, Svenska kraftnät, Ellevio och Tele2.

Triangelbolaget offers dark fiber between most major cities in Sweden. The network consists of 1700 km fiber cable. Triangelbolaget interacts with international, regional and local actors and fiber can deliver the entire connection from point to point.

The dark fiber is built on existing power lines.



- Alvesta
- Falkenberg
- Enköping
- Gislaved
- Gnosjö
- Göteborg
- Halmstad
- Jönköping
- Kalmar
- Karlskrona
- Karlshamn
- Karlstad
- Kungsbacka
- Köping
- Lessebo
- Linköping
- Ljungby
- Mölnadal
- Norrköping
- Nybro
- Nynäshamn
- Ronneby
- Stockholm
- Södertälje
- Sölvesborg
- Trollhättan
- Varberg
- Västervik
- Västerås
- Värnamo
- Växjö
- Åmål
- Örebro

## MUNICIPAL- AND RURAL FIBER NETWORKS

### A short history

In 1993, the Swedish telecom market was deregulated and Telia AB was founded. At the same time a new set of regulations (the Telecommunications Act) was put in force. The purpose of the deregulation was that competing market forces would increase the rate of technology development.

After only a few years some municipalities started to build their own telecommunication networks. The main reason for this was cost savings. **In 1998, there was 138 municipality owned fiber networks in Sweden.** At first mainly for the municipal administration and education. Only 28% offered fiber capacity to external operators.

The first governmental support program for broadband development (2001-2007) was the start of a strong development of municipal fiber networks. Many city networks was expanded to also cover communities and villages. The program also supported the connection of private homes and companies to the fiber networks. The municipal networks became open networks.

### Fact about municipal networks

**Municipal fiber networks (often subsidiary to the local power company).**

A city network is a broadband network that is locally established, normally within a municipality.

City networks own about 60% of access fiber network.

City networks have open networks based on fiber optics.

City networks exist in almost 200 municipalities. In over 150 communities, there is an urban networks with a clear commercial orientation.

16% of municipalities with city network is a private city network (a city network can be found in several municipalities) and 84% is municipally owned.

**Seven out of ten city networks are today investing entirely with their own investment funds, that is, without support from the State, the municipality and/or EU. The majority of city network expands its infrastructure based on purely commercial principles, i.e. with a market premium payback and return requirements.**

**SUPPORT PROGRAMS**

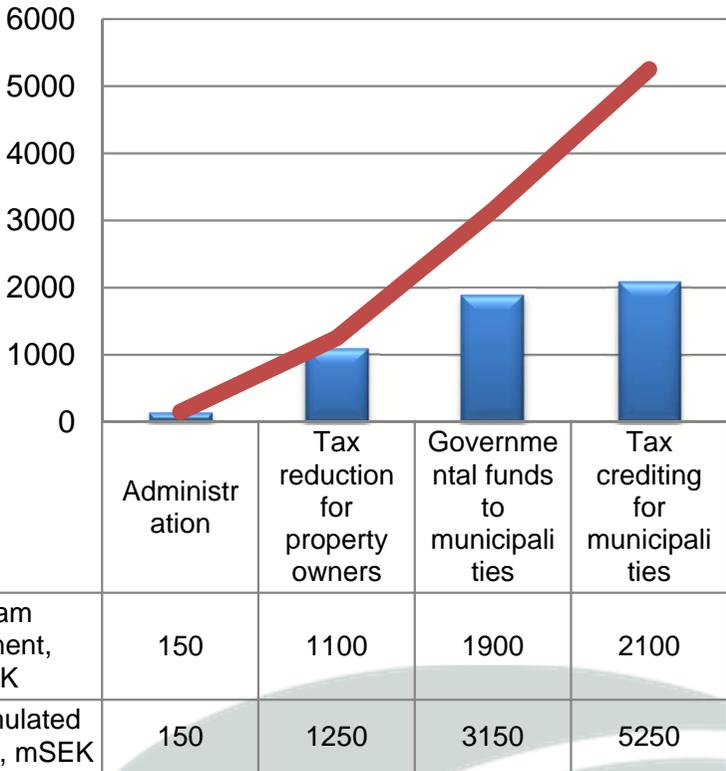
## National Broadband Support Program 2001-2007

The funding was aimed at providing support for a national operator neutral backbone, providing incentives for municipalities to develop access networks, support regional networks and connect public institutions.

A requirement for interested parties to receive financial support was that networks were operator-neutral, and that no network had been deployed in an area in order to be compatible with European Union state aid rules.

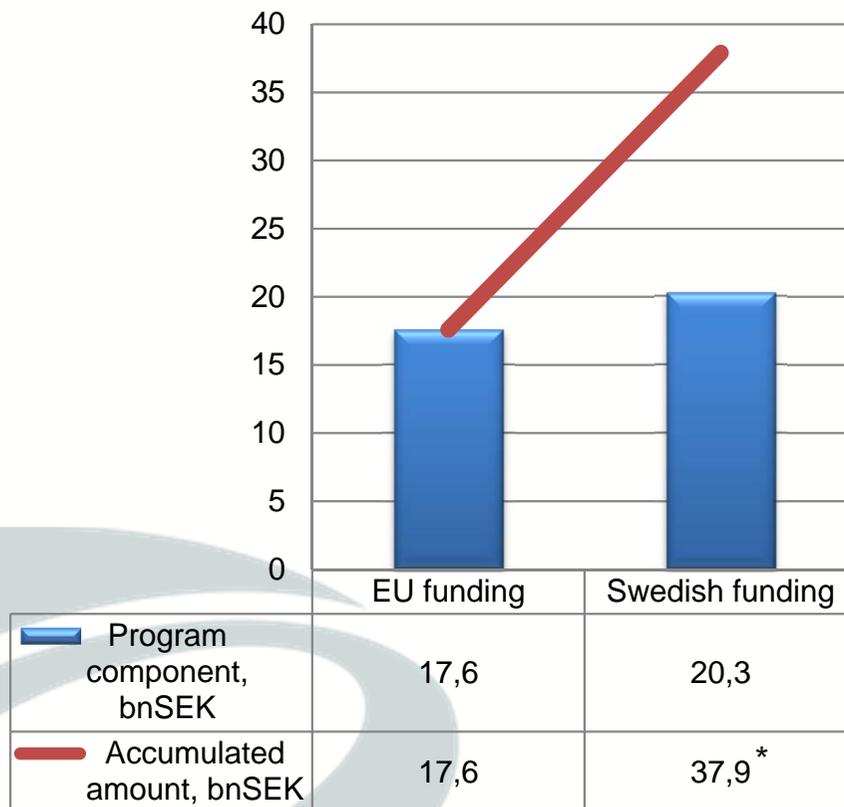
In many ways, the bill can be said to have kick started broadband developments in Sweden.

Source: OECD Science, Technology and Industry Policy Papers No. 26 *Development of High-speed Networks and the Role of Municipal Networks*



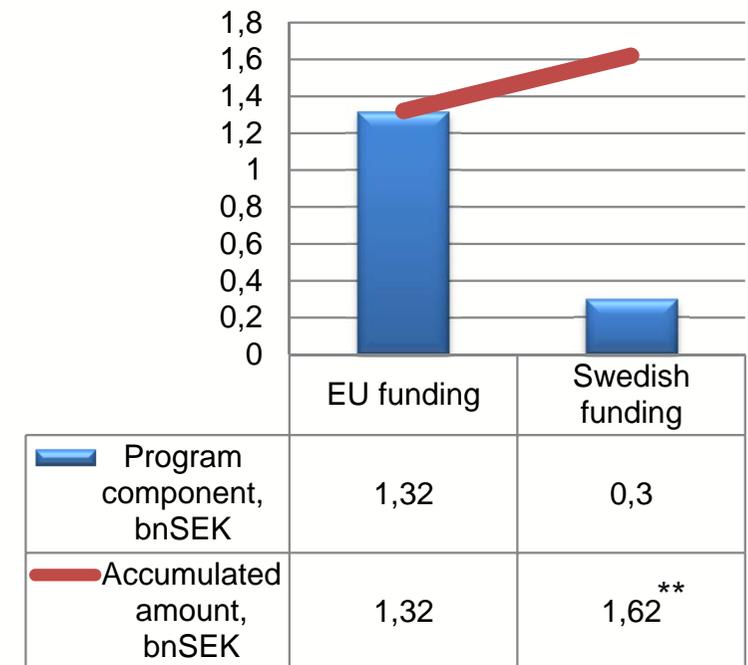
## National Rural Development Program 2007-2013

Entire National Rural Development Program



## Broadband development support was a minor part of the program

Broadband development part

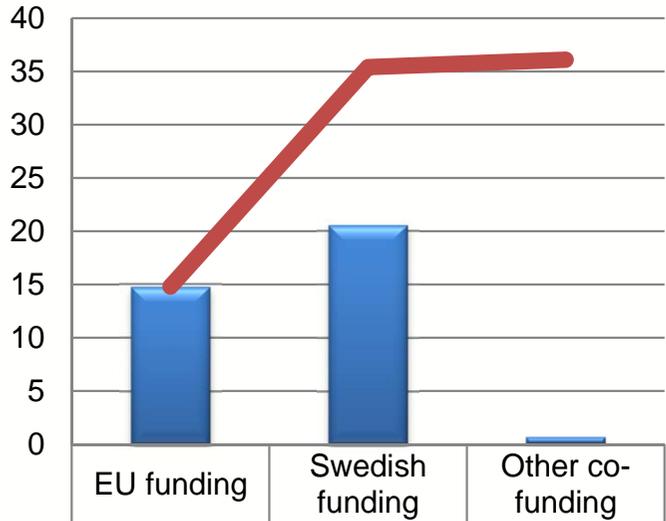


\* 95% was used during the period

\*\* 100% was used during the period

## National Rural Development Program 2014-2020

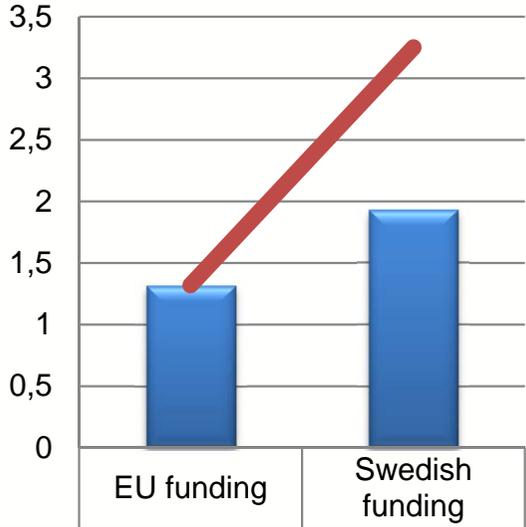
Entire National Rural Development Program



Program component, bnSEK	EU funding	Swedish funding	Other co-funding
Program component, bnSEK	14,8	20,6	0,7
Accumulated amount, bnSEK	14,8	35,4	36,1

The broadband support has been doubled in the current program

Broadband development part



Program component, bnSEK	EU funding	Swedish funding
Program component, bnSEK	1,32	1,93
Accumulated amount, bnSEK	1,32	3,25

## IMPLEMENTATION ISSUES

In fact, only 5-7% of the municipal fiber networks have been built using governmental funding. The expansion of municipal networks in Sweden is a result of the deregulation of the Swedish telecom market and market forces. Swedish municipalities consider broadband (fiber) networks to be a strategic asset.

The governmental funding was distributed by the municipalities either to the local municipal fiber company or to the state owned companies Telia and Teracom. The local fiber companies developed fiber optic network whilst Telia and Teracom developed a copper based fixed network.



Source: Ny Teknik, 18 November 2015

“Chaos when the Government provides support to broadband expansion”

So far, there are 800 applications for support to rural fiber optic networks (with a total investment volume of 7 bnSEK). These projects could give another 500,000 people broadband access.

Only legal entities can apply for the support which is 40-70% of the investment volume

So far nothing has been paid of the 3,25 bnSEK set aside for rural broadband expansion, This is mainly due to delays and changed conditions for applicants and some IT-/system related problems

Only villages with less than 200 inhabitants and less than 200 meters between houses can apply (previously less than 3,000 inhabitants)

### INTERVIEWED KEY PERSONS

#### **Ellevio (former Fortum)**

Bengt Johansson, Head of Asset Management

#### **Vattenfall**

Torbjörn Johansson, Business unit Complementary Business

Lars Blomberg, Business unit Complementary Business

#### **E.ON**

Jan-Erik Olsson, Head of Distribution

#### **Swedish Energy (Svensk Energi)**

Helena Laurell, legal expert

Lennart Sandebjer, legalexpert

Ronald Liljegren, head of legal department

#### **Stadsnätsföreningen**

Mikael Ek, CEO

#### **Swedish Energy Markets Inspectorate**

Matilda Lindersson



## INTERVIEW OUTCOME

## Ellevio (former Fortum)

Ellevio does not include fiber networks to the homes in their business model. Fibers are only used in the operation of their electrical grid.

The company uses co-location with fiber companies as a way of lowering investment costs. The fiber companies pay a fee to Ellevio for the access to canalization. Since the revenue base is fixed, this improves the margin in the power company.

The volume related to co-location projects is so far almost insignificant (much less than 1%) compared to the total investment volume and the company does not anticipate that its capital base will be effected in the coming period.

## Vattenfall

Vattenfall build and own fiber optic networks as part of the operation of the electrical distribution network. In case of access capacity, fibers can either be leased or sold to external operators for FTTH-access. In case of leasing, Vattenfall is responsible for maintaining the physical status of the fiber and the operator is responsible for the active equipment needed for FTTH-access.

The company also uses co-location with fiber companies as a way of lowering investment costs. The excavation cost for Vattenfall is normally reduced with approx. 30% if co-location with fiber companies is used.

Vattenfall foresees an increase in co-location project in the near future, due to a combination of external policy pressure and economic incentives.

The volume related to co-location projects compared to the total investment volume is so far insignificant and the company does not anticipate that its capital base will be effected in the coming period.

### Vattenfall (cont.)

Co-location is used in cable projects in the distribution network until the substation closest to the homes, i.e. co-location does not apply to the access network. This “last mile” is normally not more than 500 meters.

Vattenfall is only actively seeking partners for co-location to a certain extent. In most cases, the potential partners (such as fiber optic network owners, operators or rural fiber associations) contact Vattenfall to investigate the possibility for co-location. Timing of projects is the number one obstacle to pass in order to use co-location and this is often hard to achieve.

### E.ON

E.ON does not have any external broadband business. Their fiber network is entirely for the operation of their electrical grid and substations.

The company does not lease unused fibers, but E.ON has a very open attitude towards co-location projects and are actively seeking cooperation of this kind. They address both network owners, operators, municipalities and rural fiber associations.

Also for E.ON, the excavation cost is normally reduced with approx. 30% if co-location with fiber is used. This number applies to all companies because there is a standard price list used in Sweden for calculating the costs related to electrical grid projects. It is used by all electrical grid owners and provides industry average prices for all activities included in a project.

Most of the E.ON co-location projects are executed in the distribution network, leaving the last mile to the external party to handle. The distance from the last station in the distribution network to the individual homes is normally not more than 500 meters. In cases where E.ON are to connect new homes to their electrical grid, fibers are often co-located all the way to the homes.



## Swedish Energy Markets Inspectorate, EI

The current regulation has been in force since 2012 and the Inspectorate has just initiated a new period of 4 years starting from 2016.

The approved revenue frame for the previous period will now be reviewed and the actual numbers for each company will be compared with forecasted values at the time of the previous application. Any surplus or deficit will be transferred to the next period.

If an electricity grid owner has had lower investment cost than anticipated it will effect the revenue base for the next period. Co-location of cables have been used by the power companies to reduce cost, primarily in relation to weather proofing of the grid. It is not clear how this will effect their future revenue base since this has not been evaluated yet.

**CONCLUSIONS**

Governmental support programs can be a good way of infusing energy to the market and initialize the development. However, the Swedish example shows that a vast majority of the rural broadband networks have been built without governmental support.

Most municipal networks in Sweden are fiber optic networks and only a minor part are using copper based networks. In both cases the broadband networks are fixed network, only using mobile solutions where fixed lines are not economically or technically feasible. Given the rapid increase in demand for data traffic and connectivity quality it is recommended that a rural broadband network should be fiber based.

The EU directive on measures to reduce the cost of deploying high speed electronic communications networks will be implemented in Sweden in the near future and it is reasonable to assume that this can increase the speed of broadband deployment through out the country when existing infrastructure can be used as canalization.

Co-location projects is increasingly important in the development of the broadband fiber network in Sweden. All major electricity distributors uses this as a part of their business model as a way of reducing investment costs. The method is also favorable for broadband network developers and owners since it significantly reduces the excavation cost.

On a deregulated telecom market, such as in Sweden, the main driving force behind the development of the rural broadband network is the commercial market forces such as for example competitive pricing and increased municipality attractiveness.





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