

RESEARCH REPORT

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Distribution of Road Conditions and Road Temperatures in Finland as Kilometres Driven

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| <p>Summary</p> <p>Road conditions and surface temperatures are known to influence the abrasion rate of road vehicle tyres. Tyre abrasion has the side effect of generating tyre and road wear particles belonging to microplastics that end up in soils and sediments. Therefore, it is necessary to know when, where and under which conditions vehicles drive to understand tyre abrasion.</p> <p>This study examined the prevalence of road weather conditions and road temperatures in Finland as vehicle kilometres driven. The distribution of conditions was estimated for main roads using road surface sensor data. The estimate for regional and connecting roads and urban street networks was derived from the main roads estimate input from road weather experts.</p> <p>The results show that the most prevalent road condition on Finnish roads as kilometres driven is a dry road surface (56%), followed by wet and moist surfaces (29%). However, wintery conditions such as snow, ice and sleet still account for a large presence overall (12%), and especially during winter months (38%). 26% of annual vehicle kilometres are driven on surfaces below zero degrees Celsius. The distribution of conditions and temperatures is influenced both by time of the year and geography, with winters being at least partially snowy in the whole country and much colder and snowier in the north. The main result of this study is that the share of conditions in the annual kilometres driven in Finland are influenced by road class, geographic location and seasonal variation.</p> | |
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Preface

Road conditions and surface temperatures are known to influence the abrasion rate of road vehicle tyres. Tyre abrasion has the side effect of generating tyre and road wear particles which belong to microplastics that end up in soils and sediments. Therefore, it is necessary to know when, where and under which conditions vehicles drive to understand tyre abrasion.

Nokian Tyres Plc commissioned the study on distribution of road conditions as kilometres driven from VTT in August 2021. The study was carried out during August-December of 2021 by Teemu Itkonen, Johannes Mesimäki and Satu Innamaa.

The steering group consisted of Juha Pirhonen (Nokian Tyres), Lauri Heikkinen (Nokian Tyres), Satu Innamaa (VTT), Teemu Itkonen (VTT) and Johannes Mesimäki (VTT).

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1. Introduction

Road conditions, such as wet or dry road surfaces, and road surface temperatures, are known to influence the abrasion rate of road vehicle tyres. Tyre abrasion has the side effect of generating tyre and road wear particles [1]. These particles belong to microplastics that end up mostly in soils and river sediments, and an approximately 500 000 tonnes of tyre rubber is released annually in the European Union alone [2].

The European Union (EU) has announced a new initiative to address the unintentional release of microplastics in the environment which aims, among other objectives, to further develop and harmonise methods for measuring unintentionally released microplastics, especially from tyres [3]. The EU has identified the need to explore the link between road characteristics and tyre abrasion [4]. The European LEON-T project will study the particulate emissions from tyres [5]. In addition, the European Tyre and Rim Technical Organisation (ETRTO) is developing a feasible test method to measure the abrasion rates for passenger tyres. The method aims to be representative of the real driving environment in European market. [1]

Because road conditions affect tyre abrasion rates, it is necessary to understand when, where and under which conditions vehicles are driven. The road network in Finland is divided into classes. The main roads (classes I and II) comprise the most important network, which includes motorways and highways connecting cities and municipalities. A collection of smaller roads, the regional and connecting roads, serve within-municipality traffic and form links between the municipalities and main roads. The urban street networks are owned and maintained by municipalities.

The goal of this study was to assess the distribution of road conditions and road surface temperatures in Finland as the number of kilometres driven, also known as vehicle kilometres travelled (VKT). The study addressed public roads (main roads, regional and connecting roads, urban streets), with private roads excluded from the study. The kilometres driven on private roads was estimated to be minor compared to public roads.

2. Method

Methodologically the project was divided into four phases:

1. Acquisition of data (road networks, traffic, road weather)
2. Estimating the distribution of road conditions and temperatures as the share of vehicle kilometres driven on the main road network.
3. Estimating these factors for regional and connecting roads and the urban street network
4. Upscaling the estimated distributions to regional and monthly totals (in millions of km driven)

2.1 Data acquisition

Two major data needs were identified in the project: detailed information on the Finnish road network and traffic volumes, and data on road conditions and weather. The latter was acquired from Vaisala Oyj, and the Finnish Transport Infrastructure Agency (FTIA) provided a collection of open data on road networks and traffic volumes [6] [7]. Additional sources, such as traffic variation factors [8] and regional VKT estimates [9] were acquired from FTIA. To estimate kilometres driven in the urban network, the study utilized population density data from Statistics Finland [10] [11] and a total VKT estimate provided by the ecoDriver project [12].

The FTIA open dataset on roads consisted of information on the road segments for the entire main road network, including road addresses, segment length and location. Another dataset from the FTIA contained the estimated average daily traffic (ADT) volumes for the year 2020 for each road segment and the type of seasonal variation associated with them.

The weather and road condition dataset from Vaisala Oyj contained information for 276 road segments located along the main road network (shown in Figure 1), and covered a period of three years from 2017 to 2019. A road condition class for each measurement (e.g. “dry”, “snowy” or “salted”), along with road temperature was obtained from this dataset. The extracted measures were aggregated to form a time series for each associated road segment. A typical day contained several observations, but the sampling rate proved inconsistent. The irregularity in sampling was balanced by weighting each sample by the difference between the time of its occurrence and the occurrence of the previous sample before taking the mean.

Road temperatures were classified according to the project’s research interests. In line with the views of the interviewed road weather experts, temperatures below -6 degrees Celsius were considered as

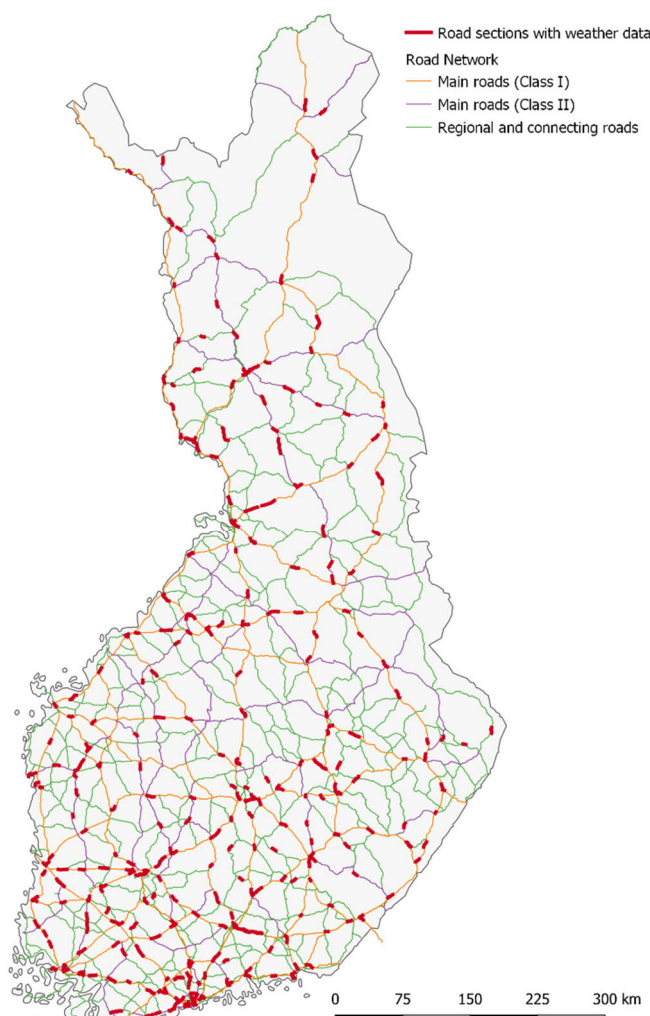


Figure 1: Geographical distribution of the road sections with road condition data

“unlikely to be salted” and likewise temperatures of -6 to 3 degrees as the likely temperatures where salting might occur. Higher temperatures were classified as “3 to 15 degrees” and “over 15 degrees”.

After pre-processing, the FTIA and Vaisala datasets were merged according to road segment addresses. The resulting dataset contained traffic data merged with the time-series on weather and road conditions data. The ADT values were modified according to traffic variation factors from the FTIA to produce a day-by-day estimate of traffic volume on the appropriate segment.

The time resolution of the combined and aggregated dataset was a 24-hour period. However, traffic volumes and road conditions vary between day and night. Therefore, days were split into two and later combined by weighting both time-periods according to their estimated VKT. For simplicity, the following sections will refer to the base time-unit simply as a “day”, ignoring this calculation. Nighttime was assumed to occur between 8 PM and 6 AM.

2.2 Estimate for the main road network



Figure 2: Regions of Finland

According to the nomenclature of territorial units for statistics (NUTS) classification by Eurostat, Finland is divided into 19 third-level NUTS regions, which coincide with the official regions defined by the Finnish state. The NUTS3 classification forms the basic geographic unit for this study. Åland was excluded from this study due to lack of data.

The VKT estimate was calculated for a single road section as

$$VKT_{i,d} = ADT_{i,d} \times L_i$$

where i = road segment, d = day and L is the length of the segment in kilometres.

Each observation was then grouped according to their NUTS3 region and the date-of-occurrence to calculate the VKT share within each group:

$$S_i = \frac{VKT_i}{\sum_{j=1}^n VKT_j}$$

where n = a group of NUTS3 region and date-of-occurrence and i = observation.

For each group, the VKT share was used to take a weighted sum of the share of road condition classes. This process results in a single estimate for each group, which represents the share of VKT for that region and on that day. The same process was applied also for the road temperature classification.

The result has the following form:



| NUTS3 region | Date | DRY | FROST | ICE | MOIST | SLEET | SNOW | WET | SALTED |
|--------------|----------|-------|-------|-------|-------|-------|-------|-------|--------|
| FI1C5 | 1.1.2017 | 0.023 | 0.000 | 0.180 | 0.415 | 0.002 | 0.000 | 0.010 | 0.370 |
| FI1C5 | 2.1.2017 | 0.202 | 0.000 | 0.000 | 0.294 | 0.075 | 0.126 | 0.000 | 0.181 |
| FI1C5 | 3.1.2017 | 0.509 | 0.000 | 0.012 | 0.199 | 0.000 | 0.176 | 0.000 | 0.104 |
| FI1C5 | 4.1.2017 | 0.627 | 0.000 | 0.069 | 0.060 | 0.000 | 0.172 | 0.000 | 0.072 |
| FI1C5 | 5.1.2017 | 0.751 | 0.000 | 0.060 | 0.000 | 0.000 | 0.143 | 0.000 | 0.046 |
| FI1C5 | 6.1.2017 | 0.436 | 0.000 | 0.418 | 0.000 | 0.000 | 0.143 | 0.000 | 0.004 |
| ... | | | | | | | | | |

2.3 Estimate for urban networks and regional and connecting roads

Since road condition data similar to that used for the main road network was unavailable for the urban network and regional and connecting roads, the distribution estimated for the main road network was used as basis for estimation of the road weather conditions on the other road types. For refining this estimate, we contacted winter maintenance experts. The respondents were FTIA, the Traffic Management Centres in Finland (Fintraffic Ltd.), the Lapland Centre for Economic Development, Transport and the Environment (ELY-Centre) as well as the Oulu municipality. The following questions were asked:

- Within what temperature range is road salting performed in your area?
- Does winter maintenance on regional and connecting roads as well as municipal street networks differ substantially from that of main roads?
- In Lapland, can roads be dry even when the road temperature is below 0 Celsius?

Contacts from the FTIA, the Oulu traffic management centre and the Lapland ELY-Centre confirmed that road salting is primarily carried out during temperatures between -6 and 3 degrees Celsius, beyond which salting was considered ineffective. Additionally, all contacts affirmed that there is a substantial difference in winter maintenance efforts between main roads and other roads. On regional and connecting roads and municipal streets, road salting is significantly less frequent, with more attention given to snow clearance and the removal of hard-packed snow. Winter maintenance is also generally less frequent on such roads than on the main road network. Finally, the contact from the FTIA clarified that during freezing temperatures, regional and connecting road surfaces are more likely to be snowy or icy when a weather station assigns the nearby main road network the condition “dry”.

Based on the responses received, the road condition distribution for regional and connecting roads was estimated from the distribution for the main roads according to the following criteria:

- Due to the rarity of road salting, the “salted” category of main roads was reduced to 5% for regional and connecting roads and the rest was assumed to be “snowy”.
- The “dry” condition on main roads is assumed to be snowy on regional and connecting roads when road temperature was below zero.
- The distribution for the urban street network was modified by reducing the “salted” category of the main roads to 20% and assuming that the remaining proportion of the category was “snowy”.
- The road temperature distribution was assumed to be the same for all road network types.



2.4 Upscaling the estimate to regional and monthly totals

As the estimated distributions were based on a sample of road sections, they needed to be upscaled to provide figures for the whole country. We established a “ground truth” of total VKT driven per network and its distribution for each region and each month of the year. There were several sources for this estimate:

- Main roads and regional and connecting roads: FTIA statistics for regional VKT figures and weekly traffic variation factors.
- Urban network: total VKT estimate for urban network from the ecoDriver project, population density figures from Statistics Finland and FTIA traffic variation factors

The estimated distribution from the earlier steps were averaged to monthly aggregates to match the resolution of the absolute figures (in millions of VKT) from the upscaling phase. Further, the three years of the examination period were averaged by month and region to arrive at an estimate of a prototypical year.

3. Results

3.1 Overall distribution

According to FTIA sources for main roads and regional and connecting roads and our estimation from the ecoDriver project, the overall VKT in Finland is 52.7 billion per year. The share of VKT is largest on the main roads (48%), with major cities in the south and south-west making up for most of the traffic. The urban street network captures 27% of the traffic and regional and connecting roads contain 25%. A detailed distribution is presented in Table 1.

Table 1: Annual VKT estimates for Finnish NUTS3 regions and road types (in millions)

| Region | NUTS3 code | Main roads | RC-roads | Urban network |
|-------------------|------------|------------|----------|---------------|
| Uusimaa | FI1B1 | 5614 | 2780 | 5144 |
| Pirkanmaa | FI197 | 2528 | 1044 | 1389 |
| Pohjois-Pohjanmaa | FI1D6 | 2197 | 1116 | 957 |
| Varsinais-Suomi | FI1C1 | 1711 | 1432 | 1236 |
| Keski-Suomi | FI193 | 1624 | 761 | 631 |
| Lappi | FI1D7 | 1447 | 573 | 363 |
| Pohjois-Savo | FI1D2 | 1298 | 610 | 575 |
| Kanta-Häme | FI1C2 | 1175 | 477 | 415 |
| Päijät-Häme | FI1C3 | 1154 | 482 | 539 |
| Etelä-Pohjanmaa | FI194 | 1043 | 636 | 346 |
| Etelä-Savo | FI1D1 | 1032 | 482 | 302 |
| Satakunta | FI196 | 1022 | 542 | 506 |
| Pohjois-Karjala | FI1D3 | 792 | 480 | 341 |
| Kymenlaakso | FI1C4 | 771 | 385 | 435 |
| Pohjanmaa | FI1D5 | 654 | 585 | 370 |
| Etelä-Karjala | FI1C5 | 648 | 272 | 325 |
| Kainuu | FI1D4 | 420 | 269 | 163 |
| Keski-Pohjanmaa | FI1D5 | 291 | 177 | 146 |
| Total | | 25421 | 13103 | 14183 |

Based on our estimation, during an average year, most VKT occur in dry conditions (56%), followed by wet and moist conditions (29%) with snow, ice, sleet, and frost also forming a smaller part (12%) of the vehicle kilometres travelled (Figure 3).

Figure 4 shows the overall distribution of road temperatures divided into classes of interest. Temperatures below -6 degrees Celsius comprise a relatively small portion of the VKT (8%). In contrast, 19% of the kilometres driven are between the range where salting typically occurs, from -6 to 3 degrees. Warmer temperatures are also very prevalent, with 27% and 36% driven in between +3 to +15 and over +15 degrees, respectively.

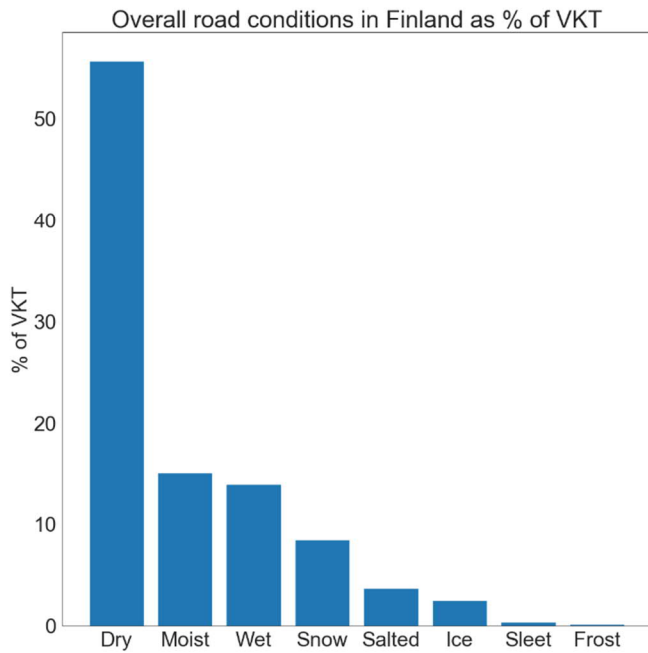


Figure 3: Road conditions in Finland as % of annual VKT

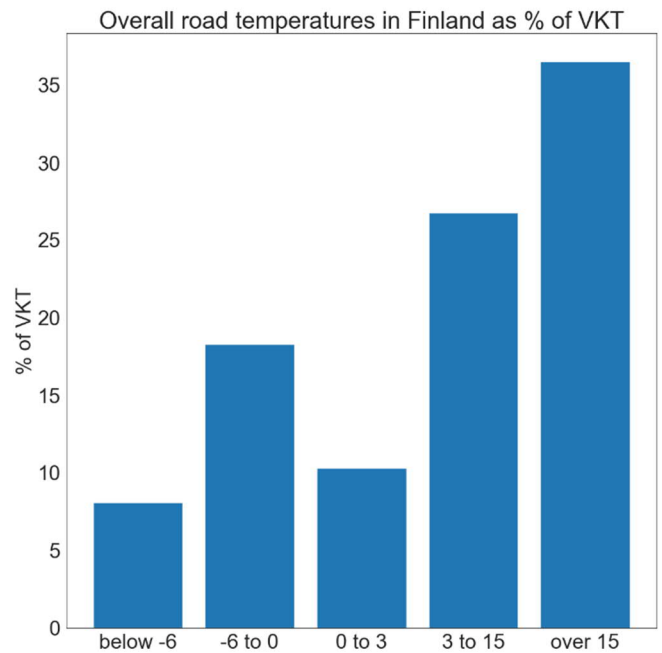


Figure 4: Road temperatures in degrees Celsius in Finland as % of annual VKT

The results in this report are presented as an estimate of an average year. Yearly variation in the examination period exists, but not enough to change the order of prevalence between the road condition classes, except for “wet” being more prevalent than “moist” in 2019. The “dry” condition above varied between 53—58%. The variation in road conditions in the years 2017 – 2019 is shown in Figure 5.

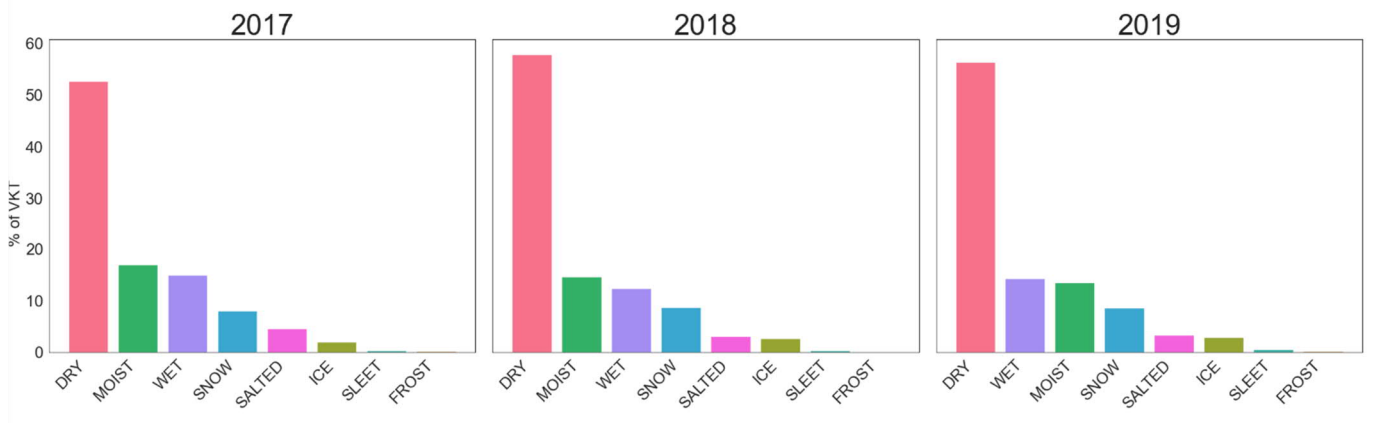


Figure 5: Yearly variation in road condition distribution during the examination period

3.2 Distribution by season and month

Road conditions and temperatures vary greatly over the time of the year. Along with monthly averages, we used a four-part seasonal division for the average year: March–May for spring, June–August for summer, September–November for autumn and December–February for winter. In terms of VKT, 31% occurs in the summer months and 20% during winter, with spring and autumn falling in between. Figure 6 shows the seasonal variation in road conditions as millions of kilometres driven. Dry road surfaces are prevalent in every season except in the winter, where snowy conditions are most common.

Table 2 presents the monthly variation as a proportion of VKT to further illustrate the relative commonness of each condition for the time of the year. January accounts for the largest share of wintery conditions (45% of VKT). The wettest month is November, with 51.6% of VKT in wet and moist conditions. In July, 84.7% of VKT occurs in dry conditions. In general, wintery conditions mainly occur between November and March.

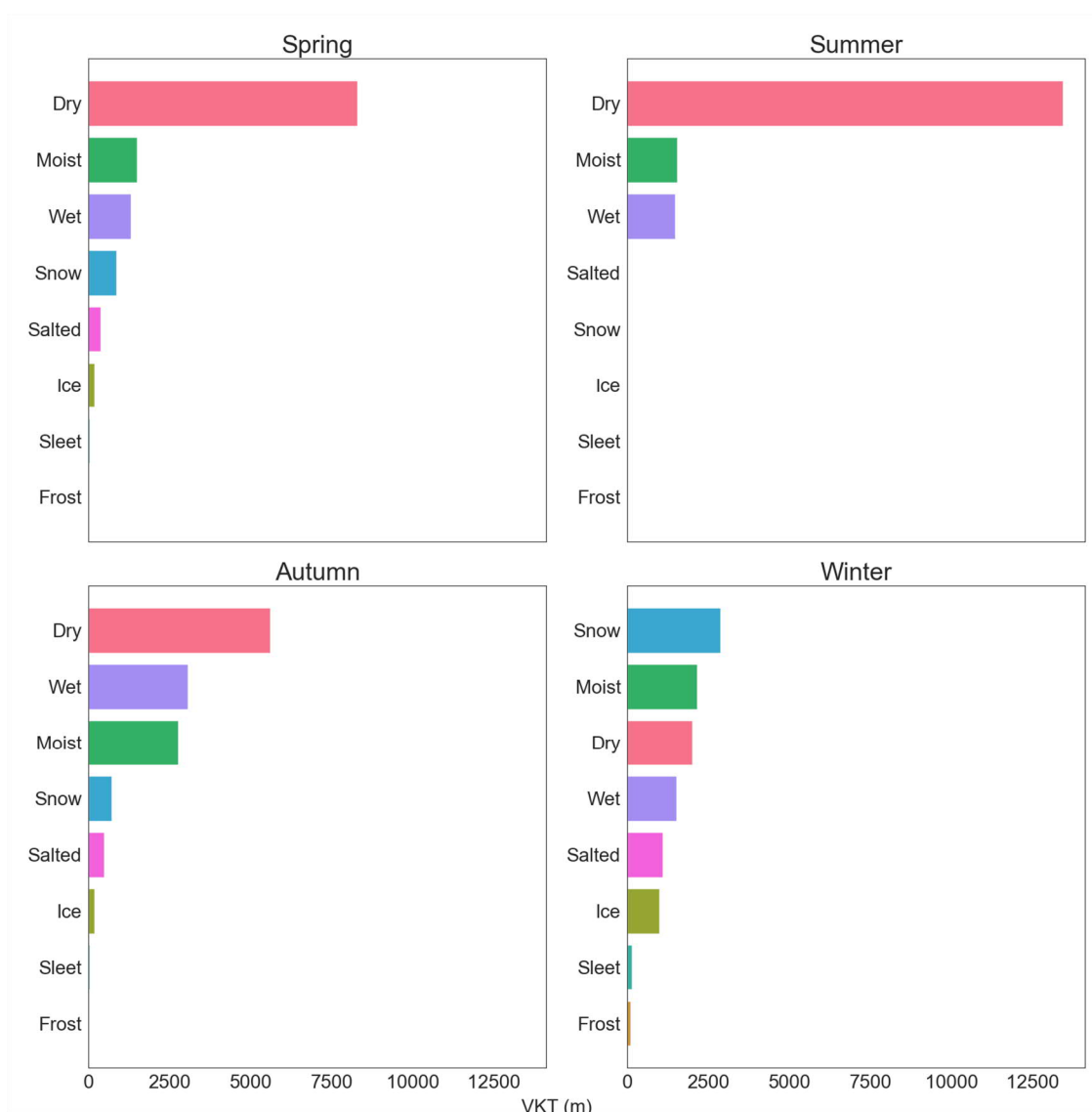


Figure 6: Seasonal variation in road conditions, in millions (m) of vehicle kilometres driven. Spring months: March–May. Summer: June–August. Autumn: September–November. Winter: December–February.



Table 2: Distribution of road conditions per average month (% of VKT)

| Month | Dry | Frost | Ice | Moist | Sleet | Snow | Wet | Salted |
|-------|--------|-------|--------|--------|-------|--------|--------|--------|
| 1 | 17.7 % | 1.3 % | 11.6 % | 18.6 % | 1.1 % | 31.0 % | 9.4 % | 9.3 % |
| 2 | 26.6 % | 0.5 % | 8.1 % | 17.8 % | 1.0 % | 26.8 % | 9.9 % | 9.2 % |
| 3 | 41.5 % | 0.1 % | 3.8 % | 16.4 % | 0.7 % | 17.6 % | 13.3 % | 6.6 % |
| 4 | 71.6 % | 0.0 % | 0.5 % | 12.0 % | 0.2 % | 3.5 % | 9.9 % | 2.1 % |
| 5 | 83.2 % | 0.0 % | 0.1 % | 8.0 % | 0.0 % | 0.4 % | 8.0 % | 0.3 % |
| 6 | 82.6 % | 0.0 % | 0.0 % | 8.7 % | 0.0 % | 0.1 % | 8.4 % | 0.1 % |
| 7 | 84.7 % | 0.0 % | 0.0 % | 8.0 % | 0.0 % | 0.1 % | 7.2 % | 0.1 % |
| 8 | 77.0 % | 0.0 % | 0.0 % | 11.3 % | 0.0 % | 0.2 % | 11.4 % | 0.2 % |
| 9 | 64.8 % | 0.0 % | 0.0 % | 16.3 % | 0.0 % | 0.2 % | 18.3 % | 0.3 % |
| 10 | 40.4 % | 0.0 % | 0.6 % | 25.4 % | 0.2 % | 4.2 % | 25.9 % | 3.4 % |
| 11 | 21.1 % | 0.4 % | 3.7 % | 23.5 % | 0.9 % | 13.8 % | 28.1 % | 8.4 % |
| 12 | 11.1 % | 0.7 % | 7.8 % | 22.9 % | 1.8 % | 22.2 % | 21.9 % | 11.6 % |

Road temperatures follow a similarly predictable pattern in terms of seasonal variation (see Figure 7). As much as 80% of the VKT occurs on road surfaces below zero degrees Celsius during winter. In the spring, this share drops to 22%, and autumns have a proportion of 18% of below-zero driving surface. 68% of kilometres driven during wintertime fall under the temperature range where salting can occur (-6 to 3 degrees). Similarly, in the spring the salting temperature range occurs on 29% of the VKT, and 31% in autumn.

A further breakdown on road conditions by each month and region is available in Appendix A. A similar table is available for road temperatures in Appendix B.

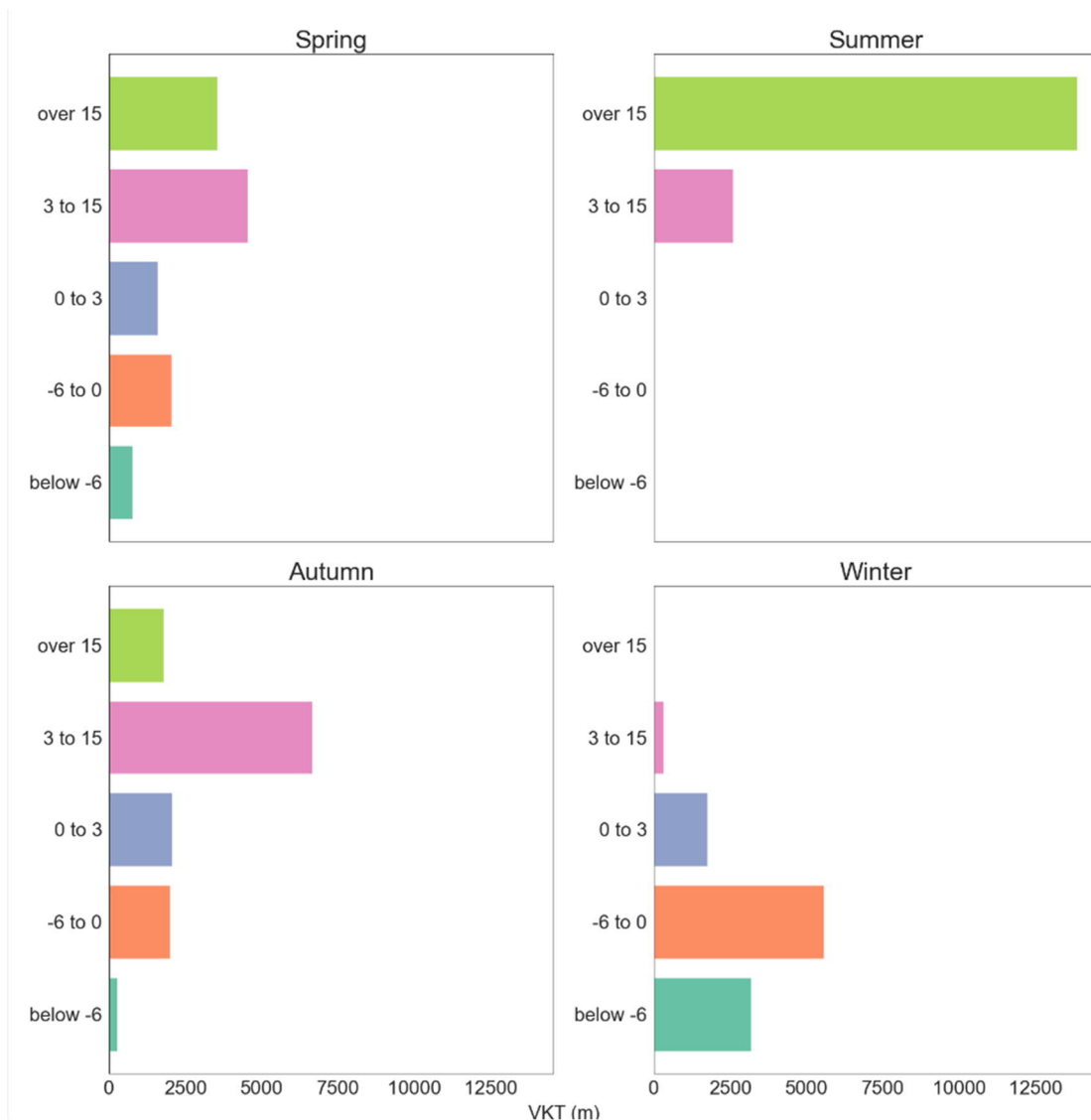


Figure 7: Seasonal variation in temperature ranges in degrees Celsius, in millions (m) of VKT

Table 3: Monthly variation in temperature ranges in degrees Celsius, % of VKT

| Month | below -6 | -6 to 0 | 0 to 3 | 3 to 15 | over 15 |
|-------|----------|---------|--------|---------|---------|
| 1 | 37.6 % | 51.7 % | 9.9 % | 0.8 % | |
| 2 | 39.5 % | 44.1 % | 13.4 % | 3.1 % | |
| 3 | 18.3 % | 36.3 % | 22.6 % | 22.1 % | 0.7 % |
| 4 | 1.2 % | 13.2 % | 13.4 % | 49.8 % | 22.3 % |
| 5 | | 1.4 % | 3.0 % | 36.4 % | 59.2 % |
| 6 | | | 0.1 % | 19.1 % | 80.8 % |
| 7 | | | | 10.4 % | 89.6 % |
| 8 | | | | 18.4 % | 81.6 % |
| 9 | | 0.8 % | 2.1 % | 60.2 % | 36.8 % |
| 10 | 0.7 % | 13.6 % | 19.0 % | 65.2 % | 1.5 % |
| 11 | 6.5 % | 36.7 % | 30.1 % | 26.6 % | |
| 12 | 12.2 % | 58.2 % | 24.9 % | 4.7 % | |



3.3 Distribution by region

The largest cities in Finland are located mainly in the south and south-west, with the region of Uusimaa containing the capital city and several of the most populous cities. This is reflected in the distribution of VKT regardless of road network type. In terms of VKT, Uusimaa contributes 26% to the national total. By comparison, the second largest region, Pirkanmaa, contributes 8% of VKT, and the smallest, Keski-Pohjanmaa, only 1.2%.

Figure 8 shows nine examples of regional distribution of road conditions, with southern regions on top, middle regions on second row and three northern regions in the bottom. Road conditions are in the order of prevalence. To illustrate the effect of region size on the national total, units are millions of kilometres driven. The most common road condition in all these regions is dry, with main differences in the increase of snowy road conditions toward the north. The relative distributions between road conditions for each region can be seen in



Table 4. The effect of geography is clearest in the categories of snow and ice, where the northern regions of Lappi and Kainuu have much larger share kilometres driven under those conditions.

To illustrate the regional differences in road temperatures, Figure 9 shows three different regions, one from the south, middle and north of Finland. In the northernmost region Lapland, 38% of kilometres are driven at below zero degrees Celsius, whereas the share for the middle region of Pohjois-Savo is 32% and for the southernmost Uusimaa is 20%. For the temperature range where salt could be applied, the ranges are much more even, with every region having their proportion of VKT in 27–30%. The temperature range distribution for each region is shown in Table 5.

Appendix A contains a table with detailed figures for each month and each region for road conditions. Appendix B holds the same information for road temperatures.

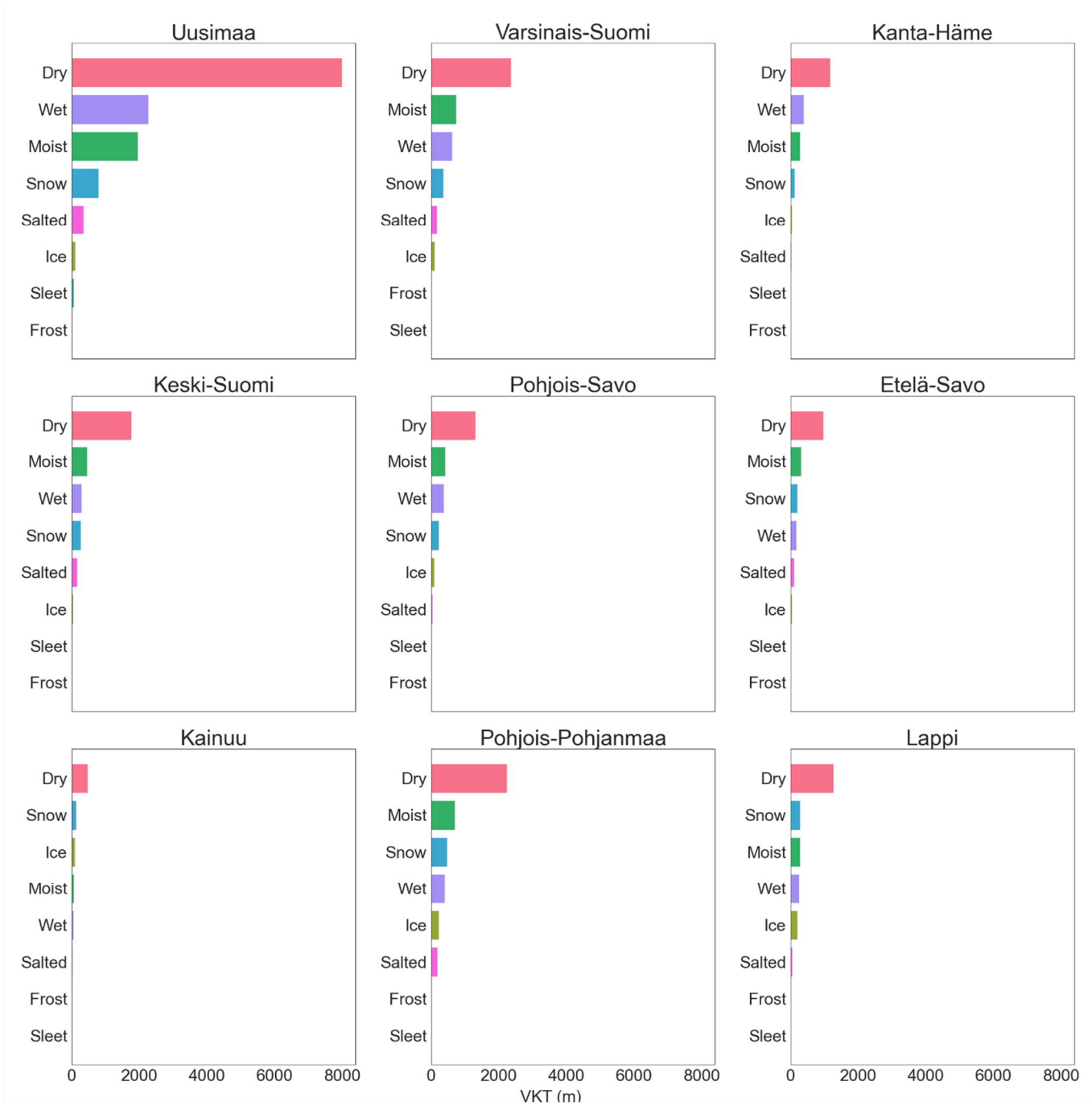


Figure 8: Examples of regional distributions of driving conditions, in millions of VKT

Table 4: Distribution of road conditions in each region (% of VKT)

| | NUTS3 | Dry | Frost | Ice | Moist | Sleet | Snow | Wet | Salted |
|-------------------|-------|--------|-------|--------|--------|-------|--------|--------|--------|
| Etelä-Karjala | FI1C5 | 49.2 % | 0.1 % | 3.3 % | 17.4 % | 0.6 % | 7.9 % | 17.0 % | 4.6 % |
| Etelä-Pohjanmaa | FI194 | 55.6 % | 0.2 % | 2.8 % | 15.8 % | 0.4 % | 9.6 % | 10.8 % | 4.7 % |
| Etelä-Savo | FI1D1 | 53.9 % | 0.1 % | 2.6 % | 16.9 % | 0.2 % | 10.8 % | 9.4 % | 6.0 % |
| Kainuu | FI1D4 | 55.6 % | 0.9 % | 10.6 % | 8.6 % | 0.0 % | 15.3 % | 6.3 % | 2.8 % |
| Kanta-Häme | FI1C2 | 57.1 % | 0.2 % | 1.8 % | 13.5 % | 0.8 % | 5.9 % | 19.1 % | 1.5 % |
| Keski-Pohjanmaa | FI195 | 55.9 % | 0.1 % | 2.9 % | 13.4 % | 0.0 % | 11.7 % | 9.4 % | 6.6 % |
| Keski-Suomi | FI193 | 58.6 % | 0.1 % | 1.3 % | 15.3 % | 0.2 % | 9.2 % | 10.0 % | 5.3 % |
| Kymenlaakso | FI1C4 | 53.4 % | 0.1 % | 2.7 % | 16.4 % | 0.7 % | 7.3 % | 16.2 % | 3.2 % |
| Lappi | FI1D7 | 53.4 % | 0.8 % | 8.3 % | 11.9 % | 0.3 % | 12.0 % | 10.7 % | 2.5 % |
| Pirkanmaa | FI197 | 53.4 % | 0.2 % | 1.3 % | 18.2 % | 0.6 % | 6.7 % | 16.6 % | 3.0 % |
| Pohjanmaa | FI195 | 54.1 % | 0.3 % | 3.2 % | 14.4 % | 0.4 % | 10.3 % | 12.7 % | 4.5 % |
| Pohjois-Karjala | FI1D3 | 52.1 % | 0.3 % | 3.4 % | 14.3 % | 0.5 % | 11.2 % | 16.1 % | 2.1 % |
| Pohjois-Pohjanmaa | FI1D6 | 52.7 % | 0.3 % | 5.3 % | 16.4 % | 0.3 % | 11.1 % | 9.4 % | 4.6 % |
| Pohjois-Savo | FI1D2 | 52.5 % | 0.3 % | 3.7 % | 16.6 % | 0.8 % | 9.4 % | 15.2 % | 1.5 % |
| Päijät-Häme | FI1C3 | 55.2 % | 0.1 % | 1.8 % | 12.3 % | 0.7 % | 8.7 % | 15.7 % | 5.5 % |
| Satakunta | FI196 | 61.2 % | 0.1 % | 0.8 % | 10.6 % | 0.0 % | 11.6 % | 6.1 % | 9.7 % |
| Uusimaa | FI1B1 | 59.0 % | 0.1 % | 0.8 % | 14.4 % | 0.5 % | 5.9 % | 16.7 % | 2.6 % |
| Varsinais-Suomi | FI1C1 | 53.9 % | 0.1 % | 2.5 % | 16.9 % | 0.1 % | 8.3 % | 14.1 % | 4.0 % |

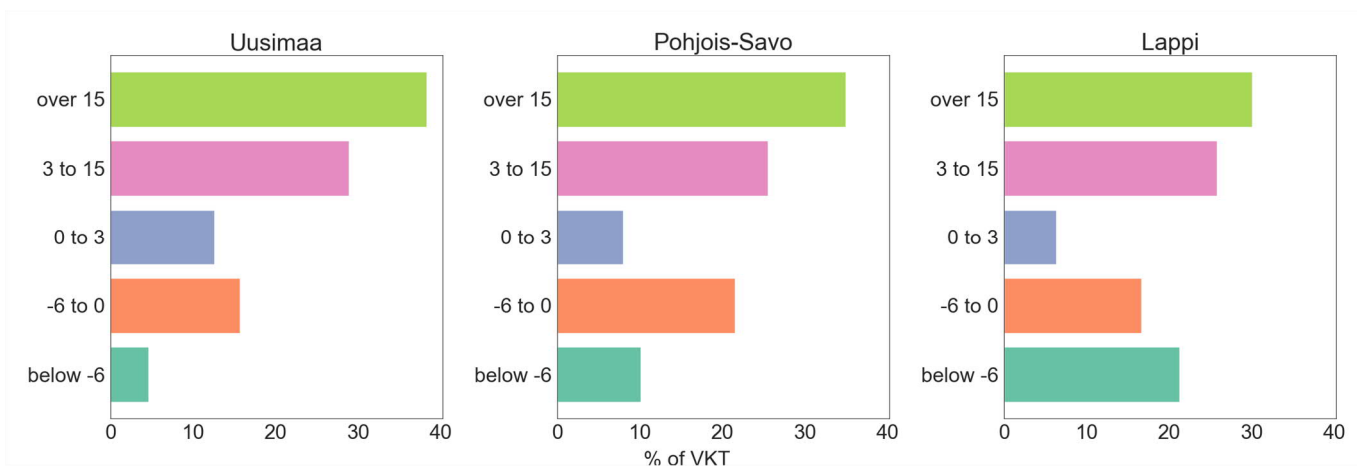


Figure 9: Example of regional differences in road temperature in degrees Celsius (% of VKT)

Table 5: Regional distribution in road temperature range in degrees Celsius (% of VKT)

| Region | NUTS3 | below -6 | -6 to 0 | 0 to 3 | 3 to 15 | over 15 |
|-------------------|-------|----------|---------|--------|---------|---------|
| Lappi | FI1D7 | 21.2 % | 16.6 % | 6.3 % | 25.8 % | 30.0 % |
| Kainuu | FI1D4 | 17.4 % | 20.5 % | 5.8 % | 24.6 % | 31.7 % |
| Pohjois-Pohjanmaa | FI1D6 | 13.0 % | 20.7 % | 6.6 % | 25.9 % | 33.8 % |
| Pohjois-Karjala | FI1D3 | 10.6 % | 21.6 % | 8.0 % | 26.3 % | 33.4 % |
| Keski-Pohjanmaa | FI1D5 | 10.2 % | 21.3 % | 7.7 % | 25.5 % | 35.3 % |
| Pohjois-Savo | FI1D2 | 10.1 % | 21.5 % | 8.0 % | 25.5 % | 34.9 % |
| Etelä-Savo | FI1D1 | 9.2 % | 21.2 % | 8.4 % | 25.3 % | 35.9 % |
| Keski-Suomi | FI193 | 9.1 % | 19.9 % | 9.8 % | 27.3 % | 34.0 % |
| Etelä-Pohjanmaa | FI194 | 9.0 % | 20.5 % | 9.0 % | 25.2 % | 36.3 % |
| Pohjanmaa | FI195 | 8.7 % | 20.2 % | 9.8 % | 25.2 % | 36.2 % |
| Etelä-Karjala | FI1C5 | 7.7 % | 19.6 % | 9.5 % | 25.7 % | 37.6 % |
| Päijät-Häme | FI1C3 | 7.4 % | 19.5 % | 10.3 % | 26.3 % | 36.5 % |
| Pirkanmaa | FI197 | 7.2 % | 17.8 % | 11.6 % | 27.1 % | 36.4 % |
| Satakunta | FI196 | 6.8 % | 18.6 % | 11.0 % | 25.8 % | 37.8 % |
| Kanta-Häme | FI1C2 | 6.4 % | 18.2 % | 11.0 % | 25.7 % | 38.6 % |
| Kymenlaakso | FI1C4 | 5.7 % | 17.3 % | 11.6 % | 25.7 % | 39.8 % |
| Varsinais-Suomi | FI1C1 | 4.6 % | 17.0 % | 11.9 % | 27.1 % | 39.3 % |
| Uusimaa | FI1B1 | 4.6 % | 15.7 % | 12.6 % | 28.9 % | 38.3 % |

4. Discussion

The most prevalent road condition on Finnish roads by vehicle kilometres driven is a dry road surface (56%), followed by wet and moist surfaces (29%). However, wintery conditions such as snow, ice and sleet still account for a significant proportion (12%). The distribution of conditions and temperatures is influenced both by season and geography, with winters being at least partially snowy in the whole country and much colder and snowier in the north. The main result of this study is that the share of annual VKT in different conditions in Finland is influenced by road class, geographic location and seasonal variation. These factors are unlikely to change in the short-term.

The prevalence of dry conditions in the overall VKT can mostly be attributed to the fact that a large share of the kilometres are driven on the main roads, which are maintained well even in winter conditions. The larger cities are a major source of traffic, and urban road conditions differ only slightly from the main roads. In addition, the largest cities are in the southern and western parts of the country, which do not experience the coldest temperatures and are not as prone to be snowy or icy as the northern, more sparsely populated areas.

Lapland (*Lappi*) is the northernmost region. Its VKT is low, but winter conditions dominate: snowy and icy conditions account for 26% of annual VKT, and 38% of annual VKT is driven on road surfaces below zero degrees Celsius in temperature. The regional differences are greatest between the sparsely populated northern regions and the densely populated southern regions, especially the capital region Uusimaa.

According to the interviewed winter maintenance experts, the “dry” category for the main roads could in some cases be best interpreted as “bare” rather than “dry”. It can refer to conditions where any snow or ice is cleared away and the surface temperature is below zero with no moisture present. One of the limitations of the study was that we were not able to determine the exact criteria of classification for the road conditions, except that they were based on road surface sensors (incl. moisture, temperature).

It should be noted that data was only available for the main road network, and although geographically well distributed, it consisted of only ~12% of all road segments in the network and approximately 10% of the total VKT for the main roads. This leaves open the possibility that sensor placement may have influenced the result by some unknown quantity, possibly by sensors being placed on especially well-maintained road segments. It is unlikely to have greatly affected the road temperature distribution, which is determined primarily by weather conditions. Further, ambiguity in the Vaisala Oyj dataset and the difficulty of interpreting the exact definition criteria for each road condition class may be another source of error. However, the general consistency of the results with well-known facts of weather and geography leads us to believe that the data quality was robust.

5. Summary

The study examined the prevalence of road conditions and road temperatures in Finland as vehicle kilometres driven. The distribution of conditions was estimated for the main roads using data originating from road surface sensors. The estimate for regional and connecting roads and urban street networks was derived from the estimate for main roads with help from road weather experts. The results are presented as yearly averages and broken down into monthly and regional estimates to explain where and when the kilometres were driven and how these factors influenced the distribution. The most common road condition per vehicle kilometre driven is dry (56%), followed by wet and moist conditions (29%). Furthermore, snowy and icy conditions (12%) are an important category for the whole country, especially during winter, when 38% of kilometres are driven on icy or snowy surfaces. 26% of the annual driving occurs on surfaces below zero degrees Celsius.

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7. Appendixes

The appendixes consist of two parts: Appendix A contains the estimated amount of different road conditions in millions of VKT for an average year for each month and each region. Appendix B contains the same information for the road temperature classes.

7.1 APPENDIX A

Road conditions in millions (m) of VKT.

| Month | Region | DRY | FROST | ICE | MOIST | SLEET | SNOW | WET | SALTED |
|-------|---------------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 | Etelä-Karjala | 10.83 | 0.05 | 11.88 | 12.06 | 1.30 | 24.94 | 9.22 | 8.83 |
| 2 | Etelä-Karjala | 17.67 | 0.16 | 11.19 | 17.55 | 1.49 | 20.61 | 10.16 | 9.65 |
| 3 | Etelä-Karjala | 34.53 | 0.01 | 4.11 | 16.98 | 0.75 | 14.02 | 15.46 | 7.81 |



| | | | | | | | | | |
|----|-----------------|--------|------|-------|-------|------|-------|-------|-------|
| 4 | Etelä-Karjala | 68.18 | 0.00 | 0.52 | 12.48 | 0.26 | 2.55 | 12.57 | 2.07 |
| 5 | Etelä-Karjala | 73.88 | 0.00 | 0.11 | 13.85 | 0.02 | 0.10 | 15.65 | 0.12 |
| 6 | Etelä-Karjala | 91.16 | 0.00 | 0.00 | 21.31 | 0.00 | 0.04 | 11.32 | 0.05 |
| 7 | Etelä-Karjala | 103.37 | 0.00 | 0.00 | 24.92 | 0.00 | 0.01 | 10.34 | 0.01 |
| 8 | Etelä-Karjala | 90.19 | 0.00 | 0.00 | 23.45 | 0.00 | 0.00 | 13.39 | 0.01 |
| 9 | Etelä-Karjala | 70.16 | 0.00 | 0.00 | 19.59 | 0.00 | 0.00 | 21.21 | 0.00 |
| 10 | Etelä-Karjala | 33.12 | 0.11 | 0.95 | 20.16 | 0.10 | 3.92 | 40.78 | 4.16 |
| 11 | Etelä-Karjala | 16.85 | 0.32 | 3.34 | 17.71 | 1.26 | 13.29 | 26.61 | 9.96 |
| 12 | Etelä-Karjala | 3.00 | 0.03 | 9.50 | 16.26 | 2.19 | 18.67 | 24.48 | 14.51 |
| 1 | Etelä-Pohjanmaa | 27.00 | 1.60 | 15.27 | 21.96 | 1.40 | 40.90 | 5.68 | 14.75 |
| 2 | Etelä-Pohjanmaa | 41.95 | 0.63 | 10.43 | 23.42 | 0.82 | 43.55 | 8.56 | 14.43 |
| 3 | Etelä-Pohjanmaa | 63.25 | 0.11 | 7.31 | 21.84 | 1.28 | 32.27 | 14.14 | 12.05 |
| 4 | Etelä-Pohjanmaa | 109.26 | 0.00 | 0.61 | 20.64 | 0.45 | 7.13 | 16.70 | 5.50 |
| 5 | Etelä-Pohjanmaa | 141.61 | 0.00 | 0.22 | 12.84 | 0.04 | 0.79 | 12.33 | 0.77 |
| 6 | Etelä-Pohjanmaa | 163.55 | 0.00 | 0.00 | 21.29 | 0.00 | 0.21 | 16.02 | 0.27 |
| 7 | Etelä-Pohjanmaa | 192.03 | 0.00 | 0.00 | 21.81 | 0.00 | 0.09 | 11.31 | 0.12 |
| 8 | Etelä-Pohjanmaa | 164.62 | 0.00 | 0.00 | 21.51 | 0.00 | 1.11 | 17.80 | 1.45 |
| 9 | Etelä-Pohjanmaa | 115.34 | 0.00 | 0.01 | 30.88 | 0.00 | 1.43 | 30.81 | 1.86 |
| 10 | Etelä-Pohjanmaa | 73.75 | 0.00 | 0.76 | 45.50 | 0.54 | 8.86 | 33.09 | 5.42 |
| 11 | Etelä-Pohjanmaa | 19.34 | 0.68 | 8.05 | 43.16 | 1.18 | 23.32 | 32.15 | 17.32 |
| 12 | Etelä-Pohjanmaa | 14.43 | 1.68 | 13.70 | 35.70 | 2.48 | 35.21 | 19.66 | 21.20 |
| 1 | Etelä-Savo | 18.80 | 1.15 | 14.01 | 21.74 | 0.74 | 41.17 | 4.35 | 13.35 |
| 2 | Etelä-Savo | 30.67 | 0.66 | 9.70 | 21.46 | 0.44 | 43.35 | 4.23 | 18.45 |
| 3 | Etelä-Savo | 44.47 | 0.10 | 5.92 | 27.31 | 0.54 | 30.95 | 9.99 | 17.27 |
| 4 | Etelä-Savo | 100.00 | 0.00 | 0.80 | 21.08 | 0.23 | 6.26 | 10.65 | 4.74 |
| 5 | Etelä-Savo | 126.08 | 0.00 | 0.01 | 14.43 | 0.07 | 0.40 | 9.75 | 0.46 |
| 6 | Etelä-Savo | 148.85 | 0.00 | 0.00 | 20.63 | 0.00 | 0.00 | 11.10 | 0.00 |
| 7 | Etelä-Savo | 169.87 | 0.00 | 0.00 | 21.38 | 0.00 | 0.00 | 10.87 | 0.00 |
| 8 | Etelä-Savo | 144.54 | 0.00 | 0.00 | 26.09 | 0.00 | 0.00 | 14.56 | 0.00 |
| 9 | Etelä-Savo | 105.90 | 0.00 | 0.01 | 31.42 | 0.00 | 0.04 | 24.34 | 0.03 |
| 10 | Etelä-Savo | 56.65 | 0.05 | 0.64 | 39.65 | 0.16 | 8.83 | 33.58 | 11.04 |
| 11 | Etelä-Savo | 24.25 | 0.21 | 3.72 | 32.02 | 0.66 | 25.81 | 23.94 | 19.60 |
| 12 | Etelä-Savo | 8.99 | 0.09 | 11.86 | 30.50 | 1.17 | 39.74 | 12.50 | 24.35 |
| 1 | Kainuu | 3.73 | 3.33 | 23.66 | 2.07 | 0.00 | 20.30 | 0.12 | 0.95 |
| 2 | Kainuu | 7.84 | 1.87 | 21.42 | 5.38 | 0.00 | 20.15 | 0.17 | 3.73 |
| 3 | Kainuu | 21.17 | 0.23 | 8.35 | 5.14 | 0.00 | 24.41 | 1.91 | 2.91 |
| 4 | Kainuu | 48.97 | 0.00 | 0.91 | 4.85 | 0.00 | 7.02 | 4.16 | 1.61 |
| 5 | Kainuu | 56.68 | 0.00 | 0.26 | 6.63 | 0.00 | 2.19 | 4.20 | 1.05 |
| 6 | Kainuu | 73.25 | 0.00 | 0.01 | 6.65 | 0.00 | 0.05 | 4.83 | 0.03 |
| 7 | Kainuu | 88.07 | 0.00 | 0.00 | 4.56 | 0.00 | 0.00 | 2.29 | 0.00 |
| 8 | Kainuu | 73.82 | 0.00 | 0.00 | 6.21 | 0.00 | 0.01 | 6.94 | 0.01 |
| 9 | Kainuu | 57.11 | 0.00 | 0.00 | 9.03 | 0.00 | 0.34 | 9.21 | 0.27 |
| 10 | Kainuu | 31.83 | 0.00 | 0.66 | 13.65 | 0.00 | 8.57 | 11.09 | 4.92 |
| 11 | Kainuu | 6.86 | 0.41 | 7.36 | 6.11 | 0.00 | 25.76 | 8.61 | 6.04 |
| 12 | Kainuu | 4.35 | 1.66 | 27.54 | 3.18 | 0.00 | 21.34 | 0.20 | 2.42 |
| 1 | Kanta-Häme | 16.78 | 1.71 | 13.28 | 26.56 | 2.48 | 37.35 | 27.68 | 5.39 |



| | | | | | | | | | |
|----|-----------------|--------|------|-------|-------|------|-------|-------|-------|
| 2 | Kanta-Häme | 35.36 | 0.55 | 8.29 | 30.11 | 2.91 | 34.26 | 29.45 | 5.84 |
| 3 | Kanta-Häme | 67.48 | 0.01 | 3.13 | 29.34 | 3.13 | 15.61 | 33.28 | 3.44 |
| 4 | Kanta-Häme | 122.93 | 0.00 | 0.69 | 15.97 | 0.57 | 2.10 | 20.06 | 1.27 |
| 5 | Kanta-Häme | 155.15 | 0.00 | 0.03 | 5.02 | 0.00 | 0.05 | 11.82 | 0.01 |
| 6 | Kanta-Häme | 177.58 | 0.00 | 0.00 | 7.18 | 0.00 | 0.00 | 20.74 | 0.00 |
| 7 | Kanta-Häme | 198.34 | 0.00 | 0.00 | 14.65 | 0.00 | 0.00 | 17.03 | 0.00 |
| 8 | Kanta-Häme | 172.20 | 0.00 | 0.00 | 13.68 | 0.00 | 0.00 | 24.88 | 0.00 |
| 9 | Kanta-Häme | 125.37 | 0.00 | 0.00 | 22.67 | 0.00 | 0.00 | 36.04 | 0.00 |
| 10 | Kanta-Häme | 72.24 | 0.00 | 0.48 | 38.34 | 0.27 | 2.06 | 56.55 | 1.46 |
| 11 | Kanta-Häme | 27.38 | 1.03 | 4.01 | 36.44 | 2.81 | 12.44 | 59.64 | 4.46 |
| 12 | Kanta-Häme | 9.38 | 1.62 | 7.00 | 39.77 | 4.99 | 17.72 | 57.55 | 9.01 |
| 1 | Keski-Pohjanmaa | 8.11 | 0.61 | 4.80 | 7.59 | 0.00 | 12.39 | 0.20 | 5.33 |
| 2 | Keski-Pohjanmaa | 9.70 | 0.06 | 5.14 | 8.50 | 0.00 | 13.72 | 0.52 | 5.99 |
| 3 | Keski-Pohjanmaa | 16.62 | 0.05 | 2.04 | 7.05 | 0.00 | 11.95 | 3.08 | 5.42 |
| 4 | Keski-Pohjanmaa | 33.96 | 0.00 | 0.17 | 5.58 | 0.00 | 2.88 | 4.04 | 2.02 |
| 5 | Keski-Pohjanmaa | 42.20 | 0.00 | 0.02 | 4.10 | 0.00 | 0.53 | 3.84 | 0.49 |
| 6 | Keski-Pohjanmaa | 52.64 | 0.00 | 0.00 | 4.17 | 0.00 | 0.15 | 3.98 | 0.17 |
| 7 | Keski-Pohjanmaa | 60.47 | 0.00 | 0.00 | 4.18 | 0.00 | 0.03 | 3.69 | 0.03 |
| 8 | Keski-Pohjanmaa | 50.72 | 0.00 | 0.00 | 5.89 | 0.00 | 0.04 | 5.98 | 0.04 |
| 9 | Keski-Pohjanmaa | 33.86 | 0.00 | 0.03 | 7.78 | 0.00 | 0.20 | 12.63 | 0.23 |
| 10 | Keski-Pohjanmaa | 25.22 | 0.00 | 0.10 | 9.78 | 0.00 | 3.22 | 10.26 | 2.39 |
| 11 | Keski-Pohjanmaa | 4.63 | 0.02 | 2.03 | 9.66 | 0.00 | 11.43 | 7.14 | 9.17 |
| 12 | Keski-Pohjanmaa | 5.48 | 0.17 | 3.20 | 8.18 | 0.00 | 15.10 | 2.47 | 9.13 |
| 1 | Keski-Suomi | 52.76 | 1.46 | 12.54 | 37.86 | 0.79 | 55.25 | 7.33 | 23.57 |
| 2 | Keski-Suomi | 65.45 | 0.72 | 11.65 | 36.52 | 1.09 | 61.93 | 7.42 | 29.45 |
| 3 | Keski-Suomi | 94.04 | 0.09 | 4.44 | 38.71 | 0.71 | 46.30 | 16.49 | 26.07 |
| 4 | Keski-Suomi | 171.50 | 0.00 | 0.66 | 28.44 | 0.31 | 11.00 | 18.12 | 8.80 |
| 5 | Keski-Suomi | 207.32 | 0.00 | 0.03 | 22.44 | 0.07 | 1.84 | 17.36 | 2.14 |
| 6 | Keski-Suomi | 254.72 | 0.00 | 0.00 | 23.77 | 0.00 | 0.01 | 21.48 | 0.01 |
| 7 | Keski-Suomi | 298.57 | 0.00 | 0.00 | 22.54 | 0.00 | 0.00 | 14.65 | 0.01 |
| 8 | Keski-Suomi | 246.78 | 0.00 | 0.00 | 36.11 | 0.00 | 0.00 | 24.78 | 0.00 |
| 9 | Keski-Suomi | 185.34 | 0.00 | 0.04 | 42.33 | 0.00 | 0.22 | 40.48 | 0.30 |
| 10 | Keski-Suomi | 99.65 | 0.02 | 0.29 | 63.99 | 0.10 | 13.85 | 56.71 | 15.59 |
| 11 | Keski-Suomi | 50.56 | 1.03 | 3.12 | 52.71 | 1.64 | 31.64 | 52.53 | 23.11 |
| 12 | Keski-Suomi | 39.40 | 0.51 | 7.18 | 55.55 | 2.19 | 54.02 | 23.86 | 31.95 |
| 1 | Kymenlaakso | 10.79 | 0.82 | 12.93 | 20.80 | 1.78 | 33.69 | 11.95 | 8.31 |
| 2 | Kymenlaakso | 20.47 | 0.31 | 12.70 | 18.80 | 2.71 | 31.05 | 14.40 | 12.58 |
| 3 | Kymenlaakso | 40.99 | 0.13 | 4.85 | 24.77 | 1.41 | 17.61 | 22.75 | 7.16 |
| 4 | Kymenlaakso | 84.44 | 0.01 | 0.41 | 21.20 | 0.22 | 3.79 | 13.35 | 2.58 |
| 5 | Kymenlaakso | 112.07 | 0.00 | 0.04 | 9.86 | 0.00 | 0.14 | 10.30 | 0.14 |
| 6 | Kymenlaakso | 130.42 | 0.00 | 0.00 | 14.49 | 0.00 | 0.02 | 13.31 | 0.03 |
| 7 | Kymenlaakso | 152.25 | 0.00 | 0.00 | 12.39 | 0.00 | 0.01 | 12.49 | 0.02 |
| 8 | Kymenlaakso | 129.09 | 0.00 | 0.00 | 15.99 | 0.00 | 0.01 | 17.21 | 0.02 |
| 9 | Kymenlaakso | 91.75 | 0.00 | 0.00 | 22.28 | 0.00 | 0.08 | 27.58 | 0.09 |
| 10 | Kymenlaakso | 44.05 | 0.06 | 0.83 | 41.29 | 0.43 | 4.22 | 37.25 | 3.90 |
| 11 | Kymenlaakso | 25.62 | 0.22 | 3.01 | 30.41 | 0.94 | 9.04 | 39.44 | 5.47 |



| | | | | | | | | | |
|----|-----------------|--------|------|-------|--------|------|-------|--------|-------|
| 12 | Kymenlaakso | 7.23 | 0.62 | 8.74 | 28.33 | 2.92 | 17.22 | 38.14 | 10.05 |
| 1 | Lappi | 15.25 | 5.76 | 45.52 | 14.36 | 1.63 | 62.70 | 3.35 | 2.79 |
| 2 | Lappi | 29.40 | 3.51 | 43.34 | 27.21 | 0.40 | 52.70 | 5.99 | 6.73 |
| 3 | Lappi | 56.61 | 0.58 | 28.12 | 26.31 | 0.89 | 48.59 | 11.72 | 6.42 |
| 4 | Lappi | 134.17 | 0.01 | 3.21 | 20.76 | 0.34 | 10.33 | 15.72 | 4.15 |
| 5 | Lappi | 163.85 | 0.00 | 0.18 | 12.65 | 0.05 | 0.77 | 20.49 | 0.48 |
| 6 | Lappi | 201.73 | 0.00 | 0.00 | 15.23 | 0.00 | 0.11 | 19.75 | 0.20 |
| 7 | Lappi | 244.27 | 0.00 | 0.00 | 10.55 | 0.00 | 0.15 | 10.05 | 0.28 |
| 8 | Lappi | 186.69 | 0.00 | 0.00 | 27.56 | 0.00 | 0.03 | 28.74 | 0.06 |
| 9 | Lappi | 139.15 | 0.00 | 0.16 | 34.79 | 0.00 | 0.39 | 37.69 | 0.13 |
| 10 | Lappi | 75.56 | 0.37 | 7.84 | 44.77 | 0.17 | 12.50 | 43.93 | 12.56 |
| 11 | Lappi | 13.41 | 3.92 | 27.93 | 27.79 | 0.98 | 37.51 | 42.76 | 16.63 |
| 12 | Lappi | 13.37 | 4.87 | 40.53 | 21.98 | 3.17 | 60.65 | 14.87 | 10.16 |
| 1 | Pirkanmaa | 63.40 | 3.84 | 18.40 | 65.02 | 4.27 | 97.01 | 36.94 | 26.23 |
| 2 | Pirkanmaa | 94.09 | 1.45 | 14.89 | 69.62 | 5.05 | 80.12 | 57.44 | 29.74 |
| 3 | Pirkanmaa | 155.02 | 0.30 | 8.08 | 65.41 | 4.56 | 46.81 | 73.61 | 19.35 |
| 4 | Pirkanmaa | 282.21 | 0.01 | 1.44 | 46.34 | 1.04 | 7.22 | 49.48 | 5.11 |
| 5 | Pirkanmaa | 358.39 | 0.00 | 0.16 | 25.81 | 0.00 | 0.59 | 27.67 | 0.57 |
| 6 | Pirkanmaa | 395.37 | 0.00 | 0.00 | 46.95 | 0.00 | 0.04 | 51.04 | 0.05 |
| 7 | Pirkanmaa | 444.62 | 0.00 | 0.00 | 51.08 | 0.00 | 0.00 | 56.62 | 0.00 |
| 8 | Pirkanmaa | 356.12 | 0.00 | 0.00 | 83.45 | 0.00 | 0.00 | 66.51 | 0.00 |
| 9 | Pirkanmaa | 246.28 | 0.00 | 0.02 | 99.27 | 0.00 | 1.77 | 92.27 | 2.39 |
| 10 | Pirkanmaa | 139.55 | 0.01 | 0.91 | 145.04 | 0.58 | 11.38 | 103.22 | 10.87 |
| 11 | Pirkanmaa | 69.84 | 4.08 | 8.47 | 104.37 | 3.86 | 32.40 | 109.70 | 23.13 |
| 12 | Pirkanmaa | 41.93 | 2.31 | 13.00 | 102.32 | 8.29 | 57.17 | 98.58 | 29.48 |
| 1 | Pohjanmaa | 12.52 | 2.07 | 15.38 | 18.27 | 1.38 | 33.24 | 6.86 | 12.45 |
| 2 | Pohjanmaa | 22.86 | 0.56 | 9.24 | 20.41 | 1.35 | 36.92 | 11.75 | 11.18 |
| 3 | Pohjanmaa | 41.35 | 0.18 | 5.71 | 19.01 | 0.69 | 28.04 | 17.08 | 8.93 |
| 4 | Pohjanmaa | 77.06 | 0.00 | 0.98 | 19.12 | 0.14 | 10.22 | 13.20 | 6.67 |
| 5 | Pohjanmaa | 110.35 | 0.00 | 0.06 | 11.40 | 0.07 | 0.52 | 11.17 | 0.42 |
| 6 | Pohjanmaa | 136.77 | 0.00 | 0.00 | 8.98 | 0.00 | 0.09 | 14.10 | 0.08 |
| 7 | Pohjanmaa | 161.93 | 0.00 | 0.00 | 8.64 | 0.00 | 0.05 | 8.43 | 0.04 |
| 8 | Pohjanmaa | 140.71 | 0.00 | 0.00 | 11.49 | 0.00 | 0.05 | 11.82 | 0.05 |
| 9 | Pohjanmaa | 95.91 | 0.00 | 0.31 | 18.76 | 0.00 | 0.05 | 28.24 | 0.05 |
| 10 | Pohjanmaa | 52.17 | 0.00 | 0.96 | 33.81 | 0.35 | 9.00 | 31.93 | 5.23 |
| 11 | Pohjanmaa | 10.86 | 1.15 | 5.77 | 38.07 | 0.72 | 18.50 | 28.68 | 11.64 |
| 12 | Pohjanmaa | 7.94 | 1.21 | 13.85 | 24.30 | 1.97 | 28.55 | 20.37 | 16.29 |
| 1 | Pohjois-Karjala | 18.79 | 1.98 | 12.51 | 12.63 | 0.57 | 40.64 | 10.74 | 4.61 |
| 2 | Pohjois-Karjala | 26.98 | 1.18 | 14.32 | 13.74 | 1.13 | 39.90 | 10.75 | 6.60 |
| 3 | Pohjois-Karjala | 43.73 | 1.50 | 4.74 | 17.99 | 1.35 | 29.48 | 17.71 | 4.86 |
| 4 | Pohjois-Karjala | 87.14 | 0.00 | 1.66 | 14.59 | 0.56 | 5.84 | 16.42 | 1.53 |
| 5 | Pohjois-Karjala | 101.96 | 0.00 | 0.18 | 12.95 | 0.13 | 0.46 | 18.54 | 0.15 |
| 6 | Pohjois-Karjala | 128.56 | 0.00 | 0.00 | 10.71 | 0.00 | 0.01 | 21.18 | 0.01 |
| 7 | Pohjois-Karjala | 140.31 | 0.00 | 0.00 | 12.89 | 0.00 | 0.01 | 26.40 | 0.01 |
| 8 | Pohjois-Karjala | 115.35 | 0.00 | 0.00 | 25.16 | 0.00 | 0.00 | 24.06 | 0.00 |
| 9 | Pohjois-Karjala | 83.19 | 0.00 | 0.25 | 32.94 | 0.00 | 0.09 | 27.22 | 0.04 |



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|----|-------------------|--------|------|-------|-------|------|-------|-------|-------|
| 10 | Pohjois-Karjala | 53.24 | 0.00 | 1.40 | 32.43 | 0.55 | 6.95 | 35.77 | 3.50 |
| 11 | Pohjois-Karjala | 26.00 | 0.30 | 5.61 | 22.71 | 1.75 | 21.71 | 31.41 | 6.23 |
| 12 | Pohjois-Karjala | 14.85 | 0.18 | 14.88 | 21.54 | 2.14 | 36.33 | 18.90 | 6.01 |
| 1 | Pohjois-Pohjanmaa | 29.79 | 5.90 | 68.22 | 56.50 | 1.87 | 84.83 | 3.22 | 20.88 |
| 2 | Pohjois-Pohjanmaa | 56.35 | 2.32 | 51.28 | 72.06 | 1.40 | 87.55 | 5.22 | 27.14 |
| 3 | Pohjois-Pohjanmaa | 98.36 | 0.65 | 26.97 | 60.11 | 1.08 | 84.29 | 21.26 | 28.44 |
| 4 | Pohjois-Pohjanmaa | 231.11 | 0.00 | 2.78 | 43.80 | 0.28 | 18.95 | 28.23 | 12.97 |
| 5 | Pohjois-Pohjanmaa | 277.14 | 0.00 | 0.88 | 37.66 | 0.25 | 3.88 | 32.69 | 3.14 |
| 6 | Pohjois-Pohjanmaa | 360.18 | 0.00 | 0.00 | 32.83 | 0.00 | 0.28 | 31.05 | 0.37 |
| 7 | Pohjois-Pohjanmaa | 424.22 | 0.00 | 0.00 | 31.86 | 0.00 | 0.24 | 18.75 | 0.32 |
| 8 | Pohjois-Pohjanmaa | 328.26 | 0.00 | 0.00 | 46.18 | 0.00 | 3.61 | 52.70 | 4.83 |
| 9 | Pohjois-Pohjanmaa | 247.40 | 0.00 | 0.20 | 70.28 | 0.00 | 1.16 | 60.06 | 1.33 |
| 10 | Pohjois-Pohjanmaa | 144.15 | 0.00 | 4.48 | 91.21 | 0.61 | 21.63 | 74.44 | 17.70 |
| 11 | Pohjois-Pohjanmaa | 25.16 | 1.13 | 19.55 | 84.87 | 3.27 | 74.57 | 56.15 | 41.58 |
| 12 | Pohjois-Pohjanmaa | 26.64 | 2.62 | 51.01 | 71.89 | 3.38 | 91.79 | 19.22 | 37.33 |
| 1 | Pohjois-Savo | 30.78 | 1.55 | 19.30 | 22.43 | 2.66 | 59.66 | 14.97 | 6.33 |
| 2 | Pohjois-Savo | 48.77 | 2.49 | 20.10 | 28.65 | 2.48 | 51.09 | 15.45 | 7.31 |
| 3 | Pohjois-Savo | 65.82 | 0.47 | 13.00 | 33.96 | 2.04 | 35.13 | 32.24 | 4.06 |
| 4 | Pohjois-Savo | 137.35 | 0.39 | 3.23 | 20.40 | 0.86 | 5.90 | 27.27 | 1.16 |
| 5 | Pohjois-Savo | 152.10 | 0.00 | 0.19 | 27.50 | 0.30 | 0.68 | 25.92 | 0.08 |
| 6 | Pohjois-Savo | 183.33 | 0.00 | 0.00 | 39.99 | 0.00 | 0.02 | 23.57 | 0.02 |
| 7 | Pohjois-Savo | 219.51 | 0.00 | 0.00 | 38.36 | 0.00 | 0.02 | 18.47 | 0.03 |
| 8 | Pohjois-Savo | 200.95 | 0.00 | 0.00 | 27.45 | 0.00 | 0.01 | 24.82 | 0.01 |
| 9 | Pohjois-Savo | 131.22 | 0.00 | 0.02 | 40.25 | 0.00 | 0.15 | 49.34 | 0.20 |
| 10 | Pohjois-Savo | 91.31 | 0.04 | 1.64 | 49.15 | 0.59 | 5.30 | 57.10 | 0.81 |
| 11 | Pohjois-Savo | 28.05 | 0.83 | 10.44 | 46.84 | 4.69 | 24.46 | 54.01 | 8.75 |
| 12 | Pohjois-Savo | 15.28 | 1.10 | 24.04 | 38.06 | 6.18 | 50.32 | 34.39 | 7.30 |
| 1 | Päijät-Häme | 25.04 | 1.24 | 14.03 | 16.41 | 2.89 | 44.01 | 16.05 | 18.48 |
| 2 | Päijät-Häme | 36.32 | 0.20 | 8.09 | 20.55 | 2.68 | 44.54 | 20.97 | 21.15 |
| 3 | Päijät-Häme | 66.60 | 0.03 | 4.09 | 21.48 | 1.82 | 28.90 | 22.18 | 18.49 |
| 4 | Päijät-Häme | 124.60 | 0.00 | 0.75 | 18.47 | 0.45 | 5.84 | 17.54 | 4.59 |
| 5 | Päijät-Häme | 159.42 | 0.00 | 0.08 | 9.07 | 0.02 | 0.11 | 12.43 | 0.04 |
| 6 | Päijät-Häme | 180.49 | 0.00 | 0.00 | 16.76 | 0.00 | 0.00 | 19.10 | 0.00 |
| 7 | Päijät-Häme | 209.36 | 0.00 | 0.00 | 17.77 | 0.00 | 0.00 | 15.03 | 0.00 |
| 8 | Päijät-Häme | 174.12 | 0.00 | 0.00 | 19.52 | 0.00 | 0.00 | 28.24 | 0.00 |
| 9 | Päijät-Häme | 121.16 | 0.00 | 0.00 | 26.83 | 0.00 | 0.00 | 45.79 | 0.00 |
| 10 | Päijät-Häme | 57.49 | 0.00 | 0.31 | 46.19 | 0.34 | 8.41 | 59.66 | 8.04 |
| 11 | Päijät-Häme | 34.75 | 0.19 | 2.60 | 24.59 | 2.46 | 23.35 | 46.17 | 21.91 |
| 12 | Päijät-Häme | 12.16 | 0.45 | 8.14 | 30.89 | 4.76 | 34.06 | 37.62 | 26.71 |
| 1 | Satakunta | 21.25 | 0.94 | 7.79 | 13.54 | 0.01 | 47.53 | 3.34 | 37.08 |
| 2 | Satakunta | 42.19 | 0.07 | 2.77 | 13.85 | 0.02 | 51.05 | 4.18 | 32.91 |
| 3 | Satakunta | 74.97 | 0.00 | 1.30 | 15.58 | 0.00 | 32.85 | 7.69 | 23.30 |
| 4 | Satakunta | 124.66 | 0.00 | 0.27 | 15.16 | 0.00 | 8.59 | 6.81 | 8.41 |
| 5 | Satakunta | 154.48 | 0.00 | 0.08 | 9.56 | 0.00 | 1.50 | 5.05 | 1.74 |
| 6 | Satakunta | 182.37 | 0.00 | 0.00 | 12.57 | 0.00 | 1.48 | 7.62 | 1.85 |
| 7 | Satakunta | 211.29 | 0.00 | 0.00 | 11.61 | 0.00 | 1.31 | 4.58 | 1.64 |



| | | | | | | | | | |
|----|-----------------|---------|------|-------|--------|-------|--------|--------|-------|
| 8 | Satakunta | 183.73 | 0.00 | 0.00 | 15.67 | 0.00 | 1.69 | 7.93 | 2.12 |
| 9 | Satakunta | 133.92 | 0.00 | 0.02 | 23.13 | 0.00 | 5.67 | 14.58 | 7.09 |
| 10 | Satakunta | 86.56 | 0.00 | 0.18 | 38.35 | 0.00 | 12.77 | 20.44 | 13.42 |
| 11 | Satakunta | 33.97 | 0.07 | 1.57 | 24.21 | 0.01 | 31.49 | 26.38 | 30.76 |
| 12 | Satakunta | 17.12 | 0.34 | 2.15 | 25.49 | 0.01 | 44.38 | 17.09 | 40.74 |
| 1 | Uusimaa | 197.96 | 5.79 | 36.20 | 191.84 | 11.77 | 222.93 | 125.79 | 67.68 |
| 2 | Uusimaa | 345.28 | 1.08 | 24.16 | 176.04 | 13.74 | 199.98 | 131.77 | 69.67 |
| 3 | Uusimaa | 521.00 | 0.26 | 9.34 | 157.65 | 7.10 | 116.44 | 159.96 | 46.56 |
| 4 | Uusimaa | 803.24 | 0.00 | 1.73 | 121.49 | 2.58 | 21.90 | 110.57 | 10.57 |
| 5 | Uusimaa | 954.56 | 0.00 | 0.31 | 83.14 | 0.13 | 0.82 | 88.21 | 0.46 |
| 6 | Uusimaa | 1111.52 | 0.00 | 0.00 | 117.22 | 0.00 | 0.00 | 117.90 | 0.00 |
| 7 | Uusimaa | 1236.36 | 0.00 | 0.00 | 115.65 | 0.00 | 0.00 | 155.30 | 0.00 |
| 8 | Uusimaa | 1051.25 | 0.00 | 0.00 | 131.03 | 0.00 | 0.00 | 198.83 | 0.00 |
| 9 | Uusimaa | 820.18 | 0.00 | 0.04 | 157.51 | 0.00 | 0.02 | 228.49 | 0.00 |
| 10 | Uusimaa | 479.72 | 0.00 | 1.47 | 257.93 | 1.77 | 28.58 | 331.85 | 21.82 |
| 11 | Uusimaa | 321.98 | 1.03 | 11.78 | 215.51 | 6.11 | 66.24 | 312.39 | 36.10 |
| 12 | Uusimaa | 150.03 | 2.80 | 21.77 | 229.30 | 18.87 | 141.38 | 305.29 | 94.13 |
| 1 | Varsinais-Suomi | 28.22 | 2.55 | 43.95 | 60.11 | 1.03 | 79.30 | 27.16 | 35.84 |
| 2 | Varsinais-Suomi | 66.38 | 1.09 | 23.51 | 63.29 | 1.42 | 90.63 | 31.17 | 33.60 |
| 3 | Varsinais-Suomi | 140.57 | 0.24 | 8.97 | 60.27 | 0.14 | 54.34 | 46.60 | 18.25 |
| 4 | Varsinais-Suomi | 248.88 | 0.00 | 1.90 | 50.76 | 0.08 | 9.96 | 29.88 | 5.30 |
| 5 | Varsinais-Suomi | 305.69 | 0.00 | 0.40 | 31.17 | 0.00 | 1.08 | 25.57 | 0.83 |
| 6 | Varsinais-Suomi | 358.37 | 0.00 | 0.00 | 33.17 | 0.00 | 5.01 | 34.70 | 4.33 |
| 7 | Varsinais-Suomi | 413.50 | 0.00 | 0.00 | 43.57 | 0.00 | 1.04 | 28.65 | 0.78 |
| 8 | Varsinais-Suomi | 330.35 | 0.00 | 0.00 | 69.63 | 0.00 | 1.62 | 43.73 | 1.40 |
| 9 | Varsinais-Suomi | 238.55 | 0.00 | 0.05 | 77.64 | 0.00 | 0.13 | 73.67 | 0.11 |
| 10 | Varsinais-Suomi | 148.41 | 0.00 | 3.35 | 100.59 | 0.02 | 11.51 | 93.14 | 6.26 |
| 11 | Varsinais-Suomi | 58.13 | 0.31 | 13.37 | 72.24 | 0.29 | 40.15 | 105.16 | 24.47 |
| 12 | Varsinais-Suomi | 23.37 | 2.25 | 15.98 | 76.91 | 1.50 | 70.15 | 77.59 | 43.90 |

7.2 APPENDIX B:

Road temperatures in millions (m) VKT.

| Month | Region | (-50, -6] | (-6, 0] | (0, 3] | (3, 10] | (10, 15] | (15, 30] | (30, 50] |
|-------|---------------|-----------|---------|--------|---------|----------|----------|----------|
| 1 | Etelä-Karjala | 32.68 | 39.40 | 7.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2 | Etelä-Karjala | 35.37 | 43.27 | 7.92 | 1.91 | 0.00 | 0.00 | 0.00 |
| 3 | Etelä-Karjala | 14.25 | 33.45 | 22.38 | 18.65 | 4.25 | 0.70 | 0.00 |
| 4 | Etelä-Karjala | 0.84 | 11.61 | 12.70 | 33.74 | 15.94 | 22.26 | 1.53 |
| 5 | Etelä-Karjala | 0.00 | 0.96 | 2.63 | 15.61 | 19.62 | 42.42 | 22.49 |
| 6 | Etelä-Karjala | 0.00 | 0.00 | 0.25 | 4.89 | 17.56 | 58.46 | 42.63 |
| 7 | Etelä-Karjala | 0.00 | 0.00 | 0.00 | 0.32 | 13.33 | 76.36 | 48.12 |
| 8 | Etelä-Karjala | 0.00 | 0.00 | 0.00 | 1.47 | 18.80 | 79.62 | 27.14 |
| 9 | Etelä-Karjala | 0.00 | 0.32 | 2.11 | 25.12 | 38.87 | 42.68 | 1.86 |



| | | | | | | | | |
|----|-----------------|-------|--------|-------|-------|-------|--------|-------|
| 10 | Etelä-Karjala | 0.29 | 11.01 | 21.71 | 55.70 | 12.98 | 1.62 | 0.00 |
| 11 | Etelä-Karjala | 2.05 | 45.48 | 22.72 | 19.08 | 0.00 | 0.00 | 0.00 |
| 12 | Etelä-Karjala | 10.25 | 57.89 | 18.97 | 1.53 | 0.00 | 0.00 | 0.00 |
| 1 | Etelä-Pohjanmaa | 53.31 | 70.44 | 4.82 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Etelä-Pohjanmaa | 62.45 | 63.54 | 14.98 | 2.80 | 0.01 | 0.00 | 0.00 |
| 3 | Etelä-Pohjanmaa | 29.51 | 61.81 | 30.12 | 23.14 | 6.88 | 0.80 | 0.00 |
| 4 | Etelä-Pohjanmaa | 2.10 | 22.55 | 24.35 | 52.91 | 23.50 | 32.53 | 2.34 |
| 5 | Etelä-Pohjanmaa | 0.00 | 2.39 | 5.06 | 31.34 | 31.18 | 63.53 | 35.04 |
| 6 | Etelä-Pohjanmaa | 0.00 | 0.00 | 0.02 | 6.30 | 30.90 | 106.62 | 57.47 |
| 7 | Etelä-Pohjanmaa | 0.00 | 0.00 | 0.00 | 0.95 | 19.92 | 118.95 | 84.88 |
| 8 | Etelä-Pohjanmaa | 0.00 | 0.00 | 0.00 | 6.47 | 34.17 | 132.04 | 33.77 |
| 9 | Etelä-Pohjanmaa | 0.00 | 2.67 | 4.24 | 50.40 | 60.53 | 60.18 | 2.32 |
| 10 | Etelä-Pohjanmaa | 0.90 | 30.21 | 31.92 | 83.45 | 14.24 | 2.12 | 0.00 |
| 11 | Etelä-Pohjanmaa | 14.30 | 59.40 | 42.70 | 28.79 | 0.00 | 0.00 | 0.00 |
| 12 | Etelä-Pohjanmaa | 18.53 | 101.27 | 24.26 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Etelä-Savo | 52.75 | 56.57 | 5.97 | 0.03 | 0.00 | 0.00 | 0.00 |
| 2 | Etelä-Savo | 62.09 | 56.71 | 8.44 | 1.72 | 0.00 | 0.00 | 0.00 |
| 3 | Etelä-Savo | 28.14 | 56.49 | 27.81 | 20.45 | 3.06 | 0.59 | 0.00 |
| 4 | Etelä-Savo | 2.02 | 21.08 | 19.63 | 50.48 | 23.01 | 26.19 | 1.33 |
| 5 | Etelä-Savo | 0.00 | 1.97 | 5.06 | 25.82 | 29.02 | 62.53 | 26.80 |
| 6 | Etelä-Savo | 0.00 | 0.00 | 0.37 | 7.33 | 25.48 | 93.61 | 53.64 |
| 7 | Etelä-Savo | 0.00 | 0.00 | 0.00 | 1.07 | 21.08 | 116.36 | 62.92 |
| 8 | Etelä-Savo | 0.00 | 0.00 | 0.00 | 3.29 | 30.59 | 121.63 | 29.59 |
| 9 | Etelä-Savo | 0.00 | 1.46 | 4.43 | 45.08 | 57.51 | 51.58 | 1.68 |
| 10 | Etelä-Savo | 0.37 | 23.91 | 31.33 | 77.82 | 11.45 | 1.15 | 0.00 |
| 11 | Etelä-Savo | 4.84 | 67.50 | 34.48 | 23.40 | 0.00 | 0.00 | 0.00 |
| 12 | Etelä-Savo | 16.21 | 98.48 | 14.34 | 0.17 | 0.00 | 0.00 | 0.00 |
| 1 | Kainuu | 39.62 | 14.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Kainuu | 44.50 | 15.52 | 0.52 | 0.03 | 0.00 | 0.00 | 0.00 |
| 3 | Kainuu | 24.64 | 28.37 | 6.09 | 4.78 | 0.26 | 0.00 | 0.00 |
| 4 | Kainuu | 2.40 | 15.41 | 10.26 | 18.51 | 8.64 | 11.84 | 0.44 |
| 5 | Kainuu | 0.00 | 3.27 | 4.24 | 16.14 | 14.45 | 23.75 | 9.16 |
| 6 | Kainuu | 0.00 | 0.06 | 0.42 | 6.08 | 15.66 | 40.84 | 21.74 |
| 7 | Kainuu | 0.00 | 0.00 | 0.00 | 1.44 | 10.89 | 49.10 | 33.20 |
| 8 | Kainuu | 0.00 | 0.00 | 0.00 | 5.24 | 20.25 | 50.76 | 10.72 |
| 9 | Kainuu | 0.00 | 1.81 | 3.01 | 30.48 | 22.63 | 17.64 | 0.39 |
| 10 | Kainuu | 2.38 | 19.92 | 14.65 | 30.13 | 1.39 | 0.12 | 0.00 |
| 11 | Kainuu | 12.67 | 36.57 | 9.70 | 2.21 | 0.00 | 0.00 | 0.00 |
| 12 | Kainuu | 21.60 | 39.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Kanta-Häme | 42.41 | 74.86 | 13.87 | 0.09 | 0.00 | 0.00 | 0.00 |
| 2 | Kanta-Häme | 46.90 | 71.29 | 22.21 | 6.36 | 0.01 | 0.00 | 0.00 |
| 3 | Kanta-Häme | 22.74 | 52.00 | 36.69 | 32.39 | 9.63 | 1.94 | 0.00 |
| 4 | Kanta-Häme | 1.65 | 18.55 | 20.93 | 47.71 | 30.51 | 41.21 | 3.05 |
| 5 | Kanta-Häme | 0.00 | 1.51 | 3.82 | 24.98 | 28.02 | 68.06 | 45.65 |
| 6 | Kanta-Häme | 0.00 | 0.00 | 0.07 | 6.37 | 28.97 | 98.02 | 71.85 |
| 7 | Kanta-Häme | 0.00 | 0.00 | 0.00 | 1.13 | 20.07 | 121.75 | 85.94 |



| | | | | | | | | |
|----|-----------------|--------|--------|-------|--------|-------|--------|--------|
| 8 | Kanta-Häme | 0.00 | 0.01 | 0.02 | 5.69 | 28.16 | 131.10 | 45.74 |
| 9 | Kanta-Häme | 0.01 | 0.87 | 3.75 | 40.13 | 62.30 | 74.19 | 2.82 |
| 10 | Kanta-Häme | 0.25 | 17.64 | 32.63 | 90.28 | 21.25 | 4.14 | 0.00 |
| 11 | Kanta-Häme | 6.84 | 52.15 | 46.57 | 42.63 | 0.00 | 0.00 | 0.00 |
| 12 | Kanta-Häme | 10.97 | 86.74 | 45.99 | 3.35 | 0.00 | 0.00 | 0.00 |
| 1 | Keski-Pohjanmaa | 18.87 | 19.30 | 0.85 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Keski-Pohjanmaa | 22.24 | 17.71 | 3.40 | 0.29 | 0.00 | 0.00 | 0.00 |
| 3 | Keski-Pohjanmaa | 10.15 | 19.58 | 8.66 | 6.83 | 0.96 | 0.03 | 0.00 |
| 4 | Keski-Pohjanmaa | 0.81 | 7.47 | 7.27 | 15.42 | 6.91 | 10.23 | 0.53 |
| 5 | Keski-Pohjanmaa | 0.00 | 1.07 | 1.65 | 10.62 | 9.90 | 18.40 | 9.52 |
| 6 | Keski-Pohjanmaa | 0.00 | 0.00 | 0.04 | 2.17 | 9.15 | 29.42 | 20.32 |
| 7 | Keski-Pohjanmaa | 0.00 | 0.00 | 0.00 | 0.57 | 6.05 | 33.97 | 27.49 |
| 8 | Keski-Pohjanmaa | 0.00 | 0.00 | 0.00 | 1.90 | 11.83 | 38.25 | 10.69 |
| 9 | Keski-Pohjanmaa | 0.00 | 0.48 | 1.01 | 17.09 | 18.69 | 16.87 | 0.59 |
| 10 | Keski-Pohjanmaa | 0.43 | 8.94 | 10.49 | 27.06 | 3.85 | 0.19 | 0.00 |
| 11 | Keski-Pohjanmaa | 3.52 | 23.48 | 9.56 | 7.51 | 0.00 | 0.00 | 0.00 |
| 12 | Keski-Pohjanmaa | 6.76 | 32.81 | 4.15 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Keski-Suomi | 83.22 | 94.89 | 13.46 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Keski-Suomi | 100.83 | 88.72 | 21.32 | 3.38 | 0.00 | 0.00 | 0.00 |
| 3 | Keski-Suomi | 45.49 | 93.43 | 46.79 | 35.23 | 5.25 | 0.65 | 0.00 |
| 4 | Keski-Suomi | 3.81 | 37.00 | 34.34 | 84.90 | 36.87 | 39.73 | 2.19 |
| 5 | Keski-Suomi | 0.00 | 4.21 | 8.36 | 52.90 | 49.73 | 96.30 | 39.70 |
| 6 | Keski-Suomi | 0.00 | 0.00 | 0.76 | 13.14 | 54.47 | 160.03 | 71.53 |
| 7 | Keski-Suomi | 0.00 | 0.00 | 0.00 | 3.29 | 41.06 | 189.64 | 100.97 |
| 8 | Keski-Suomi | 0.00 | 0.00 | 0.00 | 10.07 | 57.73 | 193.18 | 46.65 |
| 9 | Keski-Suomi | 0.00 | 3.68 | 7.20 | 77.25 | 99.82 | 77.63 | 3.13 |
| 10 | Keski-Suomi | 0.58 | 36.02 | 54.95 | 132.08 | 17.15 | 1.84 | 0.00 |
| 11 | Keski-Suomi | 13.16 | 90.36 | 66.78 | 46.04 | 0.00 | 0.00 | 0.00 |
| 12 | Keski-Suomi | 25.26 | 149.77 | 39.58 | 0.04 | 0.00 | 0.00 | 0.00 |
| 1 | Kymenlaakso | 29.67 | 56.13 | 14.92 | 0.36 | 0.00 | 0.00 | 0.00 |
| 2 | Kymenlaakso | 33.17 | 59.37 | 16.68 | 3.81 | 0.00 | 0.00 | 0.00 |
| 3 | Kymenlaakso | 14.90 | 40.36 | 31.34 | 25.76 | 5.26 | 2.06 | 0.00 |
| 4 | Kymenlaakso | 0.70 | 13.18 | 14.52 | 43.79 | 21.13 | 30.81 | 1.86 |
| 5 | Kymenlaakso | 0.00 | 0.73 | 2.78 | 17.71 | 24.13 | 54.57 | 32.60 |
| 6 | Kymenlaakso | 0.00 | 0.00 | 0.18 | 3.88 | 17.89 | 79.42 | 56.71 |
| 7 | Kymenlaakso | 0.00 | 0.00 | 0.00 | 0.41 | 15.32 | 93.32 | 66.81 |
| 8 | Kymenlaakso | 0.00 | 0.00 | 0.00 | 2.00 | 17.06 | 101.94 | 41.28 |
| 9 | Kymenlaakso | 0.00 | 0.44 | 2.22 | 26.43 | 45.35 | 64.14 | 3.19 |
| 10 | Kymenlaakso | 0.31 | 11.95 | 22.88 | 69.19 | 23.55 | 4.11 | 0.01 |
| 11 | Kymenlaakso | 3.29 | 34.62 | 38.83 | 37.40 | 0.00 | 0.00 | 0.00 |
| 12 | Kymenlaakso | 8.43 | 57.89 | 39.47 | 7.45 | 0.00 | 0.00 | 0.00 |
| 1 | Lappi | 124.17 | 27.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Lappi | 128.29 | 38.59 | 2.31 | 0.09 | 0.00 | 0.00 | 0.00 |
| 3 | Lappi | 82.45 | 67.72 | 17.11 | 11.57 | 0.38 | 0.00 | 0.00 |
| 4 | Lappi | 9.04 | 41.84 | 29.97 | 57.36 | 24.81 | 25.28 | 0.39 |
| 5 | Lappi | 0.01 | 5.78 | 10.91 | 51.52 | 42.67 | 72.43 | 15.15 |



| | | | | | | | | |
|----|-------------------|--------|--------|--------|--------|--------|--------|--------|
| 6 | Lappi | 0.00 | 0.07 | 1.32 | 22.57 | 49.14 | 118.03 | 45.90 |
| 7 | Lappi | 0.00 | 0.00 | 0.00 | 5.25 | 28.87 | 138.93 | 91.86 |
| 8 | Lappi | 0.00 | 0.00 | 0.16 | 17.96 | 59.58 | 147.57 | 17.81 |
| 9 | Lappi | 0.10 | 6.60 | 10.15 | 93.99 | 60.78 | 40.55 | 0.14 |
| 10 | Lappi | 10.92 | 55.70 | 46.91 | 75.04 | 3.11 | 0.01 | 0.00 |
| 11 | Lappi | 56.99 | 77.97 | 27.31 | 8.66 | 0.00 | 0.00 | 0.00 |
| 12 | Lappi | 92.42 | 74.08 | 3.10 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Pirkanmaa | 112.52 | 170.22 | 32.34 | 0.03 | 0.00 | 0.00 | 0.00 |
| 2 | Pirkanmaa | 131.05 | 157.38 | 51.98 | 12.00 | 0.00 | 0.00 | 0.00 |
| 3 | Pirkanmaa | 59.69 | 135.59 | 90.68 | 69.63 | 15.76 | 1.77 | 0.00 |
| 4 | Pirkanmaa | 3.82 | 46.88 | 55.71 | 129.30 | 64.94 | 87.55 | 4.63 |
| 5 | Pirkanmaa | 0.00 | 4.28 | 10.18 | 68.82 | 71.90 | 164.46 | 93.57 |
| 6 | Pirkanmaa | 0.00 | 0.00 | 0.30 | 19.22 | 76.91 | 246.64 | 150.20 |
| 7 | Pirkanmaa | 0.00 | 0.47 | 0.03 | 3.82 | 60.45 | 286.77 | 198.65 |
| 8 | Pirkanmaa | 0.00 | 0.00 | 0.00 | 16.53 | 82.32 | 311.09 | 96.10 |
| 9 | Pirkanmaa | 0.00 | 3.14 | 10.45 | 113.24 | 156.94 | 151.88 | 6.34 |
| 10 | Pirkanmaa | 0.42 | 48.11 | 83.79 | 232.13 | 42.07 | 5.05 | 0.00 |
| 11 | Pirkanmaa | 17.88 | 113.71 | 124.82 | 99.44 | 0.00 | 0.00 | 0.00 |
| 12 | Pirkanmaa | 29.25 | 200.78 | 116.30 | 6.75 | 0.00 | 0.00 | 0.00 |
| 1 | Pohjanmaa | 38.94 | 58.19 | 5.02 | 0.02 | 0.00 | 0.00 | 0.00 |
| 2 | Pohjanmaa | 49.00 | 52.54 | 11.59 | 1.13 | 0.00 | 0.00 | 0.00 |
| 3 | Pohjanmaa | 24.36 | 50.12 | 24.67 | 18.49 | 3.08 | 0.29 | 0.00 |
| 4 | Pohjanmaa | 1.83 | 19.14 | 20.60 | 41.97 | 16.25 | 25.79 | 1.81 |
| 5 | Pohjanmaa | 0.00 | 1.77 | 3.87 | 25.24 | 25.37 | 49.69 | 28.06 |
| 6 | Pohjanmaa | 0.00 | 0.00 | 0.00 | 3.83 | 24.05 | 79.45 | 52.64 |
| 7 | Pohjanmaa | 0.00 | 0.00 | 0.00 | 0.51 | 14.09 | 87.34 | 76.16 |
| 8 | Pohjanmaa | 0.00 | 0.00 | 0.00 | 4.53 | 26.95 | 102.49 | 30.13 |
| 9 | Pohjanmaa | 0.00 | 1.45 | 2.59 | 41.94 | 50.51 | 44.89 | 1.90 |
| 10 | Pohjanmaa | 1.23 | 21.23 | 27.97 | 71.89 | 10.47 | 0.66 | 0.01 |
| 11 | Pohjanmaa | 10.23 | 43.63 | 37.20 | 24.25 | 0.03 | 0.04 | 0.01 |
| 12 | Pohjanmaa | 14.86 | 76.33 | 23.27 | 0.03 | 0.00 | 0.00 | 0.00 |
| 1 | Pohjois-Karjala | 53.96 | 44.83 | 3.69 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Pohjois-Karjala | 63.68 | 44.57 | 5.84 | 0.51 | 0.00 | 0.00 | 0.00 |
| 3 | Pohjois-Karjala | 28.72 | 51.40 | 23.30 | 15.34 | 2.17 | 0.41 | 0.00 |
| 4 | Pohjois-Karjala | 2.35 | 23.20 | 18.61 | 44.81 | 17.97 | 19.94 | 0.87 |
| 5 | Pohjois-Karjala | 0.00 | 3.11 | 5.29 | 30.17 | 26.44 | 52.11 | 17.26 |
| 6 | Pohjois-Karjala | 0.00 | 0.00 | 0.35 | 9.67 | 26.03 | 82.61 | 41.73 |
| 7 | Pohjois-Karjala | 0.00 | 0.00 | 0.00 | 2.66 | 21.61 | 105.16 | 49.79 |
| 8 | Pohjois-Karjala | 0.00 | 0.00 | 0.00 | 3.85 | 33.39 | 104.71 | 22.62 |
| 9 | Pohjois-Karjala | 0.00 | 1.55 | 3.66 | 45.77 | 51.29 | 40.41 | 1.06 |
| 10 | Pohjois-Karjala | 0.79 | 25.84 | 30.36 | 68.92 | 7.44 | 0.49 | 0.00 |
| 11 | Pohjois-Karjala | 5.87 | 66.36 | 27.49 | 16.01 | 0.00 | 0.00 | 0.00 |
| 12 | Pohjois-Karjala | 16.39 | 87.66 | 10.77 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Pohjois-Pohjanmaa | 160.83 | 108.77 | 1.61 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Pohjois-Pohjanmaa | 182.10 | 106.17 | 12.88 | 2.16 | 0.00 | 0.00 | 0.00 |
| 3 | Pohjois-Pohjanmaa | 92.59 | 140.03 | 46.68 | 37.58 | 4.07 | 0.20 | 0.00 |



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|----|-------------------|--------|--------|--------|--------|--------|--------|--------|
| 4 | Pohjois-Pohjanmaa | 7.22 | 54.93 | 53.14 | 107.99 | 49.36 | 63.17 | 2.30 |
| 5 | Pohjois-Pohjanmaa | 0.01 | 8.77 | 14.96 | 84.37 | 69.41 | 128.34 | 49.77 |
| 6 | Pohjois-Pohjanmaa | 0.00 | 0.04 | 0.70 | 19.66 | 71.39 | 219.05 | 113.87 |
| 7 | Pohjois-Pohjanmaa | 0.00 | 0.00 | 0.00 | 3.38 | 42.95 | 256.17 | 171.59 |
| 8 | Pohjois-Pohjanmaa | 0.00 | 0.00 | 0.00 | 14.68 | 92.01 | 272.19 | 56.70 |
| 9 | Pohjois-Pohjanmaa | 0.00 | 5.88 | 9.07 | 126.88 | 135.99 | 98.75 | 3.86 |
| 10 | Pohjois-Pohjanmaa | 6.59 | 69.13 | 67.14 | 177.07 | 22.15 | 1.41 | 0.00 |
| 11 | Pohjois-Pohjanmaa | 40.03 | 165.19 | 60.31 | 40.75 | 0.00 | 0.00 | 0.00 |
| 12 | Pohjois-Pohjanmaa | 65.68 | 223.01 | 15.19 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1 | Pohjois-Savo | 79.27 | 72.71 | 5.70 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Pohjois-Savo | 92.70 | 70.78 | 10.94 | 1.92 | 0.00 | 0.00 | 0.00 |
| 3 | Pohjois-Savo | 41.10 | 81.54 | 34.53 | 24.74 | 4.05 | 0.75 | 0.00 |
| 4 | Pohjois-Savo | 2.88 | 31.82 | 28.31 | 68.25 | 27.38 | 35.37 | 2.57 |
| 5 | Pohjois-Savo | 0.03 | 3.83 | 7.30 | 43.86 | 40.91 | 78.08 | 32.75 |
| 6 | Pohjois-Savo | 0.00 | 0.02 | 0.49 | 12.38 | 37.07 | 124.41 | 72.41 |
| 7 | Pohjois-Savo | 0.00 | 0.00 | 0.00 | 1.71 | 28.36 | 151.32 | 93.97 |
| 8 | Pohjois-Savo | 0.00 | 0.00 | 0.00 | 5.04 | 43.39 | 159.91 | 44.80 |
| 9 | Pohjois-Savo | 0.00 | 1.91 | 5.90 | 65.81 | 79.34 | 65.79 | 2.42 |
| 10 | Pohjois-Savo | 0.52 | 35.94 | 48.18 | 107.51 | 12.37 | 1.43 | 0.00 |
| 11 | Pohjois-Savo | 8.42 | 96.95 | 43.88 | 28.82 | 0.00 | 0.00 | 0.00 |
| 12 | Pohjois-Savo | 25.80 | 137.81 | 13.08 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | Päijät-Häme | 49.82 | 74.97 | 13.37 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Päijät-Häme | 59.07 | 74.62 | 18.48 | 2.33 | 0.00 | 0.00 | 0.00 |
| 3 | Päijät-Häme | 28.88 | 62.14 | 38.15 | 29.66 | 4.21 | 0.55 | 0.00 |
| 4 | Päijät-Häme | 1.85 | 22.26 | 22.76 | 60.39 | 28.71 | 34.72 | 1.53 |
| 5 | Päijät-Häme | 0.00 | 2.13 | 5.11 | 28.03 | 30.29 | 73.57 | 42.04 |
| 6 | Päijät-Häme | 0.00 | 0.00 | 0.11 | 7.67 | 31.07 | 106.84 | 70.67 |
| 7 | Päijät-Häme | 0.00 | 0.00 | 0.00 | 2.04 | 27.00 | 125.98 | 87.10 |
| 8 | Päijät-Häme | 0.00 | 0.00 | 0.00 | 5.65 | 35.75 | 144.50 | 35.96 |
| 9 | Päijät-Häme | 0.00 | 1.99 | 5.30 | 50.93 | 70.35 | 63.78 | 1.44 |
| 10 | Päijät-Häme | 0.65 | 22.14 | 36.08 | 95.82 | 18.00 | 2.25 | 0.01 |
| 11 | Päijät-Häme | 6.26 | 65.68 | 44.84 | 39.24 | 0.00 | 0.00 | 0.00 |
| 12 | Päijät-Häme | 15.07 | 97.08 | 40.12 | 2.53 | 0.00 | 0.00 | 0.00 |
| 1 | Satakunta | 42.91 | 78.01 | 10.51 | 0.04 | 0.00 | 0.00 | 0.00 |
| 2 | Satakunta | 48.80 | 73.82 | 20.66 | 3.75 | 0.00 | 0.00 | 0.00 |
| 3 | Satakunta | 23.77 | 53.10 | 37.78 | 30.08 | 9.07 | 1.88 | 0.00 |
| 4 | Satakunta | 1.73 | 21.25 | 20.43 | 51.97 | 25.50 | 39.53 | 3.49 |
| 5 | Satakunta | 0.00 | 2.04 | 4.60 | 27.42 | 30.50 | 63.57 | 44.27 |
| 6 | Satakunta | 0.00 | 0.00 | 0.11 | 5.97 | 29.34 | 98.70 | 71.64 |
| 7 | Satakunta | 0.00 | 0.00 | 0.00 | 1.35 | 18.92 | 117.38 | 90.41 |
| 8 | Satakunta | 0.00 | 0.00 | 0.00 | 5.30 | 30.60 | 128.78 | 46.43 |
| 9 | Satakunta | 0.00 | 1.16 | 4.12 | 43.68 | 62.93 | 68.70 | 3.83 |
| 10 | Satakunta | 0.77 | 24.35 | 31.85 | 88.06 | 24.11 | 2.56 | 0.00 |
| 11 | Satakunta | 9.41 | 46.15 | 50.80 | 42.09 | 0.02 | 0.00 | 0.00 |
| 12 | Satakunta | 13.03 | 85.03 | 46.64 | 2.61 | 0.00 | 0.00 | 0.00 |
| 1 | Uusimaa | 183.76 | 497.82 | 155.79 | 22.56 | 0.02 | 0.00 | 0.00 |



| | | | | | | | | |
|----|-----------------|--------|--------|--------|--------|--------|--------|--------|
| 2 | Uusimaa | 239.51 | 454.34 | 212.55 | 54.79 | 0.54 | 0.00 | 0.00 |
| 3 | Uusimaa | 115.86 | 309.12 | 285.91 | 244.23 | 53.20 | 9.98 | 0.00 |
| 4 | Uusimaa | 4.05 | 109.58 | 125.67 | 384.41 | 194.83 | 244.64 | 8.87 |
| 5 | Uusimaa | 0.19 | 10.17 | 25.91 | 169.83 | 213.00 | 490.13 | 218.39 |
| 6 | Uusimaa | 0.00 | 0.00 | 0.56 | 39.96 | 197.73 | 704.73 | 403.35 |
| 7 | Uusimaa | 0.06 | 0.01 | 0.14 | 7.24 | 143.10 | 857.41 | 496.30 |
| 8 | Uusimaa | 0.10 | 0.01 | 0.03 | 23.35 | 172.87 | 923.81 | 260.70 |
| 9 | Uusimaa | 0.00 | 2.55 | 16.83 | 222.80 | 425.73 | 521.69 | 16.63 |
| 10 | Uusimaa | 0.91 | 91.12 | 171.28 | 635.26 | 198.22 | 26.35 | 0.00 |
| 11 | Uusimaa | 22.29 | 225.87 | 341.37 | 379.69 | 1.92 | 0.00 | 0.00 |
| 12 | Uusimaa | 52.26 | 422.90 | 368.40 | 120.00 | 0.00 | 0.00 | 0.00 |
| 1 | Varsinais-Suomi | 60.26 | 172.41 | 43.23 | 2.25 | 0.00 | 0.00 | 0.00 |
| 2 | Varsinais-Suomi | 76.23 | 162.05 | 57.66 | 15.11 | 0.03 | 0.00 | 0.00 |
| 3 | Varsinais-Suomi | 38.58 | 102.83 | 89.02 | 73.74 | 20.95 | 4.25 | 0.00 |
| 4 | Varsinais-Suomi | 1.56 | 35.00 | 41.17 | 106.38 | 61.28 | 95.60 | 5.77 |
| 5 | Varsinais-Suomi | 0.13 | 3.75 | 8.18 | 54.07 | 62.22 | 141.09 | 95.19 |
| 6 | Varsinais-Suomi | 0.05 | 0.01 | 0.13 | 9.69 | 57.91 | 210.63 | 157.13 |
| 7 | Varsinais-Suomi | 0.35 | 0.07 | 0.06 | 1.20 | 37.85 | 241.35 | 203.80 |
| 8 | Varsinais-Suomi | 0.00 | 0.00 | 0.00 | 7.95 | 54.16 | 272.04 | 112.49 |
| 9 | Varsinais-Suomi | 0.00 | 1.01 | 4.71 | 80.96 | 128.41 | 167.74 | 7.33 |
| 10 | Varsinais-Suomi | 0.93 | 35.47 | 58.98 | 195.84 | 64.66 | 7.40 | 0.00 |
| 11 | Varsinais-Suomi | 7.77 | 77.57 | 109.71 | 118.91 | 0.17 | 0.00 | 0.00 |
| 12 | Varsinais-Suomi | 16.29 | 155.77 | 108.65 | 30.95 | 0.00 | 0.00 | 0.00 |

Certificate Of Completion

| | |
|--|--|
| Envelope Id: D7EC75CF39844F2FA8C402F8DE46F523 | Status: Completed |
| Subject: Please Sign: VTT-R-00072-22.pdf | |
| Source Envelope: | |
| Document Pages: 32 | Signatures: 1 |
| Certificate Pages: 1 | Initials: 0 |
| AutoNav: Enabled | Envelope Originator: |
| Envelopeld Stamping: Enabled | Christina Vähävaara |
| Time Zone: (UTC+02:00) Helsinki, Kyiv, Riga, Sofia, Tallinn, Vilnius | Vuorimiehentie 3, Espoo, .. . P.O Box1000,FI-02044 Christina.Vahavaara@vtt.fi IP Address: 130.188.17.16 |

Record Tracking

| | | |
|-------------------------|-----------------------------|--------------------|
| Status: Original | Holder: Christina Vähävaara | Location: DocuSign |
| 21 January 2022 14:25 | Christina.Vahavaara@vtt.fi | |

Signer Events

Anne Silla
anne.silla@vtt.fi
Teknologian tutkimuskeskus VTT Oy
Security Level: Email, Account Authentication (None), Authentication

Signature

DocuSigned by:

9AF4545C9F954EC...
Signature Adoption: Pre-selected Style
Using IP Address: 130.188.17.16

Timestamp

Sent: 21 January 2022 | 14:29
Viewed: 21 January 2022 | 14:33
Signed: 21 January 2022 | 14:33

Authentication Details

SMS Auth:
Transaction: 65F9F27CC4040504919117E1398A35EF
Result: passed
Vendor ID: TeleSign
Type: SMSAuth
Performed: 21 January 2022 | 14:32
Phone: +358 40 7219014

Electronic Record and Signature Disclosure:
Not Offered via DocuSign

| In Person Signer Events | Signature | Timestamp |
|-------------------------------------|------------------|-------------------------|
| Editor Delivery Events | Status | Timestamp |
| Agent Delivery Events | Status | Timestamp |
| Intermediary Delivery Events | Status | Timestamp |
| Certified Delivery Events | Status | Timestamp |
| Carbon Copy Events | Status | Timestamp |
| Witness Events | Signature | Timestamp |
| Notary Events | Signature | Timestamp |
| Envelope Summary Events | Status | Timestamps |
| Envelope Sent | Hashed/Encrypted | 21 January 2022 14:29 |
| Certified Delivered | Security Checked | 21 January 2022 14:33 |
| Signing Complete | Security Checked | 21 January 2022 14:33 |
| Completed | Security Checked | 21 January 2022 14:33 |
| Payment Events | Status | Timestamps |