

Brine with Nozzles!

Liquid only!



Delivering winter service in Denmark.

**The challenges!
The solutions!**

The benefits of a liquid only approach!

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Hello Ladies and gentleman.

I am Jens Kristian Fønnesbech, an independent consultant in Denmark.

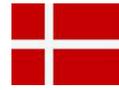
I have worked with environment and roads in the former counties in Denmark in 30 years and done research in winter service and traffic accidents with slippery roads from 1999. Especially results from spreading brine with nozzles and measurements of residual salt on the road have been publicized.

Since 2009 I have been consultant and assist with planning of winter service and measuring of residual salt.

I have had speeches on PIARC, TRB, Vianordica and many other congresses around the World

Today I will tell about Delivering winter service in Denmark, challenges, solutions and the benefit of a liquid only approach!

(Little) Denmark



AIBAN
VINTER SERVICE

Are some of you Vikings? Did the Vikings left something good in England?



I hope to inspire you to develop and research the winter service.

In earlier history Denmark has been known for the Vikings. I hope the vikings left something good here in England.

What I hope is to inspire you to develop and research winter service.

Content

- Introduction
 - Benefits and facts about Sodium Chloride (NaCl)
- Delivering winter service in Denmark.
- Challenges
 - Traffic safety, assessibility, snow and economy
- Solutions
 - Precisions salt spreading and preserving salt
- Benefits
 - Traffic safety. From 3 to 1 accidents!
 - Environment. Less salt consumption!
 - Economy. Winter routes of 65 miles!

Here is my Content and already now you have look at what benefits you in my opinion have if you choise liquid only.:

With liquid only you can make precision spreading of salt and you have the benefits:

Traffic safety: Traffic accidents with slippery road (ice or snow) reduce dramatical!

Environmental: Only a little amount of salt (NaCl) is necessary!

Economy: Normal truck velocity is acceptable when spreading!

Economy: Preventive spreading on dry road before snowstorm reduce snowplough use!

Facts about NaCl

- Sodium Chloride
- **3% NaCl in snow or ice means friction!**
 - *You know it from freezing sea water, it is not slippery!*
- **NaCl on the road surface forms a bond-breaker to snow and ice!**
 - *It is similar to how cooking oil prevents food from sticking to the frying pan.*

Facts about Sodium Chloride (NaCl).

3% NaCl (salt) in ice or snow ensure enough friction with all temperature, Haavasoja 2012 [5] og Alex Klein-Paste [6].

Most people know this from sea water: When sea water freeze it is not slippery!

NaCl (salt) on the road surface forms a bond-breaker between the pavement surface and the snow and ice layer, Haavasoja 2012 [5].

It is similar to how cooking oil prevents food from sticking to the frying pan.

Winter service in Denmark

- Salting preventive all major roads, 10.000 miles
 - Road administration take all decisions.
- State roads 2.500 miles, other is municipalities.
- The road weather forecast is excellent!
- Spreading salt 75 – 150 times per winter.
- 10-20 gram pre-wetted salt per square meter.
- 5 - 15 ton salt per lane mile per winter.
- Winter routes varies about 30 miles.

Delivering winter service in Denmark.

During the mild winters 2008-2009 and 2011-2012 an amount of nearly 50.000 tons salt (sodium chloride / $NaCl$) per year was spread on the 3,800 km (2,400 mi) national highways in Denmark . This corresponds to 1.3 kg per square meter road-surface or 7 ton salt/lane mile. In the snow winters 2009/2010 and 2010/2011 the amount was double up.

Besides the national highways, winter service on nearly 10.000 km highway (Municipalities) take form of preventive spreading of salt (anti Icing).

In Denmark, is normally spread salt between 75 and 150 times per winter, when using preventive salting. Spreading is between 10 (7.6) and 20 (15.2) gram pre wetted salt per square meter.

Road Weather forecast(RWMS) is excellent in Denmark [1] . Denmark have a dense network of road observations (almost 400 road stations equipped with more than 500 sensors measuring road surface, air and dew point temperatures). 4 hours before an event RWMS tell what will happen, and decision to salt preventive, can be taken.

The road administration in Denmark make the decision when to salt and how much to salt.

Salt spreading is done with private entrepreneurs with well educated drivers. The equipment is either a pre wetted salt spreader (pre wetted or dry salt) or a kombi salt spreader, which can use pure brine, too.

The length of a spreader route on highways varies about 30 miles.

Challenges!



Figure 1. Marts 6. 2010, motorway near Herning in Denmark. Heavy snow (5mm) the day before. Cold -10 to -15 C° in the night and day temperature up to +3 C°.

In Denmark we drive in the right lane. It means that the right lane in figure 1 has heavy traffic and is expected to be clear, but the salt was only on the left lane.

- Both pictures show the situation:
- Part of the roads has no salt at all.
- Look carefully at the next measurements!
- Six drivers crashed on the slippery roads in the morning hours!

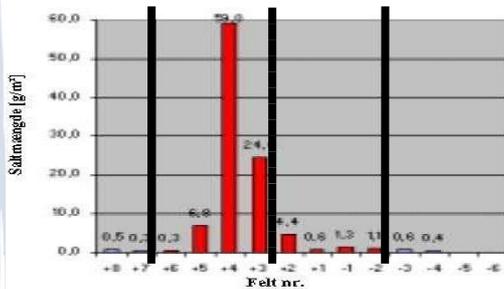


Here is no snow and a driver do not expect slippery road, when the road has been salted. In Denmark 5-10% of all traffic accidents are police reported as slippery snow or slippery otherwise.

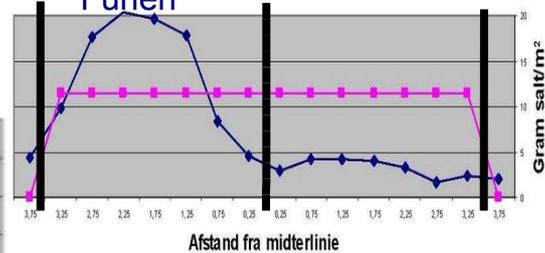
Many measurements show that precision of spreading salt is a problem. In Denmark there is three total different measurements showing it. All three measurements show situations, where the machine has been calibrated just before the spreading.

Bad examples, spinner type!

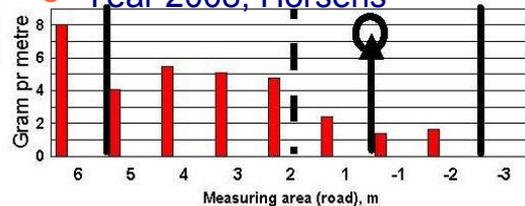
- Year 2000, Århus Airport.



- Year 2004, The County of Funen



- Year 2008, Horsens



Sobo20 measurements in the year 2000 from Århus airport [2]. In the spreading test the rotating plate spreader try to spread dry salt 8 meter asymmetrical with 30 km/hour. Nearly all salt ends up in left lane. “Felt nr.” corresponds to distance in metres from centreline of the test-lane considered. “Saltmængde” is amount of salt found by measurements with Sobo20..

Sobo20 measurements in the year 2004 [3] on a wet highway 3 hours after the rotating plate spreader try to spread pre wetted salt 7 meter asymmetrical with 60 km/hour. Most of the salt is found in left lane. “Afstand fra midterlinje” is distance in meters from middle of the road.

Laboratory measurements in the year 2008 [4] inside a hall after the rotating plate spreader try to spread dry salt 7 meter asymmetrical with 15 km/hour. Only a little amount of salt in the right lane.

Under real condition in the winter without calibration just before spreading, the result often will be worse, and it means that we after spreading of salt will have lanes without salt!

Then we have the results shown in the fotos..

Loss of salt!

- When spreading salt on a dry surface on a road with heavy traffic, nearly all is gone in an hour.
- But often the road surface is dry 1-4 hours before a snowstorm!
- And if there is no salt when a snowstorm occur, traffic will pack the snow.

The loss of salt from the road-surface.

Another challenge is preserving salt on the road surface. All road workers know that when spreading dry or pre wetted salt on a dry road with heavy traffic, there is nearly no salt on the road surface an hour later. But the challenge is, that we some times have to salt preventive on a dry road, 2 to 3 hours before a snowstorm (or ice).

Slippery roads.

There is nearly no friction, if a wet lane is without salt and temperature is below 0°C! It is a great challenge for the driver, especially when the driver know the road has been salted!

Solid snow.

If there is no salt on a lane or a road when a snowstorm occur, the traffic will pack the snow on the road. Solid and fixed snow is almost impossible to remove. It is a challenge for the snowplough driver.

Economy

In a normal winter in Denmark the truck price is $\frac{3}{4}$ of the total price and salt is only $\frac{1}{4}$. It means that the first challenge is to minimise, how many trucks are necessary.

In snow winters the really expensive is snow plough. The challenge is to do something which can help the snowplough to remove the snow.

Solutions!

Brine spread with nozzles!

- Precision salt spreading! Tender requirements, 2005 in the County of Funen:
 - *90 % of measured salt inside spreading zone!*
 - *In every meter spreading zone +-25% salt*
 - *In a lane +- 10% of expected salt!*
- And it is requirements to the worst measured example (out of 10 different spreadings)!
 - <https://www.youtube.com/watch?v=sAywptYqq6Q>
 - <https://www.youtube.com/watch?v=Goxv7C3uY9E>

Precision salt spreading.

When using liquid only (brine) spread with pencil nozzles, the salt can be placed precisely where you want it on the road. The nozzles have to point backwards, in a way, so the water velocity backwards is equal with the trucks velocity. In that way you minimise the turbulence. Many measurements show that it works in practice and the salt is placed on the road where you want it.

<https://www.youtube.com/watch?v=sAywptYqq6Q> ,
<https://www.youtube.com/watch?v=Goxv7C3uY9E>

In the former county of Funen was tender requirements, for the worst measured results out of 10 (after measurements with Sobo20 as shown in figure 2):

90 % of measured salt inside the spreading zone

The measured salt amount in every meter inside spreading zone should be +- 25% of the expected.

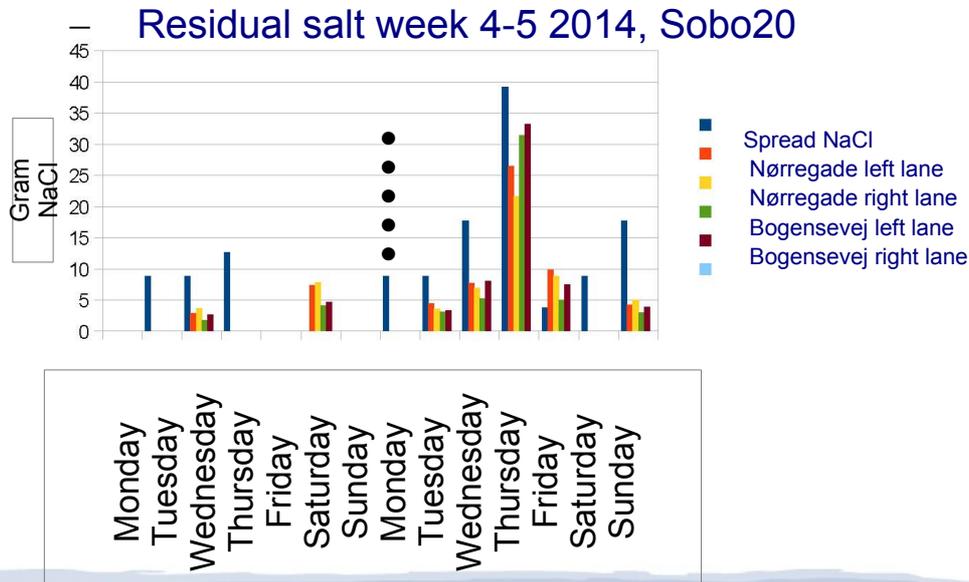
The measured salt amount in a lane should be +- 10% of the expected.

With liquid only spreading machines with pencil nozzles it causes no problem at all.

When the spreading machine can spread precisely, GPS controlled spreading helps to do it better in practice.

Solutions

- With brine you can salt preventive on a dry road, and the salt, will be in place when you need it.



Preserving salt

With brine you can salt preventive on a dry road. When the brine is drying, the salt is fixed to the road. Often you see the white salt on a dry road more days after spreading. It is especially good while you can salt preventive many hours before it is necessary, and the salt is on place when you need it.

When using liquid only spread with nozzles and GPS controlled spreading, the spreading is so precise, that you only with a few Sobo20 measurements on the road, can know how much residual salt you have on all the roads on the route.

In the municipality Middelfart they have 65 miles highway, which is salted with one truck.

When they expect residual salt on these roads, they do Sobo20 measurements before they go home in the afternoon. Measurements take place in both lanes on 2 roads with 7.5 miles between. The one road is north-south and the other east-west. Here you have an example of Sobo 20 measurements January 20th to February 2th 2014.

Solutions

● Friction

- 3 % NaCl in snow or ice means friction!
- Do local observations and Sobo20 measurements!
- You need only a little amount of NaCl
- 15 ml per square meter(4 gram NaCl).

● Snow

- Salt preventive before snow 35 ml per square meter
- Salt perhaps again 4 times per day.

Friction

When you are sure there is a little amount of salt on the road in every lane, there will be friction. Only 3% salt in the ice or in the snow on the road is enough with all temperatures, Haavasoja 2012 [5] og Alex Klein-Paste [6].

It is an old observation. Freezing sea water is not slippery and it contains 3% salt.

Often is only 1 gram Sodium Chlorid (Na Cl) per square meter enough, while a highway often only have a little amount of water (ice), especially when the temperature is under minus 5°C.

But local observations and local knowledge are important, because rainfall or other local condition can change the amount of water (ice).

In praxis in Denmark is salted with 15 ml brine per square meter (4 gram NaCl per square meter). Brine is here 24% NaCl

Snow

The solution when there is snow is to form a bond-breaker between the road surface and the snow.

Then you can use snow plough to remove the snow.

You can only be sure of the bond-breaker layer if there is salt on the road before a snow storm occur.

In praxis before snow use 35 ml brine per square meter (9 gram NaCl per square meter) preventive, and perhaps the same again 4 times on a day when it is snowing. .

Solutions

- Economy

- 1 truck with liquid only spreader, 65 miles road.
- You can drive normal truck velocity, when spreading brine with nozzles

Economy

In the municipality Middelfart one truck is salting a route of 105 km (65 miles) highways with good results. Normally in Denmark you use 2 trucks with salting machines to 105 km highway. The liquid only machine is cheaper than one kombi spreader, too.

Benefits Traffic safety!



- In mild winters police reported accidents with "slippery snow" or "slippery otherwise"
 - Liquid only : 1 every 60 miles
 - Kombi (dry, pre wetted or brine) 3 every 60 miles

Traffic safety.

A dramatical reduction of traffic accidents in mild winters, where the police say slippery roads, is the greatest benefit of liquid only Bolet and Fønnesbech, 2014 [7].

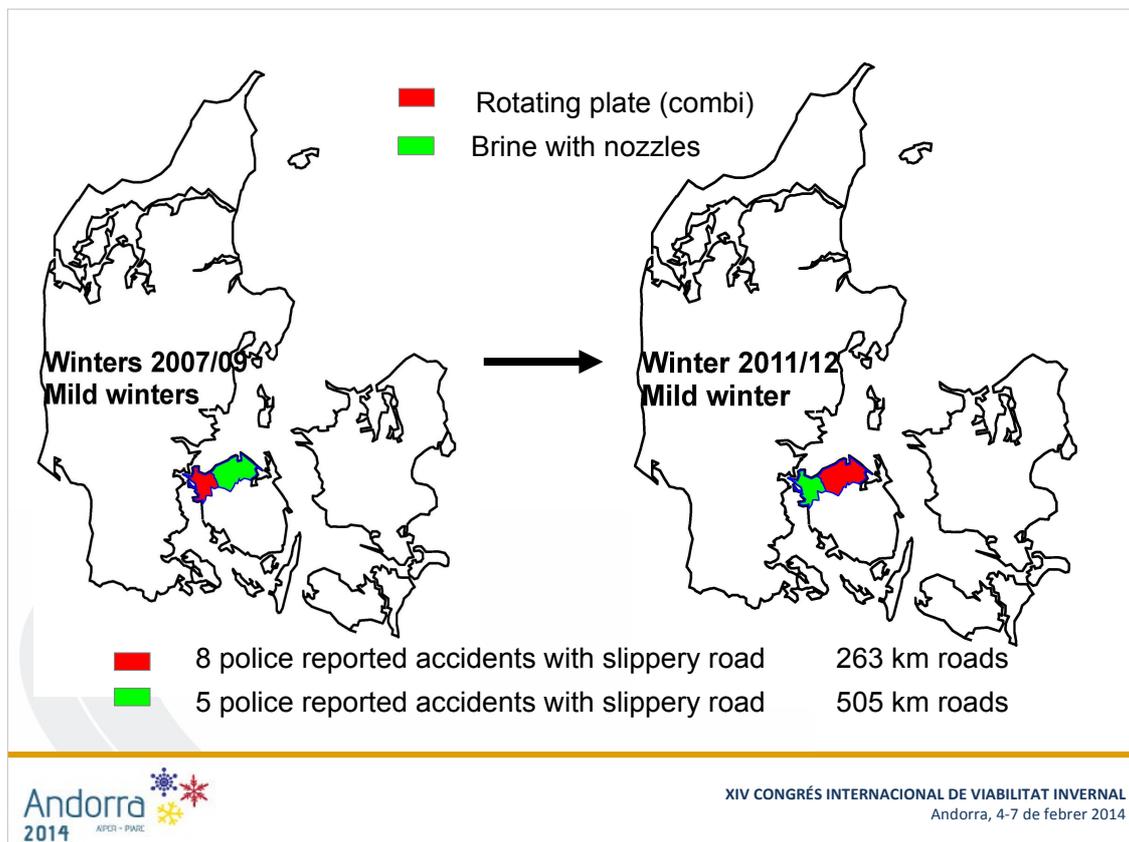
100 km road: 3 police reported accidents with slippery road every mild winter when using a kombi salt spreader strategy and only 1 when using brine spread with nozzles!

Can this be correct? Yes!

Look at the two Road boards Middelfart municipality and Nordfyns municipality. They are neighbour municipalities in the Northwest of Funen.

Middelfart used mostly kombi salt spreader in 2007/2009, where Nordfyns used brine spread with nozzles.

In 2011/2012 it was the other way around: Nordfyns used kombi salt spreader and Middelfart used brine spread with nozzles.



Take a look at the accidents from the mild winters 2007/2009 and 2011/2012.

Length of treated roads and accidents in the 2 municipalities.

| | Brine with nozzles | | Kombi salt spreader | |
|-----------------------------|--------------------|-----------|---------------------|-----------|
| | km road | Accidents | Km road | Accidents |
| Middelfart | | | | |
| 2007/2009 | 78 | 0 | 102 | 4 |
| 2011/2012 | 105 | 2 | 0 | 0 |
| Nordfyns | | | | |
| 2007/2009 | 322 | 3 | 0 | 0 |
| 2011/2012 | 0 | 0 | 161 | 4 |
| Total | 505 | 5 | 263 | 8 |
| Accidents per 100 km | | 1 | | 3 |

In a greater study which involves 2 lane highways within a distance of 50 km from the municipality Middelfart the result from these winters were:

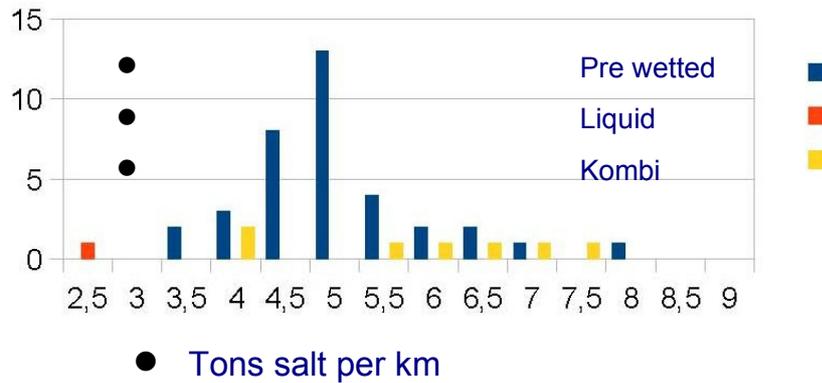
Totally 65 accidents. Totally treated highways (length * winters) = 3156 km.

| | | | |
|-------------------------|----------------------|---------------|-----------------------|
| Brine with nozzles | Totally 5 accidents | 505 km road. | (1 per 100 km) |
| Prewetted salt spreader | Totally 42 accidents | 2100 km road. | (2 per 100 km) |
| Kombi salt spreader | Totally 18 accidents | 551 km road. | (3 per 100 km) |

Benefits Environment

- Liquid only use only half the amount of salt!

— Number of winter routes in 2011/12

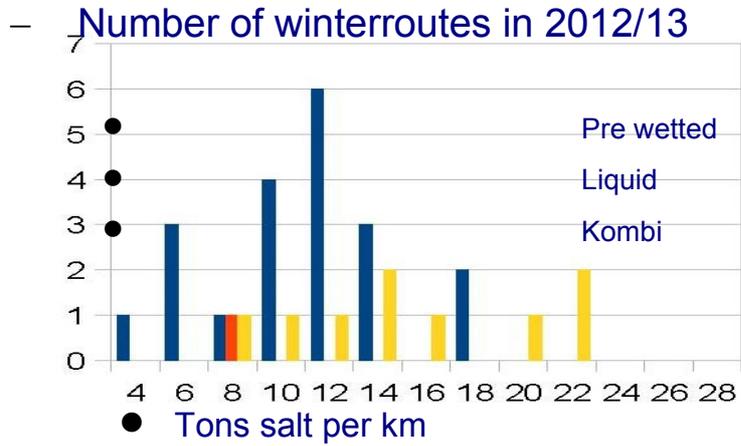


In the next diagrams is data from a number of winter route near Middelfart used. It is data from Winterman, an administration system, which collect data from spreading salt and snow ploughing. All routes are 2 lane roads with heavy traffic, and which are preventive salted.

The next 3 diagrams x-axis are tons salt used per km 2 lane road. The y-axis show how many routes have used the actual "tons per km".

Benefits Environment

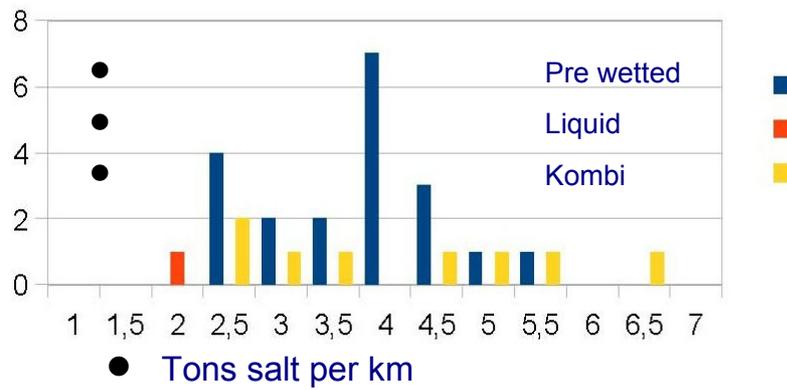
- Liquid only use only half the amount of salt!



Benefits Environment

- Liquid only use only half the amount of salt!

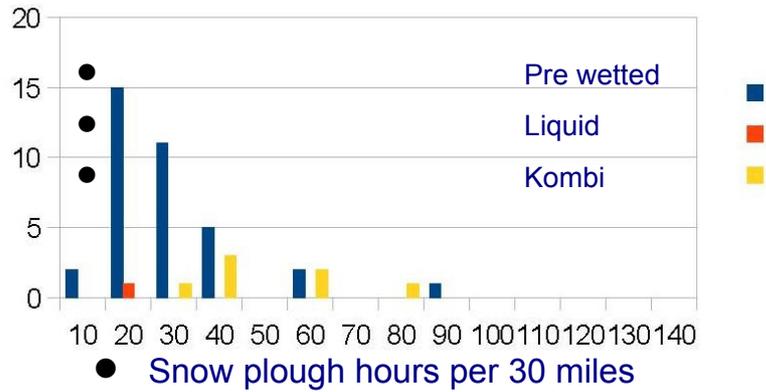
– Number of winter routes in 2013/14



Benefits Economy

- Liquid only use less snow plough hours

— Number of winter routes in 2011/12

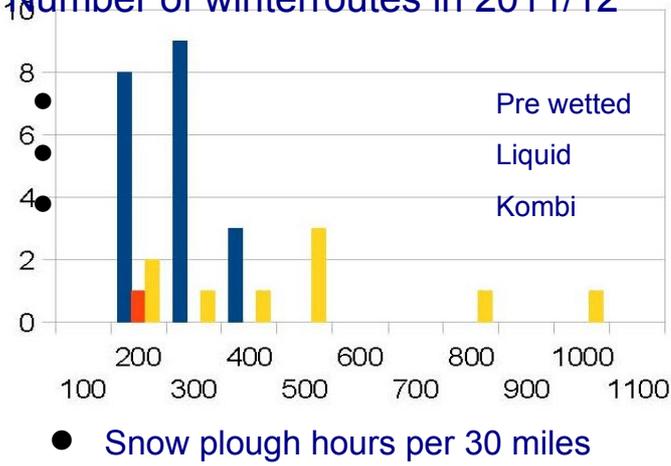


The next 3 diagrams x-axis are snow plough hours used per 30 miles 2 lane road. The y-axis show how many routes have used the actual snow plough hours.

Benefits Economy

- Liquid only use less snow plough hours

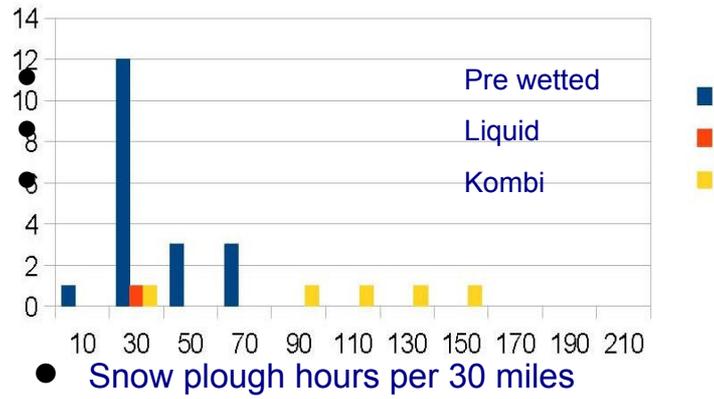
— Number of winter routes in 2011/12



Benefits Economy

- Liquid only use less snow plough hours

— Number of winter routes in 2013/14



Conclusion

Brine spread with nozzles has great potential!

- Be careful, it is a new way!
- I hope many will start using liquid only!
- And start measuring residual salt!
- If you do, we can start an innovation in winter service, based on both science and practical research!

Conclusion

Liquid only, brine spread with nozzles has great potential!

But it is a new way to do winter service, so be careful, there are many challenges, Fønnesbech [8].

When you start using liquid only, I hope you start an innovation in winter service, so we in the future can have winter service based on both science and practical research.

Thank you

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Questions?

References:

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