HOW CAN P&R FACILITIES CONTRIBUTE TO REDUCED EMISSIONS OF GREENHOUSE GASES?

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ABSTRACT

In this paper we investigate how various properties of Park & Ride (P&R) facilities affect their effects on traffic volumes and greenhouse gas (GHG) emissions. We found that if a P&R is located in an area where it stimulates urban sprawl, regional enlargement or induced traffic, it will not reduce vehicle kilometres travelled. In urban regions without such potential, those P&Rs that intercept journeys by car close to its starting point and transfer travellers to a relatively long public transport ride, contribute the most to reduced GHG emissions. This may be counteracted by increased traffic volumes if the P&R occupy a site which has an alternative use that can contribute to less transport demand and traffic, or if the P&R site stimulates to car journeys replacing travelling by foot, bicycling or public transport to the station. Based on our findings, we developed guidelines for planners and decision-makers for analysing traffic-reducing effects of P&R in the planning and decision processes. This also includes discussions on which measures can be applied instead of constructing new or expanding existing P&R facilities in different contexts.

1. INTRODUCTION

Environmental concerns – global and local – make planners and politicians look for measures which can reduce the vehicle kilometres driven by private cars. This applies especially to urban regions. The Norwegian government has stated in several policy documents that the expected increase in demand for transport in the cities shall be satisfied with walking, bicycling or the use of public transport (Ministry of Transport 2013). It has been suggested that P&R has the potential to be an efficient measure to achieve this.

Several objectives have been used to justify investing in P&R. P&R may provide easier and more attractive access to in city, it may increase the attractiveness of public transit and its ridership and it may reduce the need for parking in the city centre. It has also been assumed that P&R will reduce vehicle kilometres travelled (vkt) because it allows people to travel by public transport rather than by car. Several studies question, however, if P&R results in reduced vkt, and some studies found that it rather can result in increased vkt (Parkhurst 1995, Meek et al. 2008, 2011, Mingardo 2013, Parkhurst and Meek 2014).

One hypothesis could be that whether P&R contributes to increased or decreased vkt, depends on the conditions and location of the site. In Norway there has been little critical discussion concerning P&R and its effect on car use. Contrary to many other measures aimed at reducing car traffic, P&R are not considered to be restrictive and will therefore meet little opposition. The concern among planners and politician has rather been on the possibilities for expansion of existing sites and finding place for new ones. In the course of the last few years there has been raised questions about the benefits of more parking at stations. At the same time Norwegian authorities and operators have published strategies for the development of more P&R[1]. Hence, in our research we defined two main research questions which we have tried to answer through empirical investigations:

- What kinds of P&R (location, size/capacity, etc.) can result in reduced vehicle kilometres travelled and reduced GHG emissions? What properties, conditions and regulations affect such effects?

- How can planning and decision-making processes be organized to ensure that traffic- and GHG-reducing effects are assessed?

There are few Norwegian studies of who are the users of P&R services, and those that exist do not study what the alternatives were and what effect the use of these would have had on traffic and the environment[2]. These studies do not discuss if the provision of P&R leads to new car trips, longer car trips or increased vkt than what would have been the situation without.

This study aims at providing an improved understanding of the possible traffic-reducing and traffic-increasing effects of P&R, and by that create a platform for more knowledge-based analyses, plans and decisions concerning P&R.

2. CONDITIONS AFFECTING TRAFFIC REDUCING EFFECTS OF PARK AND RIDE FACILITIES

P&R facilities can differ from each other through a range of characteristics, such as the location of the site relative to the residential areas, access roads, the quality of the public transit (travel time, capacity), fare structure, etc. These conditions may affect whether P&R contributes to increased or reduced traffic volumes in a city or a region. Based on existing research literature (Parkhurst 1995, Meek et al. 2008, 2011, Mingardo 2013, Parkhurst and Meek 2014, Spillar 1997, Farhan and Murray 2008), as well as our own reflections, we have arrived at a number of mechanisms through which P&R can affect traffic volumes. In the empirical research, presented in section 4 and 5, we have investigated if these mechanisms are relevant for 12 P&R facilities we have chosen as our cases.

When considering the introduction of a new P&R facility, or expanding a P&R where demand is higher than capacity, it is necessary to understand that it may affect travel in different ways. It may cause people who used to drive by car all the way to work to park the car at the P&R and instead use public transport for part of the journey. This will normally reduce traffic volumes. However, people who used to walk, bike or use public transport to the station may start using their car to the P&R instead. Also, some of those who used to go by bike or public transport all the way from home to work may start driving to a P&R and use a faster or more comfortable public transport mode from there. This would increase traffic volumes. Hence, in our empirical research, we needed to investigate which alternatives the P&R-users had (if they live in walking or bicycling distance to the P&R, if they can use public transport to the P&R, how they would travel if the P&R they use did not exist, whether the distance from home to P&R is shorter than the distance from P&R to destination).

In a transport system with congestion and delays, there will often be an unreleased potential for traffic. In such situations, increased road capacity will reduce delays, and hence cause more people to choose car instead of other modes. This is often termed induced or generated traffic, and the new traffic may cause new congestions within few years (Noland and Lem 2002, Downs 1962). Likewise, in congested traffic systems, one would expect that travellers that used to drive to work, and who choose to park at the new or expanded P&R, would be replaced by other travellers on the road. This means that traffic reductions caused by P&R will be replaced with new or induced traffic. Hence, this was a condition we needed to take into consideration in our research. Further, we wanted to study if it was likely that car-trips taken out of traffic would be replaced by longer, or rather shorter car-trips.

Improved accessibility, for instance through P&R and fast public transport, makes construction of housing, workplaces, retail and other activities in peripheral, car-dependent and traffic generating areas more attractive (Litman 2015, Noland and Lem 2002, Næss 2012). This is often the case in cities with a high pressure on the housing market. When housing, work-places and retail are located far from a city centre more car use is generated. Hence, P&R can encourage urban sprawl and regional enlargement, and thereby increased road traffic volumes. In our studies, we also considered this potential.

Further, the P&R sites themselves may displace activities and urban developments in town centres and close to public transport nodal points, and push these activities and developments to more traffic-generating locations further from the centre and the nodal point. This increases traffic volumes.

The traffic-reducing effects of P&R may also be affected by public transport fare zones, whether the parking at a station is free, road tolls, differences in qualities of public transport services related to the P&Rs, as well as their occupancy. If any of these factors entice travellers to drive longer than necessary to a transfer station it will have an impact on the vkt in the region.

When asking if P&R contributes to increased or reduced traffic volumes, all these mechanisms need to be considered. Even if the number of trips is unchanged the mode choice may change and the sum of vehicle kilometres travelled may increase. If the total distance saved by those who would have driven all the way is larger than the sum of all the generated trips to a new or expanded P&R site, it means that we may have reduced the emissions of GHG.

3. RESEARCH DESIGN AND METHODOLOGY

In order to answer the research questions, we worked together with authorities in four Norwegian urban areas: Oslo, Bergen, Trondheim and Kristiansand.

We used three different approaches for data collection. First, we selected three P&R projects for a detailed study of the planning processes and what analyses had been undertaken. All three projects had recently been through planning and decision-making processes and construction was completed by the time we did the study. Document studies and interviews with planners involved in the processes were the main methods. Our intention was to describe which objectives had been defined and if reducing traffic volumes was one of these. We also asked which analyses had been done, which alternatives had been considered and which information decision-makers received. Our aim was to arrive at ways of improving processes and analyses that clarified if the suggested P&R could be expected to contribute to reducing traffic volumes.

Second, at 75 selected P&R sites, we noted the number plates of all parked cars, received home addresses of the owners from the Norwegian Public Roads Administration, and plotted these addresses on maps[3]. This allowed us to analyse the distance between the homes and the P&R site measured both "as the crow flies" (air distance) and by the real distance along the shortest road. We also made note of how early the sites filled up.

As a third approach we asked the users at 23 selected P&R sites whether they were willing to respond to a questionnaire and sent a questionnaire to those who provided us with their e-mail address. Then they could respond while travelling with public transport or later if that was more convenient. We asked the users why they were travelling, what was their destination, if they had errands on the way, if they had been driving to their closest P&R, why they did not drive all the way to the destination, how they would travel if the P&R did not exist or if they had to pay a parking fee, as well as questions concerning age, gender, children etc. The information was used for analysing car traffic saved by each of the P&R sites.

Finally, we did a comparative case study of 12 of the 23 P&R sites, where we used all the information listed above. In addition, we evaluated (through map- and air-photo studies) whether the P&R were taking up central areas that could have been used for developments or activities, and whether the P&R facilities were located in areas and regions with high potentials for urban sprawl, regional enlargement or induced traffic (congestion-data, interviews with planners).

Based on the research described above, we developed guidelines for analysing traffic- and GHG-reducing effects of P&Rs. These guidelines can be used in planning and decision making processes. We have also discussed alternative measures, which can be implemented instead of P&Rs in various contexts.

More thorough descriptions of methods and findings are documented (in Norwegian) in two reports: Christiansen and Hanssen (2014), and Hanssen, Tennøy, Christiansen and Øksenholt (2014).

4. FINDINGS

4.1 Planning and decision making processes

In order to get a better understanding of processes and analyses involved when new P&Rs or expansion of P&R are planned and decided, we investigated three relevant planning and decision making processes. At Vestby (rail) and Botilrud (bus) the existing parking capacity was expanded while Brubakken (bus) was a new facility.

For the three cases we had the following questions:

- Who initiated the process and how was it followed up?
- What should be achieved with the expanded or new facility? Was reduced car traffic (vehicle kilometres) and emissions of GHG part of the decision-making process?
- Were factors such as location, number of spaces, parking fee or other regulations included in the planning process? Were alternatives studied?
- What analyses were done in order to describe effects on local traffic, (global) emissions, etc.? On what knowledge were such analyses based?
- Were the analysis and plans described in a way that showed possible effects of the P&R-project on traffic and climate?

Our main findings are that there is little knowledge based and comprehensive planning behind the investments. The main driving force is that there is an observed demand for more spaces. We also found that because P&R is considered to be a "positive and wanted measure" and each project is small compared to other investments in transport infrastructure, it seems that it is fairly easy to finance new P&R projects or the expansion of existing ones.

New P&R would be located where land was available near an existing public transit service. There were not done any analyses of the effects of the investment on traffic and climate or if other locations or regulating measures could have given the same or better effects.

The responsibility for planning and building is partly placed at agencies responsible for road construction, the rail network or operation of public transport. Often there is not a political process involved. The politicians do therefore not see analyses or evaluations describing the effects of the actual investment.

These findings are in accordance with findings in a synthesis of practice among transit agencies in the US. Here, P&R is described as "*widely recognized as an important factor influencing transit access and ridership"* (Jacobson and Weinberger 2016). The authors found, however, that there is only limited research that documents the impact of parking policies on transit ridership. Based on their survey they found that some of the agencies had plans to expand their parking capacity even if they already had excess capacity. One argument was that they had funding available. Some agencies would increase capacity because demand exceeded the supply. Observed excess demand is an important argument also in the Norwegian context, but there is little discussion of what causes this demand.

4.2 Use and users of P&R

The P&R sites at the selected railroad stations have an average capacity of 126 spaces. At P&R served by bus there were on the average a capacity of 75 spaces. At the time of registration (usually around 0900 in the morning) the occupancy rate was 83 % at the railroad stations and 60 % at bus stops. However, nearly half of the sites at railroad stations had 95 % occupancy or higher. 52 % of all interviewed users answered that they had to travel early in order to find a free space. At the sites with full occupancy 63 % stated they had to start earlier from home than desired.

Most users, 97 %, were on the way to work or school. This result may be explained by the time of the interviews – between 0530 and 0900. However, in the cases the P&R was filled up by that time there could not be other users. 34 % of the users are between 40 and 49 years old. The age group between 30 and 59 years (those who usually are part of the work force) constitute 80 % of the users. More than half of the users are women (58 %). The survey showed that 25 % of the users have children less than 7 years old and therefore may have a reason to bring one or more children to nursery. 36 % have children between 7 and 15 years of age. We registered that among those living close to the station (2 km or less) there were more cars with a children's seat in than among those living farther away. More than 80 % of the persons being interviewed said they had been alone in the car on the way to the station.

About half of those being interviewed said they had an errand to do either on the way to or from the P&R. 24 % said that they purchased food and 24 % had to stop at a nursery. Those who live close to the P&R have more often errands than the other users.

The survey confirmed that fare structure (zones) has an effect on the choices being made. 28 % answered that they have the opportunity to use a station closer to home, but made their choice in order to use public transit from a station in a lower priced zone.

4.3 Alternatives to driving to the P&R

By mapping home addresses of the P&R-users, we could calculate distance between the homes and the P&R. We calculated distance along the road as well as the air distance. We can assume that there often will be local shortcuts for those walking or using bicycle, but this will obviously vary from place to place. Hence, we believe that the actual distance for these users usually will be somewhere between the two distances measured.

Between 20 % (measured along the road) and 39 % (measured as air distance) live between 0 and 2 kilometres from the station. Within a distance of 3 kilometres from the station we found the homes of between 35 % (along road) and 53 % (air distance) of the users. The average trip length between home and station for the car users is 5,4 kilometres measured as air distance and 7,6 kilometres along the road (figure 1). We found that between 3 % (if measured along the road) and 12 % (if measured in air distance) of the users of P&R live within a distance of 1 kilometre (walking distance), see figure 2.

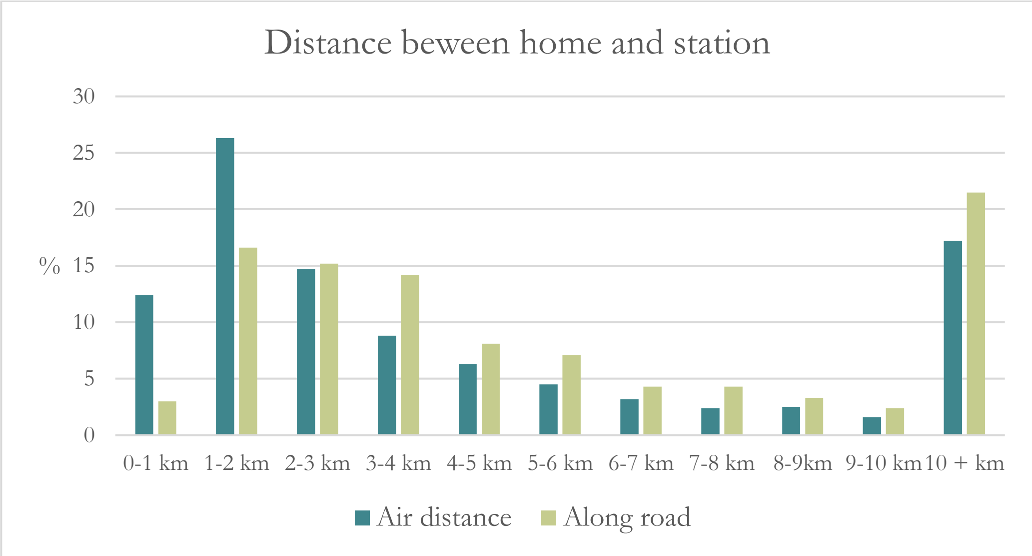
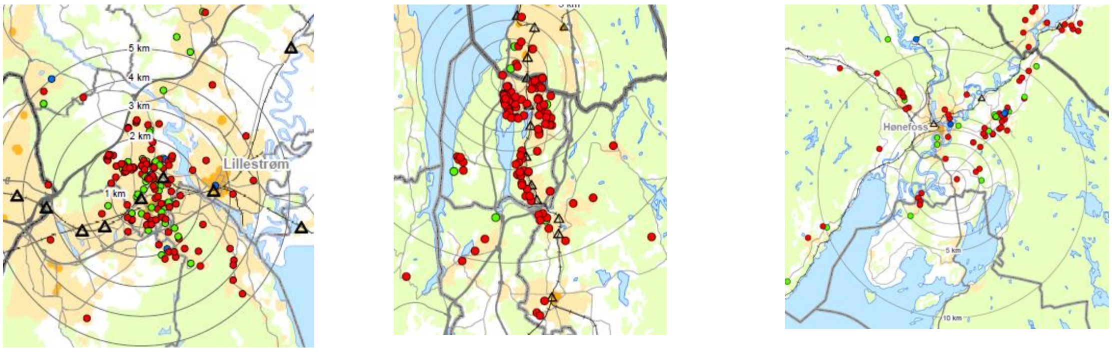


Figure 1: Distance between home and station for car users – air distance and along road. N=10167[4].

46 % of the P&R-users answered that they could have used the local bus from home to the station, rather than car and P&R. Hence, we concluded that most users do not live within walking distance to the P&R, but many could have used bus instead of car.

Naturally there are great variations between the stations. We made maps showing location of the homes of users at 75 different P&R sites, see examples in figure 2.



Strømmen Rosenholm Botilrud

Figure 2: Three stations showing different residential patterns. At Strømmen a large share of the user live close to the station while many users at Rosenholm drive parallel to the railroad in order to reach a station with local fare. Botilrud is served by bus and represent a rural area with limited local bus services[5].

The maps indicate that the use of P&R facilities do not fit into an ideal, theoretical pattern. People do not use their nearest site even when the public transport service is the same. People drive separate cars even if the neighbours have the same travel pattern. They are influenced by the road capacity, the parking capacity (how early the site is fully occupied), fare structure, toll system, etc. We also registered that a large share of the cars were equipped with children's seats. Therefore some of the drivers may have had a reason for a detour and choice of another P&R location than the one nearest to home.

4.4 Reasons for choosing P&R

Most users of P&R have the central city or major employment locations as their destination. That means that they often will experience shortage of parking or costly parking. In the survey we found that 54 % of those who drove to the station would either have to pay for parking at their destination or they said it would be difficult to find a space. 14 % answered that they had a free parking space available at their destination, but chose to use the P&R and public transport instead.

We asked the users why they did not drive their own car all the way to the destination. The main reason was congestion. Other reasons were the parking expenses and that it was faster to use public transport (figure 3). The importance of these factors vary with the regions in which the P&Rs are located i.e. how congested the roads are and the quality of the public transport.

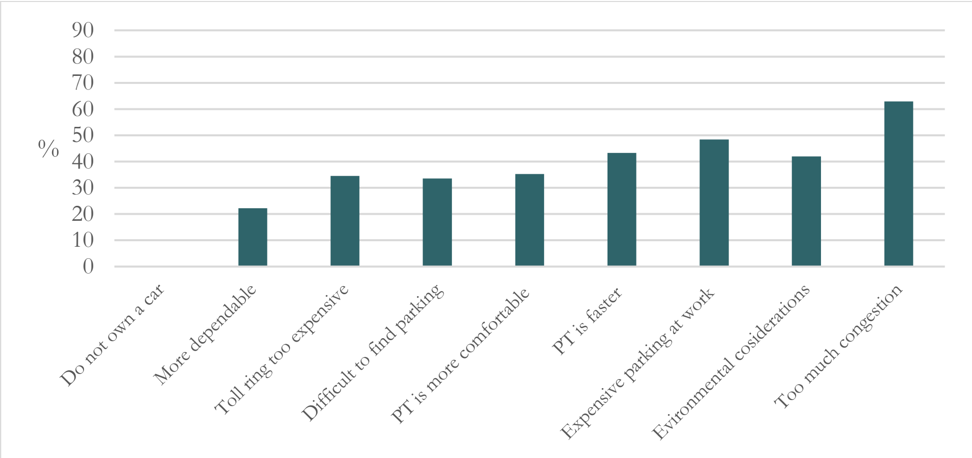


Figure 3: Reasons for not driving all the way to the destination. Multiple answers possible. N=690.

4.5 Alternatives provided the P&R used did not exist

We asked how the users would have travelled if the parking (P&R) was not offered at the station they used. 25 % said they would have driven their car all the way while 24 % would have driven to another P&R (figure 4). The rest would have used the same station but 16 % would have walked or bicycled there, 15 % would have used local public transport to the station and 20 % would try to find other parking in the area around the station.

Another hypothetical question was what they would have done if there was a parking fee of NOK 25 per day for using (P&R) at the station[6]. In such a case 23 % would have driven all the way to their destination figure 3). Only 15 % would have travelled like they used to and paid the parking fee. 14 % would have used the same station but walked or bicycled there, 11 % would have used local public transport and 13 % would look for other (free) parking in the area near by the station. 25 % would drive to another P&R[7].

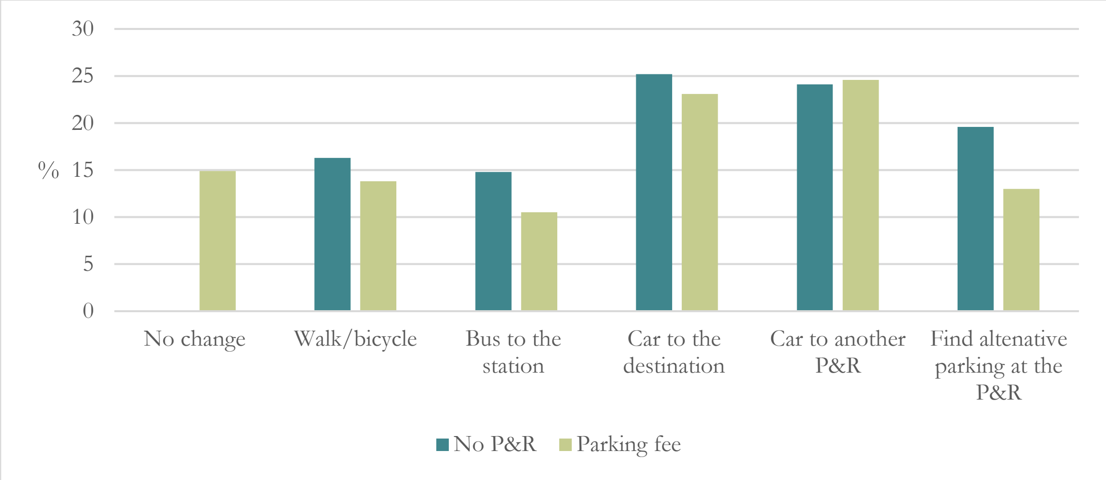


Figure 4: The users' travel choices if the P&R did not exist or if a parking fee was introduced. N=455.

More detailed analyses show that it was mainly those living closest to the station who would walk or bicycle. Those who have a parking fee at work would still prefer not to drive all the way. Those who lived within a distance of 5 kilometres from the station were asked why they did not bicycle. 44 % answered that they would have liked to bicycle more, but had various reasons for why they did not do so. 23 % said it was too far for a daily ride, 23 % meant it was not good and secure bicycle parking at the station and 8 % said they did not have a safe bicycle path to use. 36 % answered that they had to do an errand on the way to or from the station.

5. CASES: ANALYSES OF CONDITIONS AFFECTING THE TRAFFIC-REDUCING EFFECTS OF P&R

The main approach in the study is a more detailed and comparative analysis of 12 selected P&R sites. Six of the 12 cases are served by bus, five by railroad and one by ferry. The aim was to investigate all mechanisms discussed in section 2 for all P&R sites. We used data from the registrations and the surveys (the aggregated findings were presented in section 4), and also more qualitative registrations and assessments, based on maps, aerial photos and interviews with local planners (as described in section 3).

Each site is characterized by 21 indicators describing its location, which we organized in tables 1 and 2. We analysed the material, in order to answer the following questions:

- How many vkt each individual P&R save – when seeing the P&R and the users as a static and isolated system?
- What measures could be applied in order to increase the reduction of vehicle kilometres travelled?
- What alternatives existed to the expansion of the P&R in the alternative settings selected?

Table 1: Summary of six P&R sites - five at rail stations, one at ferry terminal

Location	**Rosenholm**	**Slependen**	**Ski**	**Asker**	**Hommelvik**	**Kleppestø**
Relation to local center	Outside	Outside	In center	In center	In center	In center
Spaces for cars	156	81	541	726	30	465
Site occupancy	98 %	100 %	99 %	99 %	98 %	69 %
Spaces for bicycles	24	64	733	546	-	-
Bicycle spaces used	2	9	130	88	24	-
Average distance between P&R and destination (km)	12,5	15,9	27,6	24	27,5	13,7
Average distance between home and P&R (km)	6,7	6,7	10,3	9,4	5,7	6,7
Share < 1 km	0 %	6 %	2 %	1 %	3 %	1 %
Share 1 – 3 km	21 %	54 %	45 %	16 %	28 %	25 %
Share 3 – 10 km	61 %	24 %	19 %	53 %	33 %	56 %
Share > 10 km	18 %	17 %	34 %	30 %	15 %	19 %
Share who says bus was an alternative	10 %	24 %	53 %	24 %	30 %	83 %
Share who alternatively would walk, bicycle or use bus to access the station	21 %	29 %	33 %	23 %	26 %	31 %
Share who alternatively would use car to the destination	31 %	21 %	39 %	24 %	11 %	25 %
Calculated vkm saved per user	5,8	5,6	17,8	9,3	7	-
Influence of fare zones or toll	Y	N	N	Y	N	N
Occupying land with alternative use	N	N	Y	Y	Y	Y
Cause activities to locate other places	N	N	Y	Y	N	N
Leading to urban sprawl?	N	N	Y	Y	Some	Some
Is there reason to expect induced traffic?	Y	Y	Y	Y	N	Y
Will induced traffic lead to longer travels?	Y	Y	Y	N	N	N

Table 2: Summary of data for six P&R sites served by bus

Location	**Ringerike sykehus**	**Botilrud**	**Heiatoppen**	**Melhus**	**Tangvall**	**Vennesla**
Relation to local center	Outside	Outside	Outside	In center	Outside	Outside
Spaces for cars	68	61	81	170	172	24
Site occupancy	100 %	98 %	54 %	96 %	24 %	71 %
Spaces for bicycles	0	0	6	34	42	12
Bicycle spaces used	0	0	0	9	13	0
Average distance between P&R and destination (km)	53,8	49,8	27,5	17,4	14,9	15,0
Average distance between home and P&R	5,6	7,5	9,4	6,2	13	4,6
Share < 1 km	3 %	0 %	1 %	3 %	3 %	0 %
Share 1 – 3 km	4 %	2 %	23 %	28 %	13 %	57 %
Share 3 – 10 km	66 %	58 %	39 %	50 %	47 %	36 %
Share > 10 km	28 %	40 %	37 %	19 %	37 %	7 %
Share who says bus was an alternative	33 %	39 %	50 %	41 %	67 %	25 %
Share who alternatively would walk, bicycle or use bus to access the station	17 %	8 %	40 %	22 %	0 %	0 %
Share who alternatively would use car to the destination	17 %	0 %	5 %	26 %	33 %	25 %
Calculated vkm saved per user	17,1	- 0,4[1]	- 2,7[2]	7	10	9,2
Influence of fare zones or toll	N	N	N	N	N	N
Occupying land with alternative use	N	N	N	Y	N	N
Cause activities to locate other places	N	N	N	Some	N	N
Leading to urban sprawl?	Y	Y	Y	Y	Y	Y
Is there reason to expect induced traffic?	Y	Y	Y	N	N	N
Will induced traffic lead to longer travels?	N	N	N	N	N	N

[1] None of the users at Botilrud answers that they would drive all the way. They would drive to the next P&R. In our calculations, this results in negative traffic-reducing effect for Botilrud.
[2] At Heiatoppen, a large share (40 %) answers that they would use other modes than car to the station if the P&R did not exist, while a low share would drive all the way.

Our calculations concerning saved vkt per workday per parking-space were based on the data in the tables. We found that vkt saved varied from 17,8 to -2,7 km per user per workday. The respondents' answers to how they would have travelled if the P&R facility they used did not exist had a major influence on the results. In the survey, 24 percent answered they would drive to the next P&R-facility. Hence, our calculations give answer to effects on vkt saved if each of the *individual* P&R-facilities did not exist, and not to effects of removing the whole *system* of P&R-facilities. This was a flaw in our research design, and reduced the usefulness of these results with respect to calculating vkt saved by P&R. Instead, we should have asked (in the survey) what the users would do if they could not use any P&R.

We realize that there is much uncertainty in the vkt-saving estimates and in the survey. A main uncertainty is whether the users actually would act the way they answer they would in the survey. For instance, if the P&R site used did not exist or was priced, many users say they would drive all the way, some would change to another P&R site, some would find another public transport for the journey and some would change mode for access to the station they were using. There are reasons to doubt that all those who say they would drive all the way actually would be able to find a (free) parking space at the destination and also would be willing to use more time on congested roads on their way to the city. This is especially so because most users had alternative travel options either to the station or to the destination.

Anyway, studying the individual P&R cases in depth, and by analysing them across cases, gave both a good understanding of the conditions affecting the traffic reducing potentials of P&R and which alternatives exist to expand or build new P&R sites. Not the least, it did demonstrate that we need to analyse and understand the question of the traffic reducing effect of P&R on (at least) three levels: The individual P&R sites, systems of P&R sites and P&R in a regional and long range time horizon.

6. WHAT KIND OF P&R CAN RESULT IN REDUCED CAR USE?

Based on the case analyses of 12 P&Rs, as well as more aggregated analyses of the registrations and survey data, we can now answer our main research question on the three levels:

i. Current use and users of a P&R site, static and in isolation

When analysing each site in isolation, and considering current use and users, we found that all 12 P&Rs resulted in reduced vkt. The average distance between home and P&R is shorter than the distance travelled by public transport to the final destination. In most cases, relatively low shares of the P&R users lived in walking distance to the station served by the P&R, while a large majority could have used public transport instead of car. Hence, the potential for changing car trips to P&Rs into walking trips is rather low, while there at least theoretically, is a large potential for shifting to public transport. In several cases, P&R were found to contribute to a possible dislocation of developments and activities from central areas well served by public transport. This contribute to increased traffic.

When asking which kinds of P&Rs contribute the most to traffic reduction, we found that:

- The farther away from the destination the P&R site is located, the larger effect (reduced vkt) does each parking space have
- P&Rs that do not encourage to unnecessary car use have larger effects
- Locating P&R outside the cores of cities and towns reduces traffic created by developments and activities being displaced

ii. Several P&R sites operating as a system

We analysed corridors where P&R sites influence on each other. Car drivers do not always use the P&R nearest to their home. Therefore, the relative length of the journey done by car may increase. Fare structures, toll systems, congestion and the standard of the public transport services (capacity, frequency, travel time, etc.) influence their choices. We found that:

- Systems of P&R cause less unnecessary car traffic if the attractiveness of the P&Rs in the system is quite similar

iii. P&R in a regional and long range horizon

P&R located in cities and regions with potential for urban sprawl, regional enlargement or induced traffic will contribute to increased traffic volumes and GHG emissions. In such areas, P&R provides increased mobility and greater freedom of choice. This is beneficial in itself, but will also contribute to increased traffic volumes and GHG emissions. In such areas, P&R cannot be understood as a means to reduce traffic volumes and GHG emissions. We found that this is especially true for the Oslo region.

7. GUIDELINES FOR PLANNING AND ANALYSES OF P&R FACILITIES

Based on the empirical work and analyses discussed here, we could summarise our findings in some simplified guidelines for analysing possible traffic-reducing effects of P&Rs.

Information and data which may be useful as a basis for these analyses:

- The destination for the majority of commuter trips (statistics, information from local planners)
- Where the users of the P&R live (registration and analyses of car license plates, information from local planners)
- More detailed information about the users and the use of the site (surveys, interviews with local planners)
- Information about public transport services, paths for access by walking or bicycling (statistics, operators, interviews with local planners)
- Existing land use, traffic situation and plans for future development near the proposed site (master plan, interviews with local planners)
- Study a larger part of the region in order to evaluate the potential for sprawl (master plans, regional plans, interviews with local planners)
- Information on congestions and delays on main roads and possibility for induced traffic

When analysing the traffic reducing potentials of P&R sites, we recommend that the following questions are asked (table 3). We have indicated which further actions to take, based on whether the answers to the questions are yes or no.

Table 3: Questions used for evaluating whether a P&R project may reduce traffic volumes.

Question	*If Yes*	*If No*
Does the location contribute to long car journeys compared to the length travelled by public transport?	Does not result in significant reduction, consider other alternatives	Allow, if no other significant and unwanted effects
Do many of the users of P&R live close to the site? Do many of the users have a good public transport service feeding to the site and allowing them to leave the car at home?	Results in no or limited effect, consider other alternatives	Allow, if no other significant and unwanted effects
Do users have another public transport service from home (within walking or bicycling distance) to the destination?	Could increase traffic volumes, consider other alternatives	Allow, if no other significant and unwanted effects
Are there other and better uses of the site occupied by P&R? Is the use and traffic a nuisance for other developments?	Can displace activities or developments, consider other alternatives	Allow, if no other significant and unwanted effects
Do properties of the P&R, or the system of P&R sites, cause people to travel longer by car than necessary?	Contributes to increased traffic to and from the station, consider other alternatives	Allow, if no other significant and unwanted effects
Will this P&R stimulate to urban sprawl or regional enlargement?	Could contribute to increased (induced) traffic, consider other approaches for good access to the station or bus stop	Allow, if no other significant and unwanted effects
Will the traffic relief caused by the actual P&R site be replaced by induced traffic?	Does not reduce traffic volumes, consider other approaches for good access to the station or bus stop.	Allow, if no other significant and unwanted effects

If the answer to all questions are no, the proposed P&R spaces will probably contribute to reduced traffic volumes and GHG emissions. If the answers to one or more of the questions are yes, other alternatives should be considered. What alternatives are appropriate will vary with the context, but they should include the possibilities for:

- Improved access for those walking or bicycling to the station
- Improved feeder bus service from residential areas to the station or terminal, - and/or smaller P&R sites at stops served by these routes
- Improved regional bus services with more direct buses to the urban centre
- A parking fee, or other measures regulating the use of P&R
- Adjustment of the fare zones for public transport in order to influence on users' choice of P&R site
- Implementing incentives for carpooling to the P&R - and also consider possible use of the site for carpooling from the site
- Relocating the P&R
- Reducing the number of parking spaces at the P&R
- Consider increased parking capacity (also multilevel parking structures) at selected places provided the public transport can offer needed capacity

8. CONCLUSION

The main finding in our study is that P&R cannot generally be considered as an efficient measure for reducing road traffic volumes (vkt) and GHG emissions from traffic. P&R can facilitate urban sprawl and regional enlargement, which generate increased traffic volumes. It may displace activities from centres and public transport nodal points, to more car-dependent areas where they generate more traffic. In congested traffic systems, cars taken out of traffic and parked on a P&R will be replaced by other cars, and hence there will be no reduction in traffic on arterial roads. We also found that many users of P&R have other options for transport to the station, most by bus but also some by foot or bicycle. The survey showed that a parking fee could have a significant impact on the demand for and use of the P&R sites. This may reduce the 'demand' for new and expanded P&R sites. We also found that there are a number of other ways of regulating the demand for P&R.

Our conclusion is hence that even if P&R makes daily travels easier for many commuters, offering travellers free parking at stations also have negative consequences, and in most cases they cannot be understood as a measure to reduce traffic volumes (vkt) or GHG emissions from traffic. There are other measures which are far more efficient in order to achieve this objective.

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NOTES

[1] Ruter 2010, Jernbaneverket 2010, Akershus fylkeskommune 2013, Hordaland fylkeskommune 2014.
[2] Grue og Hoelsæter (2000), Ruud og Kjørstad (2008), Ellis (2008), Kjørstad og Norheim (2009).
[3] Because it is often argued that people have to use the car in order to transport children to kindergarten or school, we also registered whether there was a child's seat in the cars.
[4] We removed cases with a travel distance of 60 kilometres or more assuming there may be errors in registration or that somebody else than the owner uses the car. The car may also be rented or leased.
[5] Green dots represent cars with a child's seat installed.
[6] NOK 25 is a typical price for parking *30 minutes* in the centre of a large Norwegian city.
[7] They did probably assume parking would be free at other stations.