

The PRT Project Phase 1 Design & Engineering

The FlyBy PRT project for the Fornebu area

- Presentation of an environmentally friendly transportation system for Fornebu



The FlyBy Consortium

POSCO Group Ltd, Telenor ASA, Statkraft SF & Interconsult ASA

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CONTENTS

1 INTRODUCTION TO PERSONAL RAPID TRANSPORT3

2 BACKGROUND4

3 THE FLYBY PROJECT7

 3.1 TRAFFIC DEMAND.....8

 3.2 JV PRT SYSTEM CAPACITY.....9

 3.3 COSTS OF PRT SYSTEMS11

 3.4 ENVIRONMENTAL ISSUES REGARDING PRT SYSTEMS12

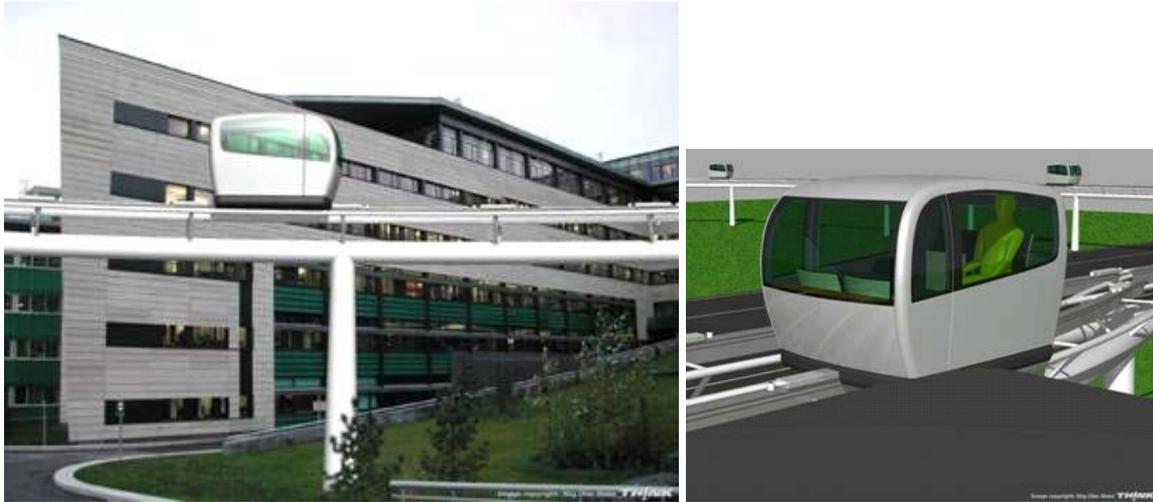
1 Introduction to Personal Rapid Transport

PRT (Personal Rapid Transport) is the international acknowledged acronym for a transport concept that can enable public transport to compete with the car in urban areas. Today, cities are increasingly multi-centred, creating a strong demand for anywhere-to-anywhere travel systems, without the damaging environmental effects of the personal car.

The PRT concept is in general characterised by:

1. **Small and automatic vehicles.** The largest unit of people usually wanting to go non-stop from exactly the same place to the same destination is the family unit, hence the need for vehicles able to hold 3-5 people.
2. **Networked and separate guideways.** Separate guideways permit higher transportation capacity and higher safety levels as the system will not interfere with current modes of transportation. The guideways will usually be positioned about 4-5 meters above street level – away from other traffic and pedestrians, and have a networked topology for large area coverage.
3. **Stations at sidetracks.** Provide for free flow of vehicles on the main tracks, while vehicles will diverge to sidetracks for pickup and delivery of passengers.
4. **On demand departures and no timetables.** Vehicles are normally waiting at the stations, departing as soon as a passenger enters and run straight to the destination without any intermediate stops. If there is no vehicle available at the station, a vacant vehicle will be routed from some other location. Therefore there will be little or no waiting for passengers on vehicles and reduced total travel time.
5. **High effective speed and high safety levels.** Each vehicle will travel at approximately 45 km/hour on uni-directional guideways. Compared to the maximum speed of cars 45 km/hour may seem slow. But, as the PRT vehicles always will go non-stop from source to destination over road congestions, the travel time will still be shorter. The chosen speed level simultaneously decreases the risk of injuries and serious accidents and the size of vehicles will prevent large-scale accidents.
6. **Robust transportation system.** If a section of the network becomes defect for some reason, vehicles will automatically bypass the faulty guideway section, preventing a complete system downtime. Further, vehicle navigation is to be performed by a distributed control system allowing less complex programming, infinite scalability and making possible failures to only have local effects.

Figur A: Concept study for the FlyBy project (property of Think AS)



2 Background

The Fornebu area is the site of the old Oslo Airport, being vacated in October 1998 when the new airport opened at Gardermoen. Local authorities have regulated the Fornebu area to be partly occupied with business offices and partly with apartment buildings. The property owners at Fornebu will be financially responsible for parts of the cost of the public infrastructure, and this also holds true for Telenor ASA – the Norwegian telecom company – which has its new corporate headquarters at Fornebu.

Telenor offers every year a Master of Telecommunications Strategy study. During the course of 2001/02, 12 students from various units of Telenor worked on the field of Intelligent Transport Systems (ITS). Of these students – six chose to proceed with PRT as their special case. In parallel to this, a corporate project was initiated to evaluate the realism of PRT for the Fornebu area. Many aspects of a PRT solution were evaluated – economic, technical as well as logistics and traffic planning. In addition planners, PRT developers and enthusiasts were contacted. All in all – PRT appeared as the best solution for the Fornebu area in terms of meeting the requirements of logistics, economy and technology.

The public transportation solution for the Fornebu area - according to decisions by the Norwegian state, county authorities and local commune government - will be an automatic elevated rail system. The system will be built and operated on a Private Public Partnership (PPP) contract between an SPC (Special Purpose Company) and the juridical counterpart, Fornebubanen AS; a company owned 100% by the county authorities of Akershus. The contract will be for a period of approx 20 years. The terms are at present still unknown, but will to some degree be disclosed when the request for prequalification is disclosed, September 2003.

Due to the political decision to build an elevated rail system, Telenor decided to proceed with the internal PRT-project with the explicit goal of establishing a consortium that could qualify for the PPP project. As PRT is clearly not a part of Telenor's core business, it was a requirement that one or more other companies would take the lead in the ensuing process. Statkraft, the incumbent Norwegian hydroelectricity provider – also situated with its headquarters in the area and with ambitions of providing “green energy” – became the first consortium member in addition to Telenor in the autumn of 2002.

In October 2002, a delegation from Korean POSCO Group Ltd. – one of the largest steel manufacturers in the world – visited Norway to present POSCO as a potential supplier and partner for a major PRT initiative. The local PRT consortium also met with POSCO, and in December 2002 it was agreed that they should work together to form a Joint Venture – with POSCO taking the leading role. The Joint Venture will assume responsibility for developing a new and competitive PRT technology and the Consortium will act as the local SPC and have the responsibility to represent the JV PRT system solution towards the Fornebu local authorities. POSCO regards PRT as a global business opportunity, and the Fornebu case fits well with its strategies for success.

At the time of writing, POSCO, Telenor, Statkraft and Interconsult have joined the consortium, and all four companies have signed an LOI for creating a PRT joint venture, and they have taken part in an initial project phase for developing a working PRT system. The final split of roles between the partners has not yet been decided, but may well be:

- Telenor Several possible roles within ICT
- Statkraft Delivering (green) energy and environmental impact analyses
- POSCO Main investor and many possible industrial roles
- Interconsult Project development

In addition to the members of the emerging PRT JV and SPC, several Norwegian, Swedish and UK companies and specialist consultants are engaged in the ongoing development project – among others Kitron, Det Norske Veritas, Aker Kværner, WGH Ltd and Force Engineering Ltd. This work has resulted in design studies which show that developing and marketing a PRT system is a very promising business case as well as an import step forward in developing more environmental friendly and attractive public transport. Economic competitiveness towards traditional elevated rail systems has been demonstrated, and a superior technological solution relative other PRT companies has been developed. This preliminary work is expected to result in the financing of a full scale PRT Test- and Demonstration system to be built at Fornebu by December 2003.

For the Fornebu project, there are some obvious competitors, especially among the suppliers of traditional elevated rail systems (APM/LRT). **Intamin** has created a consortium with the companies Veidekke and Schøyen-gruppen. They have also established a local agency, called Fornebu Monorail AS. Intamin is the company that the Akershus County most often use to illustrate an automated transport solution. **Bombardier** has to our knowledge not created any consortium yet, but they have been in contact with many of the same companies that the FlyBy Consortium has been in contact with. Further, we have strong indications that both **Frazer-Nash** and **Siemens** have shown interest in becoming pre qualified to bid.

But even after initial capital investments, APM/LRT systems often prove not to become economical in a business sense and therefore to require continuous subsidies. This opens the way to new technologies with higher potential attractiveness, such as PRT systems. The ongoing JV PRT development project has demonstrated that PRT technology in general and the JV PRT system specifically is functionally and cost-wise superior with respect to traditional elevated rail systems.

It is reasonable to assume that more companies will be interested in being pre-qualified, among which may possibly be the two PRT suppliers **ULTRA** and **Taxi2000**. When comparing the JV PRT system with competing PRT companies, the JV PRT technology is conceptually superior, especially for installations in locations which are exposed to snow and ice. The JV PRT system has been designed specifically to operate normally under such conditions.

But even providing this important operational advantage, we do not consider **ULTRA** and **Taxi2000** to be serious competitors at Fornebu. The reason for this is that the JV is significantly stronger than other PRT suppliers regarding industrial ability, financial power and local presence.

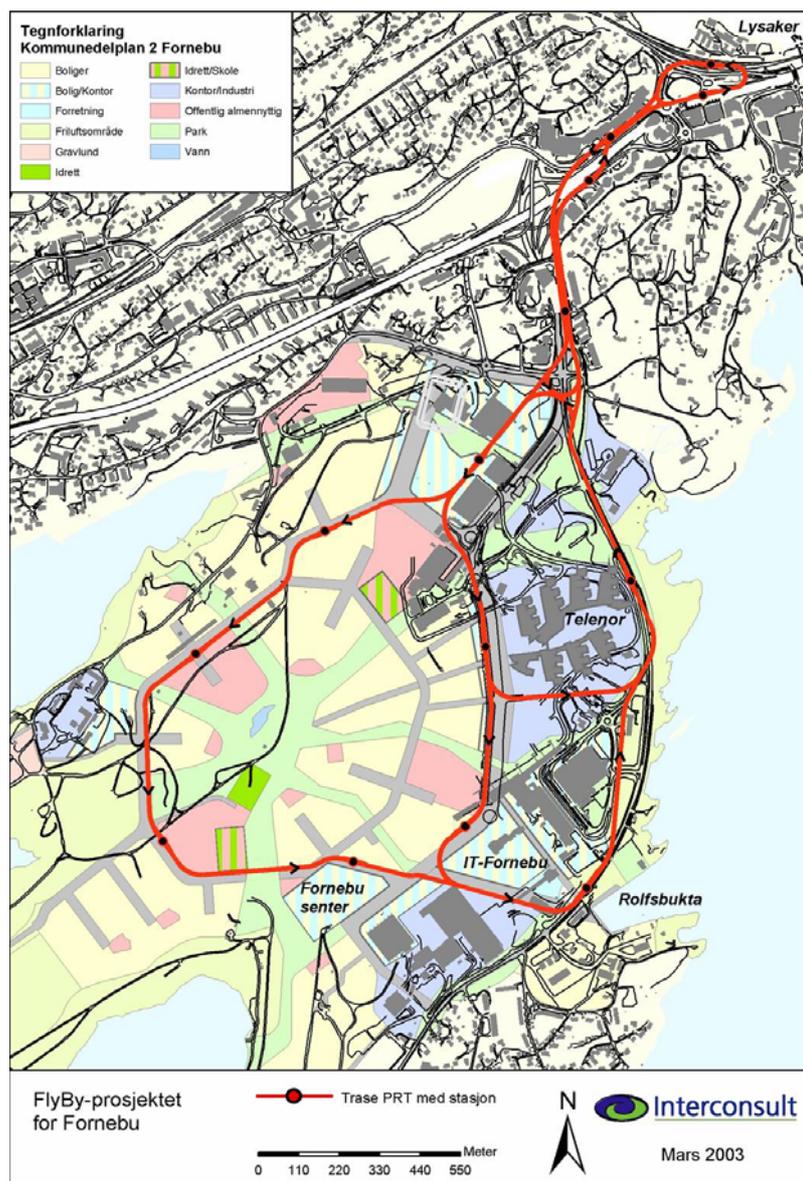
The PRT JV and FlyBy Consortium expect to become pre-qualified for submitting a tender during fall of 2003 and further to demonstrate the technological and functional feasibility of the JV PRT system at the end of 2003. Winning the contract for construction and operation of the transport network at Fornebu would result in a pilot and reference project and be a market opener for the JV PRT system.

Key milestones for the public authorities' decision process are – approximately - at present:

Prequalification	2003Q4
Tender hand-in	2004Q2
Negotiations	2004Q3 – 4
Decision	2004Q4
Build	2005Q1 –
Operations stage	2008Q1 –

3 The FlyBy Project

The preliminary layout of the PRT solution for Lysaker-Fornebu has four unidirectional loops, and the total length of the main tracks is 8.9 km. The presented configuration shown below involves 13 stations (black dots on red line), which gives a 500-600 meter distance between stations. The proposed solution gives good area coverage, good capacity and short total travel time. Special care is taken at Lysaker, where the PRT system interfaces with railroad services. The JV PRT system is easy to expand from the suggested configuration by adding new guideway loops.



Estimated required capacity for the PRT is 3,000 passengers from Lysaker to different locations in the Fornebu area during a morning peak hour. The basis for this estimate is gathered from the whitebook “Bane til Fornebu, mars 2002”, published by the County Council. With 2.0 passengers per vehicle, the estimated demand of 3000 passengers an hour gives a headway between vehicles of 2.4 seconds. The plan for the PRT system is to start operation with a conservative headway of 3.0 seconds. This will give sufficient capacity for the first years of operation.

In a new white paper from the Akershus County of April 2003, there is a suggestion on extending Kolsåsbanen Metro line down to Lysaker. This could mean an increase in traffic demand of 50%, or about 4,500 passengers in the peak hour. Development of the PRT system will therefore have a target of ultimately reaching 1.5 seconds headways by using a combination of distance sensors and a multi-level safety philosophy, to be competitive and robust for future extensions of the PRT system or development of other parts of the Public Transport network.

From the central area around the station at Lysaker, it is possible to further develop the PRT system to the North and East.



To the East it is shown developments of loops towards Vækerø and Skøyen. This will enhance the total transport facilities for businesses in the corridor Lysaker – Skøyen and decrease the load on the Lysaker station. To the north it is shown loops towards Lilleaker station and the Kolsås tram line close to Jar and Lysaker River. Such a solution will have two positive effects – enable a transit from the Lilleakerbanen and Kolsåsbanen to the Fornebu area, as well as improving the transport system in the area of these loops.

3.1 Traffic demand

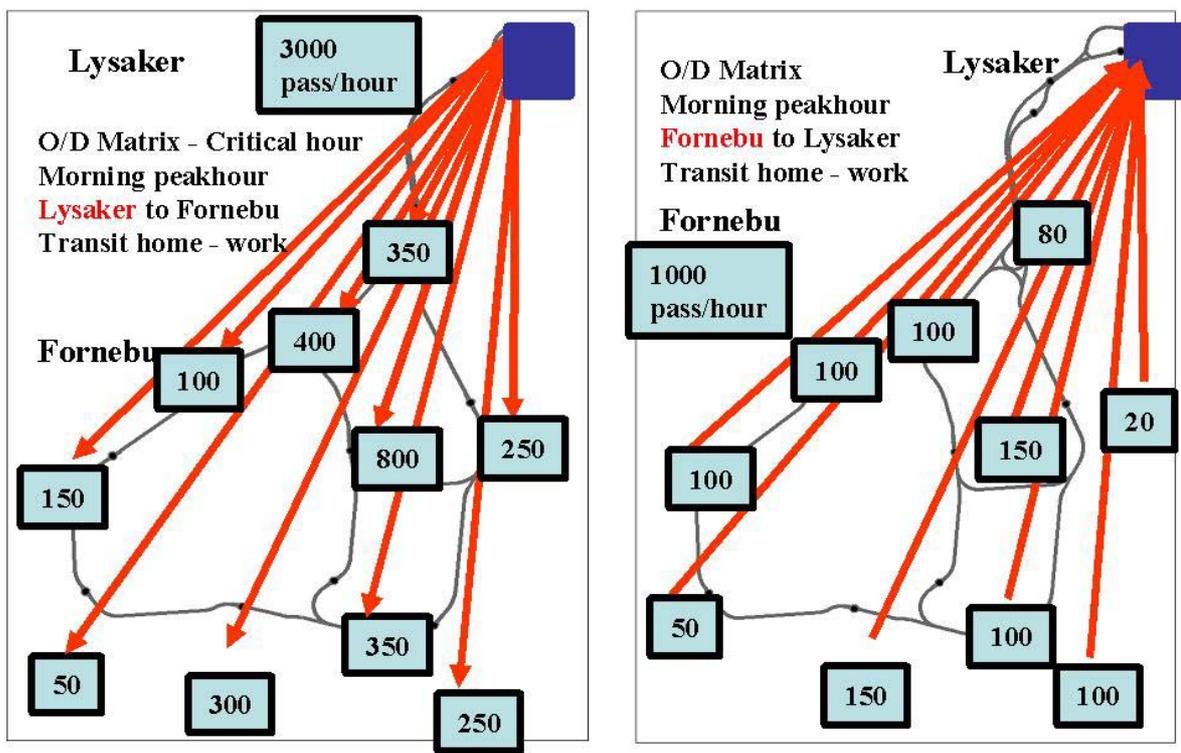
The figures below, from the whitebook, are based on the APM alternative.

Trips in and out of Fornebu every 24 hours normal working day:

Motorized travels	116 100 trips
Cars, driver	66 600 trips
Cars, passengers	21 700 trips
Total Public transport	27 800 trips
APM	17 700 trips
Total	136 700 trips

Estimated and required capacity during rush hours: 3 000 passengers in each direction. The most important factor for the dimensioning of the PRT system will be the demand during morning rush hours.

Estimates regarding the load to the different stations in the Fornebu area are given in the figure below - left. Estimates regarding the load out of the Fornebu area during morning rush hours are given in the figure below – right. The load going out of Fornebu during morning rush hours will have no impact on the dimensioning as it is going in the opposite direction as the constraining factor – the load from Lysaker towards Fornebu.



3.2 JV PRT system Capacity

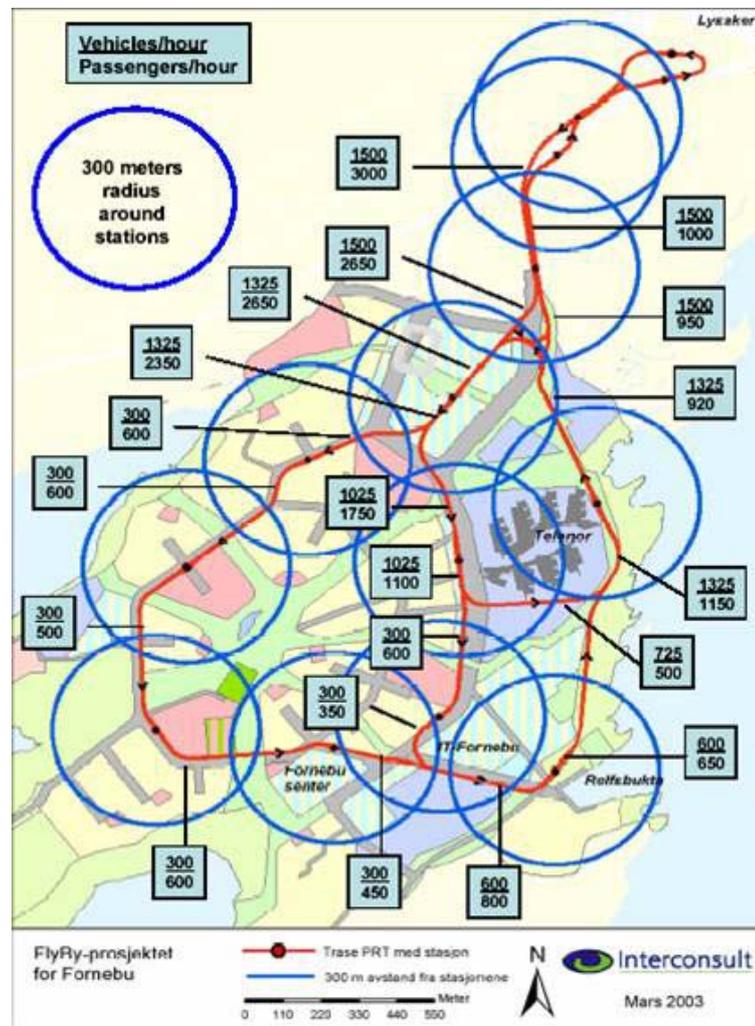
With an average of 2.0 passengers per vehicle, the estimated demand of 3000 passengers an hour gives a time-distance between vehicles of 2.4 seconds on the line from Lysaker to Fornebu.

Headway seconds	Passengers per vehicle	Capacity
1,5	1,5	3600
1,5	2	4800
1,5	2,5	6000
1,6	2	4500
2	1,5	2700
2	2	3600
2	2,5	4500
2,4	2	3000
3	1,5	1800
3	2	2400
3	2,5	3000

The estimates for traffic load given above are valid for a full development of the Fornebu area. This will be in place about 2015. However, in the first phase of the deployment – assumed to be operational by 2007 – the traffic load will be less than 50% of the complete system.

This implies that in the beginning the average timeslots between vehicles can be up to 4 seconds in the rush hour. This will give sufficient capacity for the first years of operation as shown in the table.

Below is illustrated the traffic load on the tracks during morning rush hours, both as vehicles per hour and passengers per hour. In addition – the circles indicate coverage of each station assuming a 300 meter distance from each station.



In the County whitebook there are no estimates for internal traffic in the Fornebu area. However, the design of the JV PRT system will be well suited to serve internal travel in the Fornebu area. Due to the previous mentioned dimensioning issues – there will be ample spare capacity for internal trips in the area.

Each vehicle will cover an estimated average distance on one roundtrip of 5 km. With a speed of 36 km/h this implies a time for each roundtrip of 8.9 minutes including 30 seconds delays at stations. Based on the estimation of two passengers per vehicle there will be a need for about 240 vehicles to serve the demand during rush hours.

The figure shows how the need for vehicles varies with different speed and vehicle occupancy.

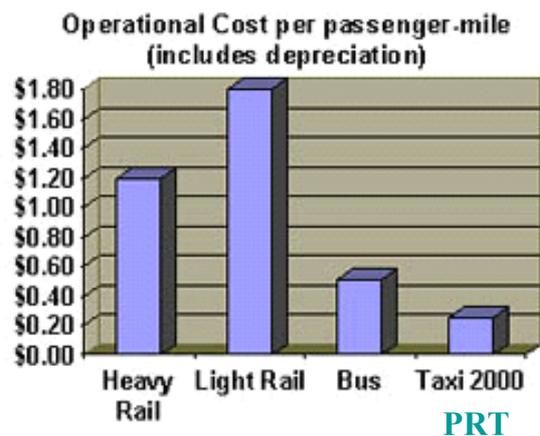
Passengers per hour	Average roundtrip	Speed		Roundtrip time	2 stops	Total	Passengers per vehicle	Vehicles per hour	Headway seconds	Number of vehicles
		km/hour	m/sec							
3000	5.0 km	36	10	8.4 minutes	0.5	8.9 minutes	1,5	2000	1,8	297
							2	1500	2,4	223
							2,5	1200	3	178
3000	5.0 km	45	12,5	6.7 minutes	0.5	7.2 minutes	1,5	2000	1,8	240
							2	1500	2,4	180
							2,5	1200	3	144

A PRT system is much more flexible than a traditional rail systems when it comes to track layout and timing. This is important for the authorities, but also for the property owners, who more easily can come to agreement both with the authorities and the PRT-developers on the track layout. It may also be possible to start operation of PRT from Lysaker to Telenor and IT Fornebu before an APM/LRT can start operation in 2008.

3.3 Costs of PRT systems

The small and lightweight vehicles of a PRT system requires much less expensive supporting infrastructure than the traditional rail systems. The use of more affordable infrastructure for PRT systems is well documented by several international studies – e.g. a comparison done by Taxi2000 of USA – even though such studies lack real life data from installation PRT.

Studies have indicated that PRT systems not only can be profitable in societal terms, but also in business terms. Net present value calculations of LRT projects are most often negative, whereas they are positive for PRT projects.



Source Taxi2000

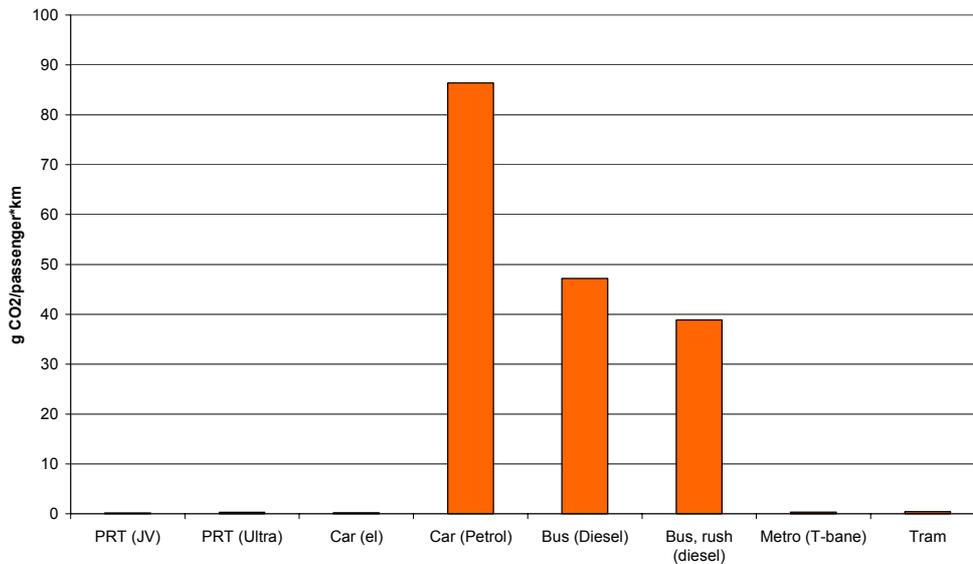
A PRT system will normally require longer guideway lengths for a given installation compared to other rail based systems due to having a network of unidirectional lines. In spite of this it is calculated that the reduction in costs for investments and operations are significant compared to rail based systems.

It should be added that there also are significant differences in flexibility as to the necessary investments: It is simpler to build out PRT systems as demand grows. The risk of “getting trapped” with huge infrastructure costs is accordingly significantly lower.

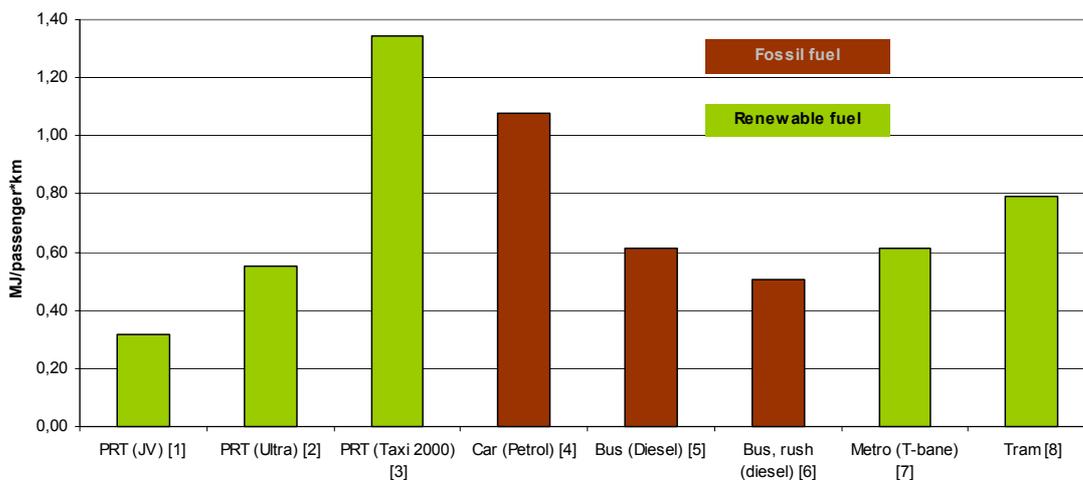
3.4 Environmental issues regarding PRT systems

The PRT joint venture has started to work on an analysis regarding the environmental impacts of a PRT system in the Fornebu area. The assessment so far – using estimations for energy demands and construction materials needed for the FlyBy application – are at present premature for being used in reporting. The assessment as to energy needs per passenger-kilometre for the JV PRT system are more advanced, and are in line with findings elsewhere in the PRT literature.

The figure shows that CO² emissions from PRT are nil, and particularly high for cars and busses.



We also see, from figure below, that energy consumption per passenger-km for PRT systems seem very low. However, to show a favourable life-cycle environmental budget, vehicles and guideways will also be designed for recycling of materials using a holistic approach by use of life-cycle analysis.



Because of low vehicle weight per passenger seat (<150 kg for full vehicle) and non-stop transportation, a PRT system has fundamentally a low energy consumption, even taking into account management of empty vehicles.