Green EFFORTS

Green and Effective Operations at Terminals and in Ports

FP7-285687

[Deliverable D8.3]

[Comparison of energy management in transport in general and in the port sector]

Organisation name of lead contractor for this deliverable: [IHS]

Due date of deliverable: [31/05/2014]
Actual submission date: [11/07/2014]

Call (part) identifier: FP7-SST-2011-RTD-1
Funding Scheme: Collaborative Project
Start date of project: 01/01/2012 Duration: 30 months

Revision: [final]

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

DOCUMENT INFORMATION

[Deliverable D8.3]

[Comparison of Energy Management]
Transport in general and in the port sector

Author(s):	[DIANA ILLING]
Issuing entity:	[IHS]
Document Code:	[2014 07 11] GREEN EFFORTS [DELIVERABLE D8.3] [COMPARISON OF ENERGY MANAGEMENT IN TRANSPORT IN GENERAL AND IN THE PORT SECTOR]
Date of Issue:	[11/07/2014]
Status:	[FINAL]
Revision:	[1]

Contributing Partners / Authors	[IHS] / [DIANA ILLING, LORENZ KLEIST]

Pages	16
Figures	2
Tables	2
Annexes	0

RECORD OF CHANGES

This is a controlled document for any changes and amendments done for the deliverable.

Amendment shall be by whole document replacement.

Version	Status	Date	Authorized by
0.1	Draft version – Consortium review		
0.2	Final version		

TABLE OF CONTENTS

List of Tables

List of Figures

1. Executive summary

The paper compares energy and emission saving measures of the maritime port industry with other transportation industries and modes. For this purpose we identify a set of key saving measures and categorise them into the three segments *Emission Standards, Technical Solutions, and Logistic and Network Infrastructure Solutions.* We find that all three measure categories are addressed in each of the transport modes and that many of the identified solutions find applications across modes and industries. Nevertheless, there are also exemplary pioneer projects which have not been taken up by the maritime industry yet. The declaration of a port area as an environmental zone where stricter emission regulation applies is such an example. Currently, only the Port of Los Angeles has taken this measure and is a pioneer in this respect.

The discussion of the three key segments of energy and emission saving measures as well as of the transport modes in which they are deployed is followed by three case studies that discuss pilot projects in that respect.

2. Introduction

Energy and emission management is not a unique domain of ports and maritime transportation. Indeed, emission and energy management in transportation is among the key topics to be dealt with in all modes of transportation and is therefore high on the political and environmental agenda of governments and businesses. Monitoring emissions and implementing modern energy and emission management solutions in the maritime and port sector are still in its infancies and it without doubt the shipping industry can still learn and profit from the experiences made with activities and processes already developed in other transport modes. Initiatives to encourage the implementation of modern energy and emission management solutions emanate almost always from the policies of the highest regulation bodies and are high on the agenda in many enterprises offering transportation services.

In this paper we provide an overview of emission and energy management in other modes of transportation and we compare some typical examples of measures undertaken in these modes with those in the maritime sector, and especially in the port sector.

3. Energy and emission management in transportation today

3.1 Elements of Energy and Emission Management Activities

Constantly high levels of innovation are a key feature of the transport sector and high levels of intra-modal and inter-modal competition are present in all key modes of transport, maritime as well as airborne and onshore modes like road and rail. Lowering energy and fuel consumption and hence emissions is approached by a variety of measures across all the transportation segments. Generally, those measures can be classified into three different main categories: Emission standards, technical solutions and logistic solutions. Emission standards are often subject of national and European regulation – in the European Union by EU directives and regulations, but also by additional regulation on the national or even at a regional level. An example for European-wide regulation is the current fuel and emission standard for the road transport, Euro-6[1].

Energy and emission management measures can be classified into the following three major categories or areas:

- Emission Standards
- Technical Solutions
- Logistic and Network Infrastructure Solutions

In the shipping industry recently so-called Emission Control Areas – ECA –Zones – were established by the IMO/Marpol convention[2] that instruct shippers to use lower sulphur content oil in these ECA zones. All these regulations aim at tightening **emission standards** in order to lower emissions from traffic, mostly SO_x, NO_x, CO_2, and particulate matters (PM).

Technical solutions also provide a large set of measures to reduce energy consumption and / or lower emissions. Innovations reach from fuel saving engines via new fuels, scrubber technologies and other technical applications like LED lighting. Many of these measures have been discussed within this project.

Logistic and network infrastructure solutions focus on the removal of bottlenecks and traffic management systems to avoid additional emissions from unnecessary congestion as well as on the availability of a sufficient dense network of fuel stations or the provision of refuelling alternatives in order to minimize fuel consumption from detour traffic.

---

[1] Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information

[2] More specifically: in Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) and its amendments from July 2011.

In Table 1 the most important options and solutions are displayed for four key modes of transportation. For each transport mode a selection of the most important measures per area is provided.

Table 1: Elements of Energy and Emission Management Activities by Type and Mode of Transport

Mea-sure Area	Measure	Road/ Public transporta-tion	Rail	Aviation/ Airports	Shipping/ Ports
Emission Standards	Fuels	Euro-5, Euro-6, e-mobility, hydrogen, CNG, LPG	Electricity from regenerative sources	e-mobility, hydrogen, hybrid propulsion	Cleaner fuels, LSFO, LNG, CNG, Hydrogen, e-mobility
	Environ-mental zones	Environmental zones (PM, NOx)		Noise emission control areas, noise protection for airplanes, ban on night flights	ECA Zones, SOx, NOx, PM
Technical Solutions	Recupera-tion	Recuperation of braking energy, bus, tram, cars	Recuperation of braking energy of trains	Recuperation of braking energy supporting vehicles	Recuperation of braking energy supporting vehicles, cranes
	Renewable energy	e-cars, buildings, lightning systems	Propulsion electricity, buildings, air conditions, etc.	Air con, buildings, lighting, luggage belts, e-vehicles, etc.	
	Fuel saving engines	Decreasing fuel consumption (luxury cars 18%, middle class cars11%)		Supporting vehicles	Supporting vehicles
	LEDs	Street lighting	Train stations	Passenger areas, gangways, shopping areas, etc.	Port/terminal lighting
	Regenerati ve Energy	Fuel Cell technology and hydrogen	Share of renewable in the electricity		Regenerative electricity production on

Measure Area	Measure	Road/ Public transportation	Rail	Aviation/ Airports	Shipping/ Ports
	production	infrastructure	mix of rail transport		site in ports, electrification of ports
	Load shifting/ peak load shaving			Cooled containers	Cooled containers
Logistic and Network Infrastructure Solutions	Appropriate infrastructure	Cities, motorways	Interconnectivi-ty of gauge and signalling systems	Airport entrance/exit, airspace structure, microwave landing system	Port in-/out gate – fast operating procedures, sufficient draught on access channels (water side),
	Traffic management systems to avoid congestion	Cities, motorways, road traffic management systems / toll systems	Train management systems	Air traffic control systems, integration into Eurocontrol, Eurocontrol traffic management	VTMS (vessel traffic management system), land-based traffic management systems for trucks and rail, improvement of 24/7
	Short distances to lower fuel consumption	Network density of fuel stations,		Availability of mobile re-fuelling	Availability of mobile re-fuelling
	Appropriate refuelling stations	LPG, CNG, electricity		CNG, electricity	LNG, CNG, electricity/cold-ironing
	New technologies	Private transport: new technologies for enhanced			new technologies for enhanced planning of

Measure Area	Measure	Road/ Public transportation	Rail	Aviation/ Airports	Shipping/ Ports
		planning of transport services and slot optimization			transport services and slot optimization

The different transport modes feature different characteristics that impact the way energy management is conducted. The differences are of both technological and organizational nature and influence the level and structure of intra-modal competition, the roles of the key actors in the respective mode as well as the level of public control and influence on infrastructure and logistics.

In the following, the characteristics and typical measure types are explained and discussed separately for each of the four main modes of transport. We also investigate the key aspects shaping the specific way, in which the energy efficiency and management measures for the different modes of freight transport are designed:

Maritime Transport/Deep Sea Ports

There is no doubt that the key feature of the maritime industry is the fact that no network infrastructure like roads or railways exists and that the key infrastructure elements, the European maritime ports, can be very large organizational entities, covering significant areas at the member states coast lines and handling very high cargo volumes.

In most cases ports are managed by a public port authority, which allow for a certain influence of public interest on the organization and on the rules of port authorities. However, it has to be noted that the level of competition between European seaports is indeed very high, which causes a substantial pressure on operating costs. This situation is thus limiting the degree of freedom to introduce cost-affecting environmental measures. In addition, there are organizational challenges regarding the relationship between the (public) port authorities and the (private) terminal operators that can represent barriers to the introduction of complex energy demand systems in seaports. Work package 9 of the Green EFFORTS project discusses port-terminal relationships in detail and investigates options to craft strategies to develop these relationships. These strategies include for example an increase of communication and coordination between the port actors such that possible barriers to the implementation of complex and coordinated solutions can be overcome.

Since international maritime transport takes place on the open sea, it has for a long time not been subject to national or international regulation regarding pollutant emission limits and the use of cleaner fuels. In more recent years, the introduction of ECA-zones and the efforts to limit the sulphur content of marine fuel oil have been important major steps in this direction. The situation in maritime transport is however still different from the more comprehensive fuel and emission related regulation for overland freight transport on road, railways and inland waterways.

Aviation/ Airports

Energy and electricity management in the aviation sector concentrates much on measures in and for airports and in particular on the infrastructure of airports including the large terminals that need high-performance cooling/heating systems. Cooling and Heating systems are- by their very nature - extremely energy intensive. Therefore, the main focus of energy management activities at the airport level is the improvement of the technological infrastructure of buildings.

These technological measures include modern technical facility solutions like sustainable air-condition systems, new LED 3 lighting concepts and complex baggage handling systems. Other technical solutions in the context of energy efficiency management in the aviation industry are alternative fuel systems for tug vehicles with hybrid propulsion and fuel cell-powered baggage vehicles.

In contrast to the vigorous efforts of the airports in the area of technical solutions, regulation activity regarding the use of cleaner fuels has been almost non-existent in the past decades.

Road Transport

Public regulation of fuel consumption and vehicle-emissions in the European Union has started in the mid-1980s. Thus, there is a much longer history of regulation in place than for maritime transport. Provisions for clean fuels and maximum pollutant emissions of road vehicles have been tightened periodically. In fact, with the introduction of the EURO-6 norm, transport-related pollutant emissions have been successfully reduced by a degree, that one can almost say that pollutant emissions by new road transport vehicles - are of no key concern any more. Existing problems caused by particulate matter emissions from road vehicles in agglomerations will ease off as the older vehicles will be replaced by modern ones.

Compared with pollutant-related regulations, the regulation of the specific fuel consumption – and thus of CO_2-emissions - of vehicles started historically later and there is still room for future improvement. The introduction of alternative clean or non-fossil fuels is still in its infancies. These alternatives include the use of LNG as vehicle fuel, the deployment of fuel cells in vehicles and, foremost, the promotion of e-mobility, which is the use of vehicles powered electrically by batteries. When the electricity used for this kind of mobility is produced by renewable sources, this is the

[3] LED: Light Emitting Diodes

cleanest possible solution for road transport, while at the same time minimizing CO_2 emissions of road transport.

The road freight transport sector is – naturally – characterized by a much more atomic competition (polypoly) than the maritime sector. Furthermore, no similar public or half-public entities like seaports or airports exist. The introduction of complex energy management systems is thus in the hands of the private sector. Since a reduction of fuel consumption always translates into a reduction of transport costs, the market forces and the high level of competition in road transport business ensure that energy costs are effectively minimized, given the available motor technology. Complex logistic solutions, involving producers, OEMs, supplying firms, as wells as large third party logistics providers and linking all relevant production and transport processes by complex communication and software systems, can be regarded as energy management systems for reducing fuel consumption, given the existing production and demand structure.

In road transport, the entities that – from a role perspective in energy demand management - can be most likely compared to ports in maritime transport are large cities and metropolitan areas. Similar to ports, there it is a key interest of the public bodies of such agglomeration areas to reduce the community's exposition to air pollution and to remove bottlenecks of and congestion on the road network infrastructure. Since less congestion means also less fuel consumption, traffic control systems can for example be regarded as a version of an energy management system. Urban Low Emission Zones on the other hand do support the local population's health requirements and are thus increasingly publicly enforced.

Rail Transport

Nowadays, rails are propelled either with electricity or with Diesel fuel. While the railway lines on the most important transport axes and corridors in Europe are usually fully electrified, there is still a large fleet of Diesel locomotives operating on the European railway systems. Still, the majority of the transport performance takes place with electric locomotives by large electric freight trains on long-distance transports. Diesel locomotives, on the other hand, are mostly used on the not-electrified railway network, which includes secondary routes, sparsely populated areas and railways with company or port areas.

Regarding the transport volumes on railways with electric trains or locomotives, the question of emissions is a question of how and from which sources the electricity for the trains is produced. Usually, one can apply the appropriate country emission average of electricity production which can differ significantly by country. Norway, for example has a very low carbon footprint as it produces much of its electricity with watercraft. Also France has a relatively low carbon footprint due to heavy usage of nuclear power plants. In contrast, Germany's CO_2 emissions are relatively high within Europe as its energy mix for producing electricity is relatively coal dependent.

Nevertheless, also in the rail sector many energy end emission saving measures regarding the use of electricity are possible. One example is the Deutsche Bahn that already today buys more than 30% of its consumed electricity from renewable sources. Furthermore, many energy saving measures like recuperation of electricity is also applicable in the train sector.

With respect to Diesel locomotives, the technical progress has led to the development of more fuel-efficient and cleaner Diesel locomotives. In addition emission regulation for Diesel locomotives exists in form of several European Directives on emissions from non-road mobile machinery, which includes seven separate directives in total[4].

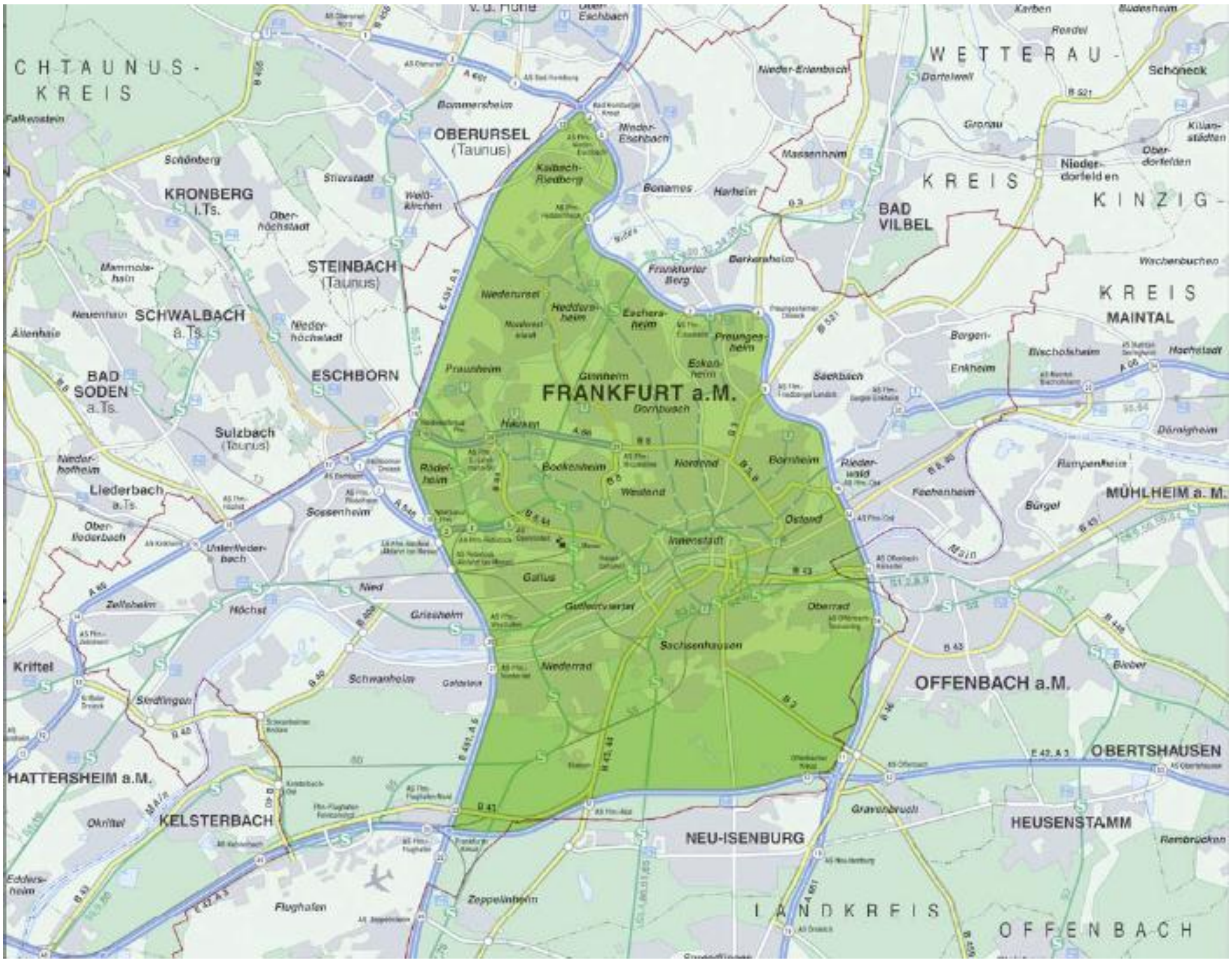
[4] The seven directives include the "mother" Directive 97/68/EC, the amendments Directive 2002/88/EC, Directive 2004/26/EC, Directive 2006/105/EC, Directive 2010/26/EU, Directive 2011/88/EU , and the last amendment Directive 2012/46/EU:

4. Case studies

4.1 Case Study 1 – Emission Standards: Low emission zone Frankfurt am Main

In many German cities so-called low-emission-zones have been set up or will be set up in the near future. Low-emission-zones aim at the further reduction of emissions from road vehicle traffic that has negative impacts to human health. In Frankfurt, exposition to air pollutants due to emissions from road traffic was and still is extremely high in several areas. Frankfurt is located in a region that features among the highest density of motorways in the world. The city is well-connected to many other cities and there is a high number of commuters from the surrounding suburbs. With a population of some 650.000 inhabitants and 550.000 work places around 300.000 employees commute to work every day. This is a key source of high pollutant emissions from road transport.

Figure 1: Low emission zone Frankfurt am Main



The Low Emission Zone in Frankfurt am Main was set up in 2008 and as of 1st January 2012, only vehicles with the so-called "green badge" – distinguishing clean cars from vehicles with higher emission factors - are allowed entry. The aim is to reduce the concentration of fine particle pollution and nitrogen dioxide in the inner city area in order to maintain some minimum air quality standards. Anyone found travelling within the Low Emission Zone without a green badge or a valid exemption is liable to pay a fee of eighty euros.

The following 7 measures were defined to reduce emissions:

- Reduce traffic congestion at the access road "Friedberger Landstraße"
- Traffic lights that control traffic flow into high volume traffic areas (gate traffic lights)
- Low emission busses
- Gas vehicles
- Public information
- Driving ban for trucks
- Low emission zone

The emission reduction targets address SOx, NOx and CO2 emissions as well as – most importantly - PM emissions. According to the EU Directive 1999/30/EC two binding values for the PM10 immissions came into force in 2005:

- An annual mean value of 40 µg/m3
- A daily limit of 50 µg/m3 not to be exceeded on more than 35 days within a calendar year

Frankfurt has introduced 3 measure points where PM, NOx, CO_2 and SO_X values are recorded. The street with the highest concentrations for all air pollutants is the measure station at Friedberger Landstraße. In Table 2 the development of the measured PM10 immission values from 2000 to 2011 is depicted:

Table 2: PM10 exposition at Friedberger Landstraße measuring station in Frankurt/ Main.

Year	Friedberger Landstraße (close to traffic)	Official limit	Number of limit exceeding	Allowed number of exceeding
2000				
2001	40,5		68	
2002	42,2		95	
2003	36,0		70	
2004	32,3		47	
2005	32,6	40	**48**	35
2006	32,7	40	**55**	35
2007	28,0	40	33	35
2008	27,3	40	22	35
2009	29,7	40	**36**	35
2010	29,0	40	26	35
2011	28,9	40	**42**	35

(Source: http://www.frankfurt.de/sixcms/media.php/738/wirksamkeit_umweltzone_frankfurt2012_bf.pdf)

The city of Frankfurt am Main summarizes the effectiveness of the 3rd level of the environmental zone, which was introduced on January 1st 2012 as follows:

"Due to the introduction of the environmental zone in combination with enhanced emission standards for vehicles, measured exposition levels of particulate matter and nitrogen oxide for 2010 at the Friedberger Landstraße significantly decreased and amounted to 8,5% and 3,5% reductions in PM and nitrogen oxide concentrations respectively."

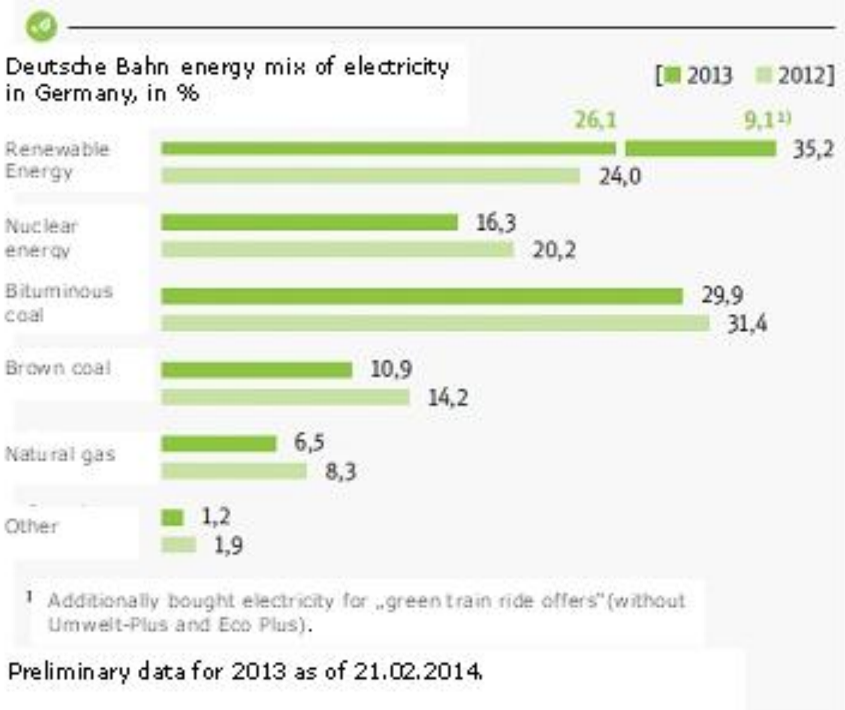
With respect to port-related low-emission-areas the Port of Los Angeles can serve as an example:

In 2008 the port of Los Angeles adopted its *Clean Truck Program*. Since this time only licensed trucks complying with the port's emission standards are allowed to enter the port area. With this measure, the truck-related emissions have been successfully reduced by nearly 90% in the port area by the year 2011. This example shows that the introduction of such emission or environmental areas is both feasible and highly effective and should therefore always be considered as an option for reducing negative impacts on human health. However, the environmental, economic and competitive context should always be explicitly evaluated and be into account before applying this measure.

4.2 Case Study 2 – Deutsche Bahn: Increasing sustainability by recuperation of breaking energy and prudent manner of driving

The publicly owned rail and logistics enterprise Deutsche Bahn AG is the largest rail company in Western and Central Europe and operates worldwide in more than 130 countries. Its core business is rail transportation with daily more than 5.5 million travellers in rail passenger traffic and around 1.1million tons of moved freight. The Deutsche Bahn owns around 33.400 kilometres of railway network and 5.688 passenger train stations. The enterprise is one of the biggest energy consumers in Germany. Therefore, the company is making significant efforts to lower its overall energy consumption, especially its energy consumption of fossil fuels. Despite the provision of increasing transport performances the enterprise was able to lower its energy consumption and CO_2 emissions since 1990 by 54% due to an increasing use of state-of-the-art technology including recuperation technology and energy saving manner of driving.

Figure 2: Energy mix of the Deutsche Bahn in Germany



All modern rail vehicles transform breaking energy back into electricity. My making use of the three-phase technology, breaking energy is not wasted by transforming it into thermal heat. Instead, it is transformed back into electricity which is then fed back into the electricity grid and can be re-used by other rails as propelling energy.

Furthermore, all train drivers are trained in sustainable and energy-efficient driving techniques, which also help to reduce energy consumption. 4000KWh can be saved for example on the route between Munich and Hamburg, which is as much as a four-person household consumes during a year.

From 2007 until 2009 the company covered around 8% of its annual energy demand for its railway operations by recuperating breaking energy. This corresponds to 820 GWh for the whole year 2009. The share of recuperated energy has continuously increased over the past years. In 2013, 11% of the electrical energy consumption from long-distance train operations could be recuperated and recycled. In the local passenger traffic 14% could be recuperated and hence saved which accounts for a total of 1.040 GWh of electricity. This amount of electricity is equivalent to an average annual electricity consumption of 300.000 four-person households. Additionally, the Deutsche Bahn increases its share of electricity from renewable energy sources. Figure 1 shows the shares of the several energy sources.

4.3 Case study 3 – The Hybrid bus fleet of the DVB AG

Since 5 years the public transport enterprise Dresdner Verkehrsbetriebe AG (DVB) uses hybrid buses. The company owns 18 of these buses which equals 10% of the whole fleet. The hybrid buses are financed by two research programs of the Federal Environmental Ministry and the Federal Ministry of Transport, Building and Urban Development. They are used for highly frequented lines operating within the city area and on routes with changing topographic conditions. The hybrid buses are an intermediate step on the way towards a fully electrified bus system in Dresden. The whole set of projects aims to reduce the emissions within the inner city areas and to increase the public acceptance of this technology. The projects are regarded as pilot projects that will help to reach the phase of technical maturity. Currently a bus costs around 700.000 Euro which is around 380.000 Euro more than a conventional, fully diesel-fuelled bus. The driving personnel as well as the repair personnel are receiving special training in order to be able to fully exploit the saving potential of the hybrid vehicles. All bus trips are monitored and the data is collected and provided to the Fraunhofer Institute in Dresden, which studies e-mobility, and to the producer of the buses to deliver input data for technical analysis and assessment to support further improvements in the future. Besides the hybrid buses where two electric engines support the diesel engine, the city also owns fully electrified buses. However, the fully electric buses have not yet reached a technical level of maturity and further research will be necessary for improved technical and economic solutions for using fully-electric buses. An option worth examining is the loading at the end points of a route. This would be an option for shorter routes where the buses then would drive completely emission-free.

All hybrid buses are using recuperation technology which uses breaking energy to reload the high-performance accumulators or condensations *("SuperCaps")*. On average these hybrid buses can drive up to 500 meter without any support from their diesel engines. Some buses can even reach a range 2 kilometres without diesel support. Electricity management is used to exactly adjust the electricity and diesel demand according to the topographic conditions. On average, the achieved fuel savings account to 16% compared to conventional buses. Another advantage of the hybrid bus is the lower level of noise and air pollutant emissions. Further research is required for the heating systems as additional heating in winter times – due to lower heat disposal of the diesel engines – can offset the achieved savings of diesel fuel. Additional research needs also relate to the energy management systems deployed and to reduction of the vehicle weight.

5. Conclusions

Though every transportation mode has its specific characteristics which can lead to very specific technical solutions for each mode, some of the energy efficiency and emission saving measures are common in most modes of transportation. Prominent examples are hydrogen-powered vehicles and e-mobility, recuperation technics, the use of electricity from renewable energy sources like wind energy and photovoltaic or the introduction of environmental zones where stricter emission regulations apply. There is no doubt that a broad implementation of these measures will help to effectively reduce transport-related emissions at reasonable costs.