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A 2050 Vision for Energy efficient and CO2-free Urban Logistics

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Abstract

The energy strategy 2050 of Switzerland is aiming at a substantial reduction of the consumption of not renewable energy and of energy sources, which are harmful for the climate, the environment and humans. The research project "Energy efficient and CO2-free Urban Logistics" aims at estimating and evaluating the potential of a more efficient use of energy, a reduction of CO2-emissions and the substitution of non-renewable energy resources regarding urban logistics in Switzerland. Possible developments in urban logistics and their impact on energy consumption and CO2-emission are shown in a scenario analysis. Furthermore a vision 2050 has been developed which fulfils the challenging targets for an "Energy efficient and CO2-free Urban Logistics" in Switzerland. The scenario analysis was completed in October 2016 and the vision has been carried out between November 2016 and June 2017. Based on the vision an action plan will be developed until end of 2017.

Keywords: Urban logistics; freight transport; energy efficiency; greenhouse gas emissions; vision; scenario

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1. Introduction

1.1. Starting Point and Challenges

In Switzerland over 80% of the population is living in urban areas; the number of inhabitants and the share of them in urban areas are increasing Swiss Federal Statistics Office (2014). Also over 80% of the employees are working in urban areas; the number of employees and the share of them in urban areas are increasing Swiss Federal Statistics Office (2014). The logistics market is further growing GS1 Switzerland (2017). Between 2006 and 2015 it has grown from 31.6 to 38.9 bln CHF (+23%); the share of logistics at the GDP reached approx. 7%. Growing segments of the logistics market are the LTL-segment, the courier segment and also the bulk segment (caused by construction activities) which are playing an important role in urban areas. Transport consumes about 40% of the overall energy consumption; from this over 97% is not renewable energy resources Infras/Tep/Prognos (2015). The share of freight transport is approximately 19%; it is increasing Infras/Tep/Prognos (2015). Transport has with 31% the biggest share regarding greenhouse gas emissions Bundesamt für Umwelt (2015). In comparison to households and industry the share is increasing Bundesamt für Umwelt (2015). Urban freight logistics, which is dominated by road freight transport is gaining importance regarding environmental impact and use of energy resources. Trends as E-Commerce (including home delivery), reduction of storage with smaller consignments, increasing number of deliveries and „logistics sprawl" (displacement of logistics facilities out of urban areas) lead to an increase in freight intensity and in an increase in energy consumption per tonne-kilometre and consignment. In the future the share of energy use by urban freight transport will further increase which is a big challenge from an energy, climate and environmental perspective. The European Commission stated in the White Paper from March 2011 the target to achieve essentially CO2-free city logistics in major urban centres by 2030 European Commission (2011). The energy strategy 2050 of Switzerland is also aiming at a substantial reduction of the consumption of not renewable energy and of energy sources, which are harmful for the climate, the environment and humans CHBR (2013).

1.2. Research objectives

The research project is addressing these challenges. It aims at estimating and evaluating the potential of a more efficient use of energy, substitution of non-renewable energy resources and the reduction of requirements (sufficiency) regarding urban logistics. The main objectives of the project are:

- To identify the current status and key characteristics of urban logistics and energy consumption
- To identify trends and drivers of change in urban logistics and energy consumption
- To develop scenarios for 2050 and their impacts on energy consumption, including assessment of problems and challenges and requirements for energy-efficient urban freight logistics
- To identify and evaluate energy-efficient and CO2-free urban freight logistics solutions
- To develop a vision for 2050 for energy-efficient and CO2-free urban freight logistics
- To develop an action plan for CO2-free and energy-efficient urban logistics solutions
- To summarize the main results in a report with key findings and recommendations

Approaches to make urban freight logistics more efficient and reducing the associated energy consumption will contribute to the realization of the Swiss energy strategy 2050. The project is focusing on the freight transport segment in urban areas and encompasses the aspects of society, economy and policy.

1.3. Project phases and work packages

The research project consists of three main project phases and 8 work packages (Fig. 1). Within Phase I the urban freight logistics schemes and the impact of urban freight logistics on energy consumption, on GHG emissions and the use of not renewable energy sources has been investigated. Special attention has been given to trends and drivers of change with a strong impact on urban logistics and energy consumption (incl. GHG emissions and the use of not renewable resources). Scenarios for 2050 have been developed taking into account existing scenarios for the development of the population, economy and energy perspectives etc. The main challenges and requirements for energy efficient and CO2-free urban freight logistics were derived. Within Phase II a vision for energy efficient and CO2-free urban freight logistics for 2050 has been developed based on the energy turnaround targets and the CO2-targets. Solutions with a high potential to contribute to the targets of the energy turnaround 2050 and reduction of GHG emissions were identified.

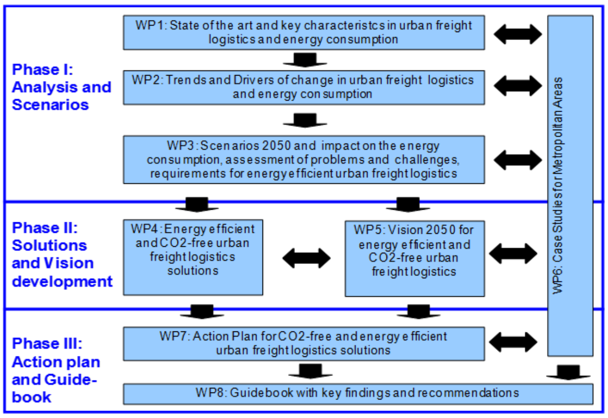

Fig. 1 Project phases and work packages

Within Phase III an action plan has been be developed which shows the necessary actions to reach the 2050 vision. A guidebook on how to reach the vision for an energy efficient CO2-free urban freight logistics with the key findings and recommendations for relevant actors is planned. Case studies for selected metropolitan gave input to the work packages for selected conurbations and took up results from phase II and III.

1.4. Research focus and boundaries

The project is focusing on freight transport trips in urban areas whereas service trips which are related to a service at a destination in an urban area (which can include a goods transport but not mandatory) are not especially considered. The spatial focus is on urban areas defined by the Swiss National Statistics Office (areas with urban character, blue and green areas in Fig. 2, based on Swiss Federal Statistics Office (2014).

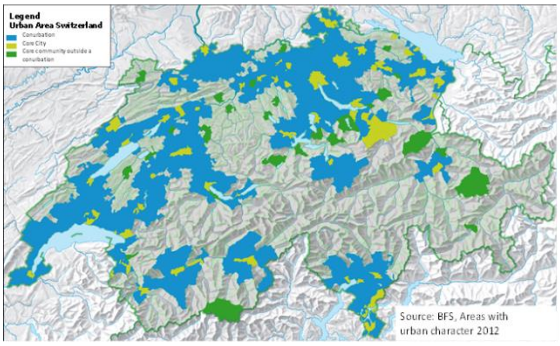

Fig. 2 Urban areas of Switzerland

1.5. Research Framework

The project has been carried out between 2015 and 2017 in the framework of the National Research Program 71 “Managing Energy Consumption”, which has been launched by the Swiss National Science Foundation (SNF) in 2014 (www.nfp71.ch). Besides the SNF the research project is co-funded by the Swiss Federal Office of Energy, the Swiss Federal Roads Office, the Swiss Federal Transport Office, the Cantons of Zurich and Basel and the City of Lucerne. Project partners as authorities, logistics and transport companies, system suppliers and various associations accompanied the project.

1.6. Focus of the paper

The paper explains the approach and methodologies used and focuses on the project results available in June 2017. These are mainly the 2050 scenarios for possible developments and the 2050 vision for an energy efficient and CO2-free urban logistics.

2. Approach and Methodology

Besides literature review the methodologies used include data analysis, an online survey, in depth-interviews, impact analysis, best practice and innovation evaluation, scenario analysis, vision development, backcasting and expert workshops (Tab. 1).

Table 1. Research Methodologies.

Methodology	Purpose	Main features
Data Analysis	Analysis of state of the art and recent developments in urban logistics, energy consumption and CO_2-emissions	• Freight transport figures: freight volumes, freight performance, freight modal split etc. (Road freight data from SFSO year 2013; rail freight data from Rail Infrastructure Manager year 2014) • Energy consumption and CO_2-emissions: based on EN 16258 (CEN 2012); transport chain approach (not territoriality approach), Tank-to-Wheel approach* (not taking into account the energy production) • Spatial levels of analysis: Switzerland, all urban areas of Switzerland; metropolitan areas of Zurich, Basel and Lucerne (based SFSO)
Online Survey	Identification of relevant trends and drivers of change for urban logistics; Identification of the status of implementation of measures to reduce energy consumption	• Sample: 499 businesses; 220 shippers (40%) and 246 logistics and transport service providers (60%) • Segmentation of companies by branches, size and language region (French/German speaking part of Switzerland) • Contacting business via shippers and logistics associations (GS1, SSC, VAP, SPEDLOGSWISS) • Online survey in October 2015. More information in Haefeli et al. 2016a
In-depth Interviews	Close gaps and verification of the online survey; Identify problems and challenges in the metropolitan areas of Zurich, Basel and Lucerne	• Sample: 15 Interviews (approx. 75% with shippers and logistics/transport service providers, 25% with authorities) • Implementation status of measures to reduce energy consumption • Identification of challenges and problems in the metropolitan areas • In-depth analysis of urban delivery concepts of main branches/logistics • Interviews have been carried out between January and June 2016
Impact Analysis	Estimation of impacts of vision elements and measures	• Steps: 1) Impact on freight performance 2) Impact on Energy Consumption 3) Impact on GHG-Emissions • Energy Consumption/GHG-Emissions: EN 16258 (CEN 2012) • Assumptions for the development of population, GDP and effects of measures on volumes, distances, propulsion systems, energy consumption
Best Pract./ Evaluation	Evaluation of practices/ innovations regarding contribution to energy strategy 2050	• Evaluation of practices and innovative solutions regarding impacts on freight transport, CO_2/energy consumption, involved actors, implementation, assessment regarding targets, costs, feasibility, success factors, barriers, transferability, etc.
Scenario Analysis	Identify possible developments (without specific urban logistics measures); Identify gap between energy strategy target and situation in 2050	• Steps of scenario development: 1) definition of relevant influencing factors 2) Reduction to key factors based on a relevance analysis 3) determination of 2 to 4 alternatives for the development of the key factors 4) Scenario construction (using the software SzenarioWizard4 Weimer-Jehle (2016) 5) Sensitivity analysis 6) Description of stories for two main scenarios 7) Impact analysis for scenarios (incl. comparison with trend development) (see also later chapter)
Vision Development	Develop a vision which fulfills the targets for energy efficient and CO_2-free urban logistics	• Steps: 1) Definition of Vision 2050 Targets 2) Definition of relevant thematic fields 3) Development and selection of vision elements for the thematic fields 4) Analysis of visions elements 5) Verification of vision elements in workshops 6) Description of the vision 7) Impact analysis and assessment 8) Verification of the vision with external experts (workshop)
Backcasting	Development of the action plan; proof of feasibility of the vision	• Steps of the Backcasting process: 1) Defining necessary actions to be implemented to reach the vision (by going back from 2050 to the present) 2) Assess the feasibility of the actions 3) Fine tuning of the vision

* The hypothesis is that by 2050 Switzerland can produce enough green energy. Other projects of the National Research Program 70 „Energy Turnaround" which is related to NRP 71 „Managing Energy Consumption" are dealing with energy production (well to tank).

In the project a central role played besides the impact analysis the scenario development, the vision development and the backcasting. Scenarios can be defined as a representation of images of the future and courses of development organised in a systematic and consistent way Miola (2008). Starting point to develop scenarios is the present. A vision is a set of ideas that describes a future state. It describes the preferred future and is the framework for strategic planning and development. Backcasting is a methodology for moving from the desired future back to the present, identifying the key events and steps that need to occur to achieve the desired future Miola (2008). The reachability of the desired future is tested against the feasibility of the key events and steps taking place. So in this case, the starting point is the future. The interrelation between the trend development, the scenarios and the vision are shown in the following figure 3. The trend 2050 status of the energy consumption and CO2-emissions in urban logistics takes into account trend developments identified in the present, which are extrapolated to 2050.

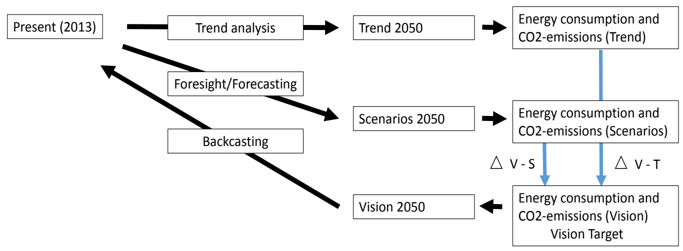

Fig. 3 Interrelation between trend, scenarios and vision

The scenario 2050 status of the energy consumption and CO2-emissions in urban logistics takes into account possible developments which are forecasted coming from the present. From the resulting energy consumption and the CO2-emissions the vision targets for 2050 can be derived (gaps). The vision 2050 status shows the desirable future fulfilling these targets. The necessary actions to reach the vision are to be identified during a backcasting process starting from the vision 2050 and going back to the present.

3. Scenario development and analysis

In this section the approach for scenario development, the resulting scenarios and their main differences are described. Furthermore the impact of the trend development and the scenarios on energy consumption and CO2-emissions in urban logistics are quantified. More detailed information can be found in Haefeli et al. (2016b).

3.1. Approach for scenario development

For the development of the scenarios we applied a "Cross Impact Analysis". This method allowed us to derive consistent pictures of the future, i.e. conceivable development potentials that are varying depending on certain surrounding conditions. In a first step we defined all conceivable factors that could have an impact on the energy consumption in urban logistics and its environment in 2050. Doing this we considered the state-of-the-art, economic development forecasts, population forecasts, freight transport forecasts, energy consumption forecasts and the mega and logistics trends identified in an earlier stage of the project. This resulted in 22 influencing factors covering the economic development (GDP, spending power), the population (demographic change, consumer priorities), the resources (public budget, energy prices, mix), the climate change, regulation (logistics and transport sector, environment, energy, transport system), spatial distribution of land use (industry, trade and logistics), superior logistics strategies (outsourcing, services) and technology and infrastructure (ICT, materials, resilience, utilization degree). Based on an expert appraisal and literature review the list was then in a second step reduced to a smaller number of key factors, considered as the most active drivers of the development. This 9 key factors are GDP/Level of income/spending power, Predominant consumer preferences, Level of climate change, Energy: offer and demand, Regulation, Spatial distribution of offer and demand, Stress on infrastructure (from volumes), Cooperation between businesses (incl. outsourcing) and Technologies and materials in transport. In a third step, we assigned different possible developments to the key factors with the goal to make up for the whole spectrum of possible paths the factors could take. Experts of the research team then assessed the impact of the characteristics on each other. The so constructed Cross Impact Matrix was transferred to the calculation software „Szenario Wizard4" Weimer-Jehle (2016) which – on the basis of mathematical algorithms – calculated self-consistent combinations of characteristics. We found two consistent scenarios that have proved to be robust when applying a sensitivity analysis. It has to be noted that these two scenarios do not fully cover spectrum of possible scenarios.

3.2. Scenario A: Protection of natural resources

In Scenario A political, social and economic life in Switzerland is dominated by the will to protect natural resources. An encompassing land use regulation has led to an only moderately increasing – and in 2050 even stagnating – built-up area. The population growth is concentrated in the metropolitan areas and the goal of the

2000 watt society is nearly achieved. Sharing economy became an important part of the society. In terms of transport policy, an encompassing mobility pricing has been introduced in order to better utilize the infrastructure capacity. In general, urban logistics is affected positively by these developments. The improved capacity utilization in transport, the logistic locations near the centers and the increasing cooperation degree of shippers and logistics service providers allow for a highly reliable and efficient supply of clients. Meanwhile, autonomous means of transports – operated nearly completely by electric engines – have become standard and the energy consumption of transport tends more and more towards zero.

3.3. Scenario B: Liberalization and technology orientation

In Scenario B urban logistics is surrounded by liberalization; not only in the economic but also in the political and social areas. The level of consumption is higher than in Scenario A and land usage remains on a high level with a further urban sprawl. The latter trend has led to urban areas that have constantly extended to formerly rural areas. The delivery requirements of the population are higher than in Scenario A. All in all, Switzerland is still one of the most competitive economies in the world and technological developments increase rapidly. Urban logistics benefits from the latter by using new materials of low weight, autonomous vehicles and more efficient technologies for the delivery on the last mile. The innovation gains of these new technologies counterbalance to some degree the negative ecological consequences of the consistent high consumption level; even though rebound effects somewhat dampen these positive developments.

3.4. Main features of the scenarios

The following table shows the main differences of the two scenarios.

Table 2. Main features of the scenarios.

Scenario A: Protection of natural resources	Scenario B: Liberalization and techn. orientation
Distribution of economic development	
Solidarity in sharing gainings	Increasing social disparity
Importance of commodities	
Decreasing, “Sharing economy”	Furthermore high
Energy demand	
Path towards 2000 watt society	Reduction of energy demand by extreme efficiency gains
Land use	
Polycentric Switzerland	Proceeding urban sprawl
Organization of logistics sector	
Networks of SME’s	Domination of mega enterprises
Spatial logistics structures	
Distribution platforms close to centers of urban areas	Concentrated logistics structures, partly outside of centers
Technological development	
One of numerous factors	Central driver of change

3.5. Quantification of scenarios

For the year 2013 (As-is-Situation), the trend extrapolation to 2050 and the two scenarios 2050 the freight volumes (in tons), the freight transport performance (in tkm), the energy consumption and the CO2-emissions have been estimated considering different developments regarding population and the economy (GDP). To consider also the impact of sharing economy and changing behavior in consuming goods, a sufficiency factor has been introduced. In addition some assumptions have been made regarding modal split, transport distances, mix of propulsion systems and improvements in specific energy consumption by mode. The following tables show the results for the urban areas in Switzerland:

Table 3. Impact of trend and scenario development until 2050 (urban areas).

Key figure		As-is-Situation	Scenario A	Scenario B	Trend
Population CH	[M Inh.]	8.1	10	11	10.1
Urban Population	[M Inh.]	6.9	9	9.4	8.8
GDP / Growth rate	[bln. CHF/%]	648.1	870/0.8	1135/1.6	1’100/1.5
Sufficiency factor		1	0.9	1.0	1.0
Total volume	[M t]	342	336	443	416
Transport performance	[M tkm]	35'654	31'018	47'930	41'433
Energy consumption	[PJ] TTW	28.31	11.98	14.29	34.03

	[PJ] WTW	34.21	15.04	18.40	40.93
Continuous consumption per inhabitant	[W] TTW	131	42	48	122
	[W] WTW	158	53	60	146
CO_2 Emissions	[M t] TTW	2.04	0.80	1.03	2.48
	[M t] WTW	2.48	0.97	1.25	3.01

Table 4. Deviation of trend and scenario development (urban areas).

Deviation to as-is situation		Scenario A	Scenario B	Trend
Total volume	[M t]	-1.7%	+29.6%	+21.7%
Transport performance	[M tkm]	-13.0%	+34.4%	+16.2%
Energy consumption	[PJ] TTW	-57.7%	-49.5%	+20.2%
	[PJ] WTW	-56.0%	-46.2%	+19.6%
Continuous consumption per inhabitant	[W] TTW	-67.7%	-62.9%	-6.5%
	[W] WTW	-66.4%	-60.5%	-7.0%
CO_2 Emissions	[M t] TTW	-60.9%	-56.0%	+21.3%
	[M t] WTW	-60.8%	-55.8%	+21.3%

Extrapolating the trends to 2050 results in an increase in energy consumption and CO2 emissions of about 20%. On the other hand for both scenarios under the assumptions made the energy consumption for freight transport in urban areas is reduced by 50-58% (TTW) and the CO2-emission by 56-61% respectively. Even though the population and GDP increase (resulting in growth in freight transport volumes and transport performance) in Scenario B the reduction ratios of energy consumption and CO2 emissions are comparable to Scenario A. Scenario A has a higher reduction because of the stronger sharing economy and the shorter distances due to the polycentric spatial development. Both scenarios cannot fulfil fully the target for energy efficient and CO2-free urban logistics.

4. Vision 2050 targets

From the trend and scenario analysis we got a rough picture where we could be with the energy consumption and CO2-emissions in 2050. The vision targets have been derived from the project targets and the trend and scenario analysis (Fig. 4). The vision 2050 targets have been derived and quantified from the quantitative analysis of the scenarios (Tab. 5). In 2050 the energy efficiency of urban logistics should increase again compared to the Scenario A, which shows already a substantial reduction compared to the As-is-Situation. This results in a reduction of about 85% compared to 2013. From the project targets (CO2-free urban logistics) the CO2-emissions have to be reduced to 0 t/a. The share of renewable resources for urban logistics has to be increased from less than 5 to 100%. These targets are the basis for design of the Vision 2050 for energy efficient and CO2-free urban logistics.

Fig. 4 Schematic Vision 2050 targets compared to Trend and Scenarios

Table 5. Vision 2050 targets.

Key figures for urban logistics	Unit	As-is-Situation (2013)	Scenario A (2050)	Scenario B (2050)	Trend	Vision Target 2050 (compared to As-is-Situation)
Continuous energy consumption per inhabitant	[W] TTW	131	42	48	122	20 (-85%)
CO2-emissions	[m t] TTW	2.04	0.8	1.03	2.48	0 (-100%)
Share of renewable energy resources	[%]	<5%	n/a	n/a	n/a	100%

5. 2050 Vision for energy efficient and CO2-free Urban Logistics

The Vision 2050 has the purpose of providing a clear picture of an energy efficient and CO2-free urban logistics Bohne et al. (2017). This vision is based on the broad and in-depth knowledge built during previous project phases, therefore taking into consideration findings about good practices, trends and developments in urban logistics. The foremost objective of this vision is to illustrate the possibility of achieving the 2050 vision goals. It must be born in mind that the vision goals are not to be achieved through unrealistic expectations regarding regulation, exaggerated reliance on ground-breaking technical solutions or overconfidence in market trends. The combination of various elements, which complement each other through intersecting components constitute the object of investigation. The justification for these elements and their embedding in the expected development path will be further investigated during the development of an “Action Plan”.

5.1. Vision 2050 development process vision elements

The first step in order to develop the Vision 2050 consisted of identifying the most important thematic fields, which have an influence on energy consumption and CO2 emissions in urban logistics. These are: technology; services and delivery concepts; market and competition, planning and regulation, infrastructure and behavior. A series of possible elements with significant importance in urban logistics were identified in workshops within the project team. This process resulted in a list of 40 elements. The relevance of each element was evaluated with regard to its relevance on urban freight energy efficiency and emissions. In subsequent assessment rounds, the contribution of each element was critically reviewed, resulting in the elimination of 10 elements. The remaining 30 vision elements were then elaborated by individual team members in a structured format. This format included a qualitative description of each element, a qualitative and partly quantitative evaluation of its contribution to the vision goal as well as its practical feasibility. The description of each element contains a description of the status quo, a view of the element in 2050, an assessment of positive and negative effects (including rebound effects) and the classification of the element with regard to its contribution to the 2050 vision goal.

Four thematic workshops had the goal of discussing each element within the project team. The goal of these workshops was to review the elements with focus on their completeness, their consonance with other studies and trends, as well as their overall contribution to the vision goals. Further on, possible milestones for 2030 and 2040 were discussed and the intersections with other elements were identified. After these workshops, the project team selected 24 elements for detailed elaboration in order to be implemented in the Vision 2050 (figure 5).

It is expected that the highest contributions come from alternative propulsion systems, alternative fuels, mobility pricing and terms of use for trucks and vans on public roads. But also other elements will have a remarkable contribution like more co-operation, underground transport systems and securing space for logistics facilities.

5.2. Vision 2050 for energy efficient and CO2-free urban logistics

Urban logistics in 2050 is carbon free and highly energy efficient, on levels which were unanticipated in the beginning of the 21st century. In 2050

- emission free, lightweight and automated transports are in operation
- the technological progress enables variable, new delivery concepts
- the market organization and competition adjust to efficiency
- the political agenda defines framework conditions for energy efficient logistics
- the change in behavior leads to higher efficiency

Emission free, lightweight and automated transports are in operation: In 2050 only CO2-free freight vehicles based on batteries and fuel cells – trucks, vans, scooters, cargo bikes, ground drones etc. - are in operation. Lightweight construction and materials for vehicles increase the payload and better suit to the delivery profiles. Automation is completely implemented in urban logistics. Automation will lead to a better routing, cutting off peaks, a smother traffic flow and a reduction of energy consumption. Ground drones are in operation for last mile services as well. Also freight trains are fully automated allowing fast coupling/decoupling and seamless deliveries to private sidings. The rolling stock (railway wagons) are light weight and low noise constructions too. Multi-functional transshipment facilities for intermodal loading units and also other goods are in operation; they are served by automated rail services. Besides transshipment also further logistics services as storage, commissioning, etc. are provided; multifunctional freight facilities allow more bundling and increase the efficiency of rail services.

Underground transport systems are in operation as well; only dedicated to freight transport. The systems connect freight intensive facilities as logistics centers, terminals, big shopping malls and airports. Internet of things has become standard and supports the management of vehicles, equipment and consignments. Sensors detect capacity utilization of vehicles and equipment, stock of inventory and the quality status of goods; operative and tactical decisions are taken by autonomous robots; strategic decisions are still taken by humans.

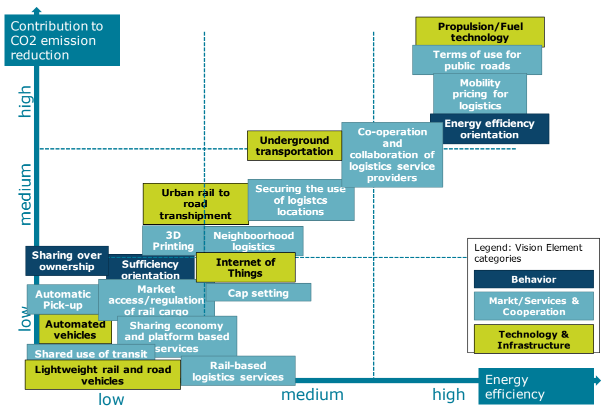

Fig. 5 Vision elements and their qualitative contribution to the vision targets

Technological progress enables variable, new delivery concepts: In 2050 goods for city areas are bundled via district-logistics platforms which provide the supply and disposal of households and businesses in the area. PPP's act as operators of these platforms and provide bundled last mile services. Beside transport and storage also 3-D-printing is an important part of the services provided. A dense network of automated and neutral operated pick-up stations with shelves of different sizes are in operation which allow to send and receive B2C and B2B goods from different LSP's. The required space is secured in building regulations. 3-D-printing which is established in the industrial manufacturing process allows bundling of raw material transports and keeps the last mile distances as short as possible.

Market organization and competition adjust to efficiency: In 2050 exist extensive co-operations between logistics service providers and shippers which share their capacities of logistics facilities and equipment. This increases the utilization degrees and reduces transport performance. The accounting and allocation of costs and revenues is enabled by internet of things. The new technologies have created a strong sharing economy which steepened in the daily routine of individuals and businesses. Business models for sharing are popular due to cost efficiency and price advantages for consumers. Goods, resources and services are shared under economic conditions (B2B, C2C, B2C). Regional and local rail services and transports to rail sidings are tendered in urban areas. Competitors bid on services to supply urban areas via rail.

Political agenda defines framework conditions for energy efficient logistics: In 2050 there is a declaration obligation for products which includes binding information on energy efficiency of production and transport. This leads to an energy efficiency orientation of the consumers and of the businesses. Research and innovation supports innovations to increase energy efficiency of logistics processes. Terms of use for public roads are in favor of energy efficient and CO2-free vehicles. This is supported by an energy efficiency CO2-declaration for goods vehicles considering vehicle capacity and standardized route profiles. Truck and van trips are limited by an auction system with tradeable rights. Locations for logistics facilities are assured in industrial zones and on railway areas in regional and local land-use plans (combinations with other land use purposes remain possible). The locations are identified within a positive planning approach taking into account key criteria as accessibility, proximity and sensitivity of the surroundings. Bigger logistics spaces have rail access and are served regularly. A mobility pricing for urban freight transport is implemented, which is part of a comprehensive mobility pricing for the overall traffic on road and rail. The management of traffic and the collection of fees are dependent on time, space and use of vehicle capacity and the processes are supported by sensors as well.

Change in behavior leads to higher efficiency: In 2050 we can observe a changed behavior of people. This includes an increasing sufficiency with more share and repair, more long living products, more consumption of regional/local products and reduced delivery requirements. These cultural and societal changes lead to a reduction of consume as a motif and also a reduction of demand for goods. Sharing represents a good attitude to life and has become easier and even more popular due to digitization. The communal use of goods enables savings and furthers social contacts. A remarkable share of the population will have energy efficiency preferences which gives an incentive that goods and services are produced and transported in an energy efficient manner.

5.3. Vision Impact

For the impact analysis of the vision 2050 and the comparison with the as-is-situation and the scenarios (see table 3) key macroeconomic development goals of the vision for the population (10.5 M), population in urban areas (9.2 M, share in urban areas 87.5%), the GDP (1'000 bn/1.2% growth/a) and the sufficiency factor (0.93) had to be determined. Only a rough estimation of the impact of the vision elements is possible, because not all vision elements have a distinct definable effect on the vision targets. The impacts of vision elements were therefore assigned to influencing factors as modal split, transport distances, fleet composition, efficiency increase of propulsion systems in a simple calculation model (the same used for the scenario impact analysis). The results of these estimations are presented in table 6 and 7.

Table 6. Vision impact and comparison with vision targets.

Key figure		As-Is-Situation	Scenario A	Scenario B	Trend	Vision Target	Reached by the vision
Total volume	[M t]	342	336	443	416		380
Volume per inhabitant	[t]	42.2					41.4
Transport performance	[M tkm]	35'654	31'018	47'930	41'433		25‘552
Transport performance by inhabitant	[tkm]	4401					2790
Energy consumption	[PJ] TTW	28.31	11.98	14.29	34.03		2.2
	[PJ] WTW	34.21	15.04	18.40	40.93		
Continous energy consumption by inhabitant	[W] TTW	131	42	48	122	20	7.7
	[W] WTW	158	53	60	146		
Share of not renewable energy	[%]					0%	Not assessed
CO_2 Emissions	[M t] TTW	2.04	0.80	1.03	2.48	0	0
	[M t] WTW	2.48	0.97	1.25	3.01		

The results show that the vision targets can be fully reached. Compared with the scenarios it becomes clear that the vision represents an urban logistics, which is again more energy efficient. Especially the propulsion technology, mobility pricing, access conditions and the energy efficiency orientation have a substantial contribution regarding reduction of energy consumption and CO2-emissions. There are also elements considered which have a rather low isolated effect, but have in combination with other elements higher combinatory effects. The vision contains a mix of different strategies as substitution of traffic, optimization of transport, continuation of flows and to minor level also a modal shift. Besides reduction of energy consumption and GHG-emissions further positive impacts can be expected as reduction of road freight trips, reduction of average road freight distances, reduction of capacity problems and increase of quality of freight services, less conflicts with other road users, increasing efficiency of last mile solutions and increasing safety. Because not only energy consumption and CO2-emissions are a challenge these further impacts are important for the acceptance of the vision.

Table 7. Vision impact and comparison with vision targets.

Key figure		Scenario A	Scenario B	Trend	Vision Target	Vision Impact
Total volume	[M t]	-1.7%	+29.6%	+21.7%		+11.2%
Volume per inhabitant	[t]					-2%
Transport performance	[M tkm]	-13%	+34.4%	+16.2%		-28.3%
Transport performance by inhabitant	[tkm]					-36.8%
Energy consumption	[PJ] TTW	-57.7%	-49.5%	+20.2%		-92.2%
	[PJ] WTW	-56.0%	-46.2%	+19.6%		
Continous energy consumption by inhabitant	[W] TTW	-67.7%	-62.9%	-6.5%	-85%	-94.1%
	[W] WTW	-66.4%	-60.5%	-7.0%		

CO_2 Emissions	[M t] TTW	-60.9%	-56.0%	+21.3%	-100%	-100%
	[M t] WTW	-60.8%	-55.8%	+21.3%		

6. Conclusions and outlook

To reduce energy consumption and CO2-emission of urban logistics has become a big challenge in Switzerland. The developed scenarios for 2050 have shown that a reduction is possible but further transformations are necessary to reach an energy efficient and CO2-free urban logistics. The scenarios helped to define the vision targets regarding energy consumption for urban logistics. The developed vision 2050 for urban logistics has shown that changes are necessary regarding the use of technologies and infrastructure, the design of services and delivery concepts, market organization and cooperation, planning and regulation and finally to a certain extent also behavior. The impact analysis carried for the vision 2050 illustrated that it is not impossible that the vision becomes reality. Besides the political will and the understanding that substantial changes are necessary another important precondition to reach the vision is the availability of green power respectively green energy. Such an investigation was not part of the project presented but it is part of other projects regarding the energy turnaround 2050 (www.nfp70.ch). Within a workshop with external experts the vision has been verified. Based on this an action plan will be developed in a backcasting process. This action plan will also give more insight in the concluding assessment of the technical, financial and political feasibility of the vision. The combination of different methodologies (e.g. forecasting, backcasting) and the involvement of a broad compound accompanying group has proved to be helpful to reach the project goals.

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