Liechtenstein

Action 4.1.1: National Frameworks

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The work done in the project "AlpStore: Strategies to use a variety of mobile and stationary storages to allow for extended accessibility and the integration of renewable energies" and the establishment and maintenance of this study receive funding from the European Union's Alpine Space Programme 2007-2013, as a part of the "European Territorial Cooperation".

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ARA Abwasserreinigungsanlage
FL Fürstentum Liechtenstein
LGV Liechtensteinische Gasversorgung
LKW Liechtensteiner Kraftwerke

1. Summary

The principality of Liechtenstein is 90% dependent from energy imports from other countries. Only around 9,8 % of energy can be produced in the country itself. A huge part of the produced energy is the result of 12 water power plants. The rest of renewable energy is taken by solar collectors, photovoltaic systems and one single biogas plant.

One unit of energy storage is right now under construction. It is the hydro pump storage Samina, which will have a storage capacity of 200,000 kWh and will produce 47,6 GWh.
One bio mass plant the ARA Bendern is connected to the sewage plant and produces power, but will soon be changed to feed directly into the gas grid.

On the individual mobility sector are nine complete electric cars are in operation. A higher amount can be found, if we have a look at the hybrid vehicles. There are two diesel/electric and 200 petrol/electric cars registered.

Policy and energy companies target an own consumption concept. Buildings should not only be a power plant, but should also work as a buffer zone, storing energy, which is produced, stored and consumed at the same place. This decentral model will help to reduce excess energy in the grid and will exercise people to manage their energy household.
Also a vehicle-to-grid concept is under discussion, which could be managed by the energy company. Loading the mobile battery, if surplus power is available and then using it for lacks of energy.

One of the bigger potentials of Liechtenstein and the Alpine Rhine Valley would be the using the Alpine Rhine for energy production. The whole theoretic capacity of this energy source would be around 420 GWh/a. The part of Liechtenstein, 210 GWh/a would increase the self-supply rate up to 70%. Focusing on an environmentally friendly integration of the dams and their effects the plant would still produce 80 GWh/a. Produced excess power over night could be used for the production of hydrogen.

2. Storage technology checklist

Please provide brief written overviews of the conditions in your country by adding information to the single technology descriptions below.

At the end of chapter 2 you will find a summarizing matrix for visualisation. It has been filled in for the German case as an illustration only. Please adjust the matrix accordingly for your country.

Please provide also an electronic map of your country with indication of major storage installations.

2.1 Market and local future options

2.1.1 Biogas digesters and storage tanks

Biogas storage tanks in combination with an enclosed pressure vessel, a digester and a combined heat and power unit form a complete biogas energy plant. Most available models feature a stiff steel or concrete ring and a flexible cover.

Market availability / number of units in operation: **At the moment there is only one unit in operation. A combined heat and power plant supplied with biogas from the sewage plant (ARA Bendern). 2010 the plant produced 797 MWh power and 1594 MWh heat.**

Local future options: **in 2013 the biogas will directly be connected to the gas grid**

Other: **A private plant was in operation, but closed because of uneconomical reasons. At the moment the unit in Bendern produces power with the bio waste, but there exist transportation problems. They could be solved by water way transportation using the Rhine or its canal as transportation medium. Agricultural areas are mainly located next to the Rhine or its canal. This would work because Bendern is situated at the end of the Liechtenstein part of the Rhine.**

2.1.2 Power-to-Gas (methane in gas grid)

Large areas of Europe, countries and the region are linked by a massive gas grid for natural gas supply connecting also private households. This historical grid could be used for the storage and transportation of bio- or renewably produced methane.

Market availability / number of units in operation: **zero**

Local future options: **import of methane and using the existing medium pressure gas grid**

Other: **If the Alpine Rhine plant would be built, it maybe becomes interesting to use the excess power over night to produce methane.**

2.1.3 Power-to-Gas (hydrogen in gas grid)

Instead of methane it may to a limited extent be possible to store and transport hydrogen in the gas grid.

Market availability / number of units in operation: **zero**

Local future options: **import of methane and using the existing medium pressure gas grid**

Other: **If the Alpine Rhine plant would be built, it maybe becomes interesting to use the excess power over night to produce hydrogen.**

2.1.4 Power-to-Gas (hydrogen local)

This connotes local energy storage in gas form. This could be done at different scales - for example in vehicle fuel tanks, stationary fuel tanks or in large salt domes or mines.

Market availability / number of units in operation: **zero**

Local future options: **import of methane and using the existing medium pressure gas grid**

Other: **If the Alpine Rhine plant would be built, it maybe becomes interesting to use the excess power over night to produce hydrogen.**

2.1.5 Chemicalstorage (zeolite etc.)

Chemical storage systems involve the storage and release of thermal energy through reversible chemical processes. For example, zeolites *are microporousaluminosilicate, adsorbent minerals that can be deployed to*

store thermal energy at high temperatures which can later be recovered when water is added to the mineral. When heat is applied to the zeolite, the process is reversed and the water is released.

Market availability / number of units in operation: **zero**

Local future options:

Other:

2.1.6 Compressed air storage

At the moment only two compressed air energy storage plants operate in the world: One in Huntdorf (Germany) and the other one in McIntosh (USA). The Huntdorf plant is located on a 300,000 m^3 salt dome, in which compressed air is stored, originally to capture excess nuclear power production. For rapid responses to power shortages, the air is channelled to a conventional gas turbine, at a capacity of up to 290 MW. Smaller, even mobile compressed air batteries are currently in deployment as well.

Market availability / number of units in operation: **zero**

Local future options: **Options in the future will reach from smaller units in domestic use to bigger storage systems for whole settlements**

2.1.7 Pump storage (regional in Alpine Space)

Regional water pump storage systems refer to using dams in nearby, higher altitude valleys, to store excess solar or wind power, or to manage and utilise hydropower harnessed from two lakes with different heights or artificial water storages, within the regional context of settlements. Water is pumped using excess or low-priced electricity - the potential gravity energy is maintained with little loss. The stored water is released to drive turbines, to dispatch power to meet peak demands.

Market availability / number of units in operation: **There is one unit under construction, which will be finished in the near future. The pump storage Samina will have a storage capacity of 200,000 kWh and will produce 47.6 GWh.**

Local future options**: Almost all capacities are exhausted, as long as bigger interventions in the landscape should be avoided.**

2.1.8 Pump storage (Scandinavia etc.)

These water pump storage systems are in principle similar to those above but are linked in a wider spatial context, such as using Norwegian storage capacity for Danish or Dutch wind power.

Market availability / number of units in operation**: LKW, the Liechtenstein energy company takes part at the Lago Bianco project. A pump storage project in Valposchiavo (CH) with a installed power production of 1,050 MW.**

Other: **LKW is searching for suitable projects to take part.**

2.1.9 Thermal energy storage systems – High temperature

These storage systems can be combined to every source of thermal heat. Storage materials can be solid or liquid for example concrete, stones, sand, water or combinations with salt.A high variation made it useful to split up the different types of thermal energy storage system. This one is for high temperature – also well know under the term HTTESS.

Market availability / number of units in operation: **no number of units assessable**

Local future options:

Other:

2.1.10 Thermal energy storage systems – Low temperature

Known as low temperature or latent heat thermal energy storage systems.

Market availability / number of units in operation: **no number of units assessable**

Local future options:

Other:

2.1.11 Thermal energy storage system - Water

Water is here the storage material.

Market availability / number of units in operation: **no number of units assessable**

Local future options: **Especially in domestic use, because it is easy to handle and could fill out former oil tank storage rooms in the existing building stock.**

Other:

2.1.12 Thermal energy storage system - Salt

In this case salt or combinations with salt are the storage material.

Market availability / number of units in operation**: no number of units assessable**

Local future options:

Other:

2.1.13 Thermal energy storage system – Materials like concrete, stones or sand

Lithic materials like stones and sand or concrete are used here for the storage. This is an important aspect in concrete core cooling – concepts.

Market availability / number of units in operation: **no number of units assessable**

Local future options: **Concrete core cooling could play a much bigger role in the built environment**

Other:

2.1.14 Flywheels (small-sized)

Flywheels are rotating mechanical devices to store kinetic energy. It releases the energy by applying torque to a mechanical load. Contemporary flywheels consist of a carbon-fibre composite rotor suspended by magnetic bearings. Rotors spin at 20,000 to over 50,000 rpm in a vacuum shell to reduce friction.

Market availability / number of units in operation: **Zero**

Local future options: **Suitable for small energy variations in the grid and in the public transportation sector.**

Other:

2.1.15 Flywheels (large-sized)

Large sized flywheels operate on the same principle, but store more energy in a higher mass und physical size.

Market availability / number of units in operation**: Zero**

Local future options: **Mainly in the industry and power production sector.**

Other:

2.1.16 Mobile batteries (electric vehicles)

Vehicle-to-grid (V2G) systems store and dispatch electrical energy stored in networked vehicle batteries which together act as one collective battery fleet for peak shaving and supplementary resource- still largely conceptual.

Market availability / number of units in operation: **9 electric, 2 diesel/electric, 200 petrol/electric (Source: Amt für Statistik, Fürstentum Liechtenstein)**

Local future options: **There are two main options which operate with mobile batteries. The first one is a decentral use of these batteries, which is connected to an own consumption concept. The producer of energy, for example by a photovoltaic on his own roof, uses the surplus power to feed in the mobile battery of his car. The other option is that the energy company will manage and operate mobile batteries, which also includes a license for extracting power to the power company, if they need it. But it would also be possible to offer both systems.**

Other:

2.1.17 Stationary batteries

Examples of stationary batteries include lead acid batteries, lithium ion batteries, redox-flow batteries or hybrid-flow batteries.

Market availability / number of units in operation**: Zero**

Local future options: **This kind of storage will be needed especially in domestic usage, for example if a PV-system is installed on the roof. This would strengthen a own consumption concept for private households and reduce the load on the power grid.**

Other:

2.2 Technology comparison

Table 1: Technology examples

Table: Technology - EXAMPLEFehler! Textmarke nicht definiert.	Market availability	Storage period	Storage volume	Response Time	Local Option
Biogas digestion and storage	+	days	+	medium	+++
Power-to-Gas (methane in gas grid)	--	weeks	+++	quick	o
Power-to-Gas (hydrogen in gas grid)	--	weeks	+	quick	o
Power-to-Gas (hydrogen local)	--	days	-	quick	o
chemical storage (zeolite etc.)	+	days	o	slow	+
compressed air storage	+	weeks	o	medium	o
pump storage (regional in AS)	+++	months	+++	quick	++
pump storage (Scandinavia etc.)	++	months	+++	quick	
Thermal energy storage system – high temperature	+	hours	+	medium	+
Thermal energy storage system – low temperature	o	days	++	medium	+
Thermal energy storage system – water	+++	days	+++	quick	+++
Thermal energy storage system – salt	o	weeks	++	medium	+

Thermal energy storage system – lithic material	o	days	o	slow	+++
fly wheels (small-sized)	+++	minutes	--	very quick	+++
fly wheels (large-sized)	---	weeks	o	very quick	o
mobile batteries (electric vehicles)	o	hours	-	very quick	+++
stationary batteries	o	days	-	very quick	+++

Explanation

Please completethe above matrix in, following these scales:
Market availability, storage volume, local option: +++ (best), ++, +, o (neutral), -, --, --- (worst)
Storage period: minutes, hours, days, weeks, months
Response time: very quick, quick, medium, slow, very slow

3. Renewable energy status: sources, supplies, network, market

Please characterize, qualify and as far as possible quantify the state of renewable energy, as a background to understanding the energy cultural context.

Policy – Energiestrategie 2020

The newest paper from the government of Liechtenstein is called Energiestrategie 2020, which removes the Energiekonzept 2013 and builds up on the successes of this former concept paper. Energiestrategie 2020 is a handbook to establish concrete measures for a save, sustainable and affordable energy supply for the Principality of Liechtenstein until the year 2020.

One of the keys to reach the goals is the building sectors. This means to redevelop the existing building stock regarding efficient housing technology, like heat pumps and solar collectors, but also to establish high energetic standards for new buildings.

One fifth of the whole energy demand is used for mobility. That is the reason why measures are also necessary in the mobility sector. By using alternative and new propulsion technology, for example by electric vehicles, the fossil fuels can be reduced and lead to a more ecofriendly mobility. Much more can be done by improving possibilities to use public transport systems and active moving by bike or foot. One major project in the near future will be the S-Bahn project, which will go from Feldkirch (A), trough Schaan (FL) and Buchs (CH).

The third point describes the potentials of energy saving by using more efficient equipment, hardware and machines in domestic, commercial but also in industrial sectors. Also the stand-by problematic and lightning need a rethinking. Here can be much done by clarifying the users – the society.

The next will be to reconsider the energy production and import. Firstly all renewable energy potentials in country itself have to be exhausted before moving abroad. Photovoltaic, hydro power, fire wood plants, wind, bio gas and deep geothermal technology are a few possible ways to supply Liechtenstein with its own energy potential. For the huge projects Alpine Rhine hydro power and deep geothermal drilling the aspects of energy, economy and ecology have to be in harmonious equilibrium.

The campaign "Energieland" will help by consciousness-raising of society and improve acceptance of renewable energy. In 2012 already eight of eleven communities of Liechtenstein are "Energiestadt". The residual three will follow in the near future. Communities labelled "Energiestadt" commit oneself in the long term for example to realize the 2000-Watt-society.

Finally the creation of a decision-making basis and a common data base including the status quo will allow an efficient use of limited financial funding.

The complete paper "Energiestrategie 2020":

http://www.regierung.li/uploads/media/Energiestrategie_Langfassung.pdf

- ***Status quo of a renewable energy self-supply***

  Liechtenstein covers its energy needs with 9.8% with renewable energy in 2011. For this calculation are included: Eleven hydroelectric power stations, the combined heat and power unit in Bendern driven by biogas and 773 solar power stations (PV), but also heatproduction by local firewood and over 1594 thermal heat collector systems. In totally the amount of energy self-supply with resources from Liechtenstein was 128 889 MWh in 2011.

  The production in eleven hydroelectric water power stations covers around 18% of the whole electric energy demand of Liechtenstein. In total this is around 72,000,000 kWh.

  The complete paper "Energiestatistik 2011, Fürstentum Liechtenstein":
  http://www.llv.li/pdf-llv-as-energiestatistik_2011_vers.1

- ***Research project Erneuerbares Liechtenstein***

  Between 2009 and 2011 a research project called "Erneuerbares Liechtenstein" under the direction of Prof. Peter Droege and supported by research and development fundings of the University and the government of Liechtenstein searched for possible future scenarios regarding the energy household of the principality of Liechtenstein. Main aim was to replace non-renewable technology by regenerative energy production, whereas only systems were allowed, which can be used in Liechtenstein. In short, the target was to look at Liechtenstein as an island and supplying the country only with renewable energy.

  The result of the research was that a complete regenerative self-supply can only be established by carefully targeted and specific efforts. This aim could be reached in around 60 years, given that the current trend of an increasing population of Liechtenstein continues.

  In the heating sector an amount of 62% and in the electric energy an amount of 78% could be reached by regenerative energies intra muros.

4. Institutional framework

List and describe the main public and private institutions charged or mandated with energy storage development, management and standard-setting together with their main activities. Describe mobility regulators and providers if relevant for the discussion of energy storagesystems.

Please use a bullet format:

Overview

- ***Energiefachstelle***
  The Energiefachstelle is an office of the Amt für Volkswirtschaft and offers especially information to the public regarding energy and a change to renewable systems. Besides managing information events for building owners, the Energiefachstelle advises also the government and parliament and prepares and manages orders and decisions of the energy commission.

- ***Liechtensteinische Kraftwerke***
  The company Liechtensteinische Kraftwerke (LKW) is a state-owned enterprise. By the task of energy supply the company gets a high influence on the energy policy of the principality. This can be noticed on the one hand in the choice of the power mixtures, on the other hand on their activities in the field of power production within or outside of Liechtenstein.

- ***Liechtensteinische Gasversorgung***
  The company Liechtensteinische Gasversorgung (LGV) is like the LKW a state-owned enterprise. It works in accordance to the state and advises government and parliament regarding energy political issues. The LGV is mainly responsible for the gas supply in Liechtenstein.

5. Policy initiatives and plans

List and describe in a brief and concise case study format the main public policies related to energy storage.

- ***Management of mobile batteries by LKW***
  LKW, the state-owned energy company has the plan to offer the management of mobile batteries to their private owners, which also includes a license for extracting power to the power company, if they need it.

- ***Own consumption concept (Eigenverbrauchsmodell)***
  An own consumption concept is promoted by the Amt für Volkswirtschaft. It will help to reduce the load on the power grid for example produced by private PV-systems.

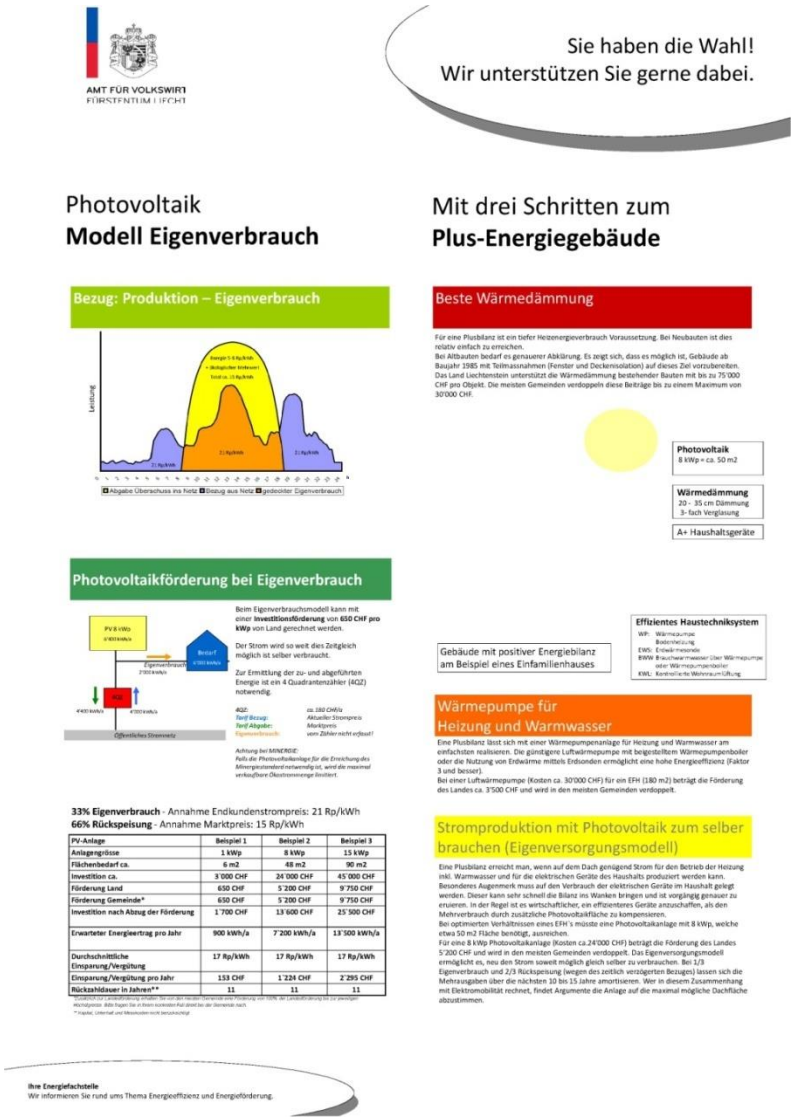

Fig. 1: Own consumption concept

6. Legislation

List and describe the main laws / general legal framework governing energy storage (including regulatory framework for grid operation and energy supply). Please also refer to legislation related to managing mobile storagesystems, i.e. EVs and PHEVs.

European legislation

- ***EU laws are implemented***
  The Principality of Liechtentein is not a member of the European Union, but the EU Legislation is implemented, independent from Switzerland.

Federal state law (Landesgesetze)

- ***Energieeffizienzgesetz; EEG***
  This law structures fundings for measures to increase energy efficiency and the use of renewable energies. It also manages the purchase and payment of electricity from renewable energy sources. It contributes to an efficient and sustainable energy use and supply.

- ***Energieeffizienzverordnung; EEV***
  This regulation implements the Directive 2004/8/EC of the European Parliament and of the Council of 11Feb 2004 on the fundings of heat demand orientated power-heat-couplin in the internal energy market.

- ***Elektrizitätsmarktgesetz; EMG***
  This law regulates production, transmission and distribution and the supply with power. It also includes organization and functioning of the electricity sector, the access to the market, criteria and procedures for tendering and procurement of permits and the operation of the energy grids.

- ***Elektrizitätsmarktverordnung; EMV***
  Purpose of the EMV is to regulate access to the power grid, the invoice and supplier change, labeling of electricity and the security of supply. It implements the Directive 2003/54/EC of the European Parliament and Council of 26 June 2003 concerning common rules of the internal market.

- ***Gasmarktgesetz; GMG***
  This law regulates the transmission, distribution, supply and storage of natural gas. Liquefied natural gas is included also as biogas or other kinds of gases. It also regulates

the organization and functioning of the natural gas sector. The access to the market, the criteria and procedures for the granting of authorizations and the operation of systems is also part of this law.

- ***Gasmarktverordnung; GMV***
  This regulation controls the access to the network, the invoice and the supplier change and the security of supply. It implements the Directive 2003/55/EC of the European Parliament and Council of 26 June 2003 concerning common rules for the internal market.

Energy efficiency measures concerning building

- ***Energieverordnung (EnV)***
  This regulation is about the minimum requirements for an energy-saving design and management of buildings, but also about the technical requirements for the energy performance of buildings and their energy improvement potentials.

All laws can be read at http://www.gesetze.li/Seite1.jsp?lrs=7&lrs2=73&clearsvs=true

7. Market

Characterise theoverall current market conditions and public policy frameworkssupporting economic activity related to energy storage. Do not hesitate to conclude or refer to any market information relating to specific storage systems, also as they relate to buffering functions in smart grids.

- ***There is no market regarding energy storage systems***
  There is a market niche in Liechtenstein regarding energy storage systems. The demand is increasing, because for example private owners would like to store and use their own energy produced by their PV-system instead of feeding into the grid.

8. R&D

List and describe research, development and pilot deployment activities related to energy storage, including storagesystems in Smart Grids. Differentiate **public** and **private** activities.

- ***Interstaatliche Hochschule für Technik Buchs, CH***
  The University of Buchs will offer a study programme regarding smart grids in the near future.

- ***Energiestrategie 2020***
  Between 2009 and 2011 a research project called "Erneuerbares Liechtenstein" under the direction of Prof. Peter Droege and supported by research and development fundings of the University and the government of Liechtenstein searched for possible future scenarios regarding the energy household of the principality of Liechtenstein. Main aim was to replace non-renewable technology by regenerative energy production, whereas only systems were allowed, which can be used in Liechtenstein. In short, the target was to look at Liechtenstein as an island and supplying the country only with renewable energy.
  The result of the research was that a complete regenerative self-supply can only be established by carefully targeted and specific efforts. This aim could be reached in around 60 years, given that the current trend of an increasing population of Liechtenstein continues.
  In the heating sector an amount of 62% and in the electric energy an amount of 78% could be reached by regenerative energies intra muros.
  For simplification the whole project excluded the difficulties of storing energy. It was assumed that all problems will be solved.

APPENDIX and supplementary material

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a. Review of existing sources and literature

b. Key contacts and resources

c. Other material

a. Review of existing sources and literature

- ***Energie Strategie 2020***
  Current status, outlook and aims regarding energy in Liechtenstein
  http://www.regierung.li/uploads/media/Energiestrategie_Langfassung.pdf

- ***Erneuerbares Liechtenstein***
  Research project to look for a renewable energy self-supply of Liechtenstein

- ***Fahrzeugstatistik (30.Juni 2012)***
  Research project to look for a renewable energy self-supply of Liechtenstein
  http://www.llv.li/pdf-llv-as-fahrzeugstatistik_bestand_30._juni_2012

- ***Energiestatistik 2011***
  Current status, outlook and aims regarding energy in Liechtenstein
  http://www.llv.li/pdf-llv-as-energiestatistik_2011_vers.1

- ***Gesetze.li***
  Laws of Liechtenstein
  http://www.gesetze.li/Seite1.jsp?lrs=7&lrs2=73&clearsvs=true

b. Key contacts and resources

- ***Amt für Volkswirtschaft (AVW) - Energiefachstelle***

Haus der Wirtschaft *Poststrasse 1* *9490 Schaan* *Tel +423 236 68 71* *Fax +423 236 68 89*	*Jürg Senn* *Tel +423 236 64 32* *Juerg.Senn@avw.llv.li*

- ***Liechtensteinische Kraftwerke***

Im alten Riet 17 *FL-9490 Schaan* *Tel +423 236 01 11* *www.lkw.li*	*Armand Jehle* *armand.jehle@lkw.li*
	Mario Nescher *Tel +423 236 02 04* *Fax +423 236 02 07* *mario.nescher@lkw.li*

c. Other material