Management Theory and Studies for Rural Business and Infrastructure Development. 2014. Vol. 36. No. 1. Scientific Journal.
ISSN 1822-6760 (print) / ISSN 2345-0355 (online)

HYDROGEN AS ENERGY SOURCE – CHALLENGES FOR REGIONS IN LATVIA (RESULTS OF PUBLIC OPINION SURVEY)

Biruta Sloka[1], Jānis Kleperis[2], Justs Dimants[3], Ilze Dimanta[4], Jānis Kleperis Jr.[5]
[1] *Prof. Dr.oec. University of Latvia, Aspazijas 5, Riga, 1050, Tel. +371 29244966. E-mail Biruta.Sloka@lu.lv*
[2] *Senior Researcher. Dr. phys. Academy of Agriculture and Forestry Sciences. E-mail Kleperis@latnet.lv*
[3] *Researcher. Dr. admin. University of Latvia. E-mail Justs.Dimants@gmail.com*
[4] *Doctoral student. Mg. biol. University of Latvia. E-mail Ilze.Dimanta@gmail.com*
[5] *Student. University of Latvia. E-mail Janis.Kleperis@gmail.com*

© Aleksandras Stulginskis University, © Lithuanian Institute of Agrarian Economics

Received 24 12 2013; accepted 03 03 2014

Hydrogen energy with every day comes into everyday life in many countries and in many national economies. Several countries, like USA, United Kingdom, Taiwan, Portugal, Spain, Slovenia, Romania, Lithuania and other have developed hydrogen economy programs and recent developments towards acceptance hydrogen as energy source comes into daily life: public transport, heating, etc. take place into economies. In many countries extensive research was performed on public awareness and acceptance of hydrogen energy. The current paper is devoted to public opinion regarding the hydrogen energy in Latvia. Extensive survey in all regions was conducted in the first half of 2013. The questions on public opinion were stated to give evaluations in scale 1–10, where 1– lower evaluation and 10 – higher evaluation. The respondents have represented all regions in the country. The results indicated that not enough information is for public, results differed in the regions. Research methods used: literature review, survey methods, descriptive statistics, correlation analysis.

Keywords: Hydrogen economy, public opinion, marketing research, attitude.
JEL codes: M30, M31.

1. Introduction

Mankind's made pollution of the environment not only makes global climate change but also shortens people's active life therefore this topic is broadly discussed last decades. Short and log-term action plans in regional and national levels are required to prevent or decrease negative impacts like a rising sea level, melting glaciers, increasing weather extremes and droughts, air pollution with particles, combustion exhaust gases. The consequences for each region are diverse influencing ecosystems and increasingly adding a political and economic note to the changes. Unusual thing is that in the South the climate change brings storms, tornadoes – along an overall negative impact, while in the Northern Hemisphere not only floods, fast temperature fluctuations, but also some short-time positive side-effects at first sight: ice-free transportation routes, altered fish occurrences and changes in the agriculture, accessibility of raw materials in the Arctic regions. However, these short-term gains can not

counterbalance the overall negative effects on regional and global level and necessary prevention and adaption policies to be taken in the upcoming years in regional and global policies around the entire World coordinated by United Nations Climate Change (United…, 2000). The last few decades characterizes with increasing finance amounts already invested in number of countries to tackle the reduction of consequences of mankind made environmental pollution. The Climate Change Financial Instrument (CCFI) is a Government budget program of Republic of Latvia (Cabinet…, 2009). Aim of CCFI is to prevent global climate change, facilitate adaptation to the effects of climate change and contribute the reduction of greenhouse gas emissions (increasing energy efficiency in buildings both in public and private sectors, develop and implement innovative technologies that use renewable energy resources, as well as support the implementation of the integrated solutions to reduce greenhouse gas emissions in regional and national levels. The financing of the Tender is formed by the Proceeds from the Assigned Amount Units (AAU) Purchase Agreements which are made within the international emissions trading under the Kyoto Protocol. From 2008 to 2012 more than 120 millions Euros are distributed to various projects in more than 20 project tenders mostly on energy efficiency topics.

Two dominant energy consuming and greenhouse gas (GHG) producing sectors in Latvia are households and transport (Institute…, 2012). In 2010, the share of transport was 28.2% compared to 23.0% in 2000. The share of households fell from 40.8% in 2000 to 35.5% in 2010. Therefore transport sector in Latvia needs more attention to different measures for energy saving and fuel shift from fossil to more environmentally friendly.

One of the most researched current energy sources around the globe is hydrogen energy: a lot of academic research, experiments and practical implementations take place during the latest decades. Even term "**hydrogen economy**" is applied in many developed countries United States, Germany, United Kingdom, Taiwan, Canada, Spain, Portugal and many other countries. Currently in Riga City Council the first negotiations are initiated about entering the hydrogen vehicles in the public transport of city, by following examples of European cities such as Berlin, Copenhagen, London, Oslo etc. Negotiations is initiated by Latvian Hydrogen Association, which called upon one of the largest fuel cell companies in the world and already recognized in Riga international public transport manufacturers. In Riga, October 17–20, 2013 international exhibition "Energy and Environment" took place, several presentations on hydrogen transport experience were discussed as well as demonstration of hydrogen car – it was in Riga and has operated in Riga streets as well as hydrogen bus was taking passengers to the exhibition from the city centre as well as from the city centre to the exhibition venue.

Department of Energy (USA) concludes that current knowledge and awareness levels of hydrogen and fuel cells are still low in the general public, and misunderstandings of hydrogen properties continue to impart negative opinions about the safe use of hydrogen as a fuel (Fuel Cell …, 2012). Riga City Council explores deployment of hydrogen applications firstly in March 21, 2013, when the Riga Energy Agency and the Latvian Hydrogen Association organized a conference on hydrogen for local energy and transport officials in Riga City Council inviting representatives

from HyER (Hydrogen Fuel Cells and Electro-mobility in European Regions) (Riga …, 2013). Therefore before introducing new technology in Latvia it is important to research public opinion in regions and municipalities going to be first in implementation of demonstration projects and early market fuel cell and hydrogen infrastructure installations. The public opinion research on public knowledge and public acceptance on hydrogen energy has been performed in many countries. The public opinion survey was performed also in Latvia in the beginning of 2013. The questions were stated taking into account experience of other countries, there were included 16 questions and statements asked to evaluate in scale 1–10, where 1– do not agree, 10 – fully agree. In survey 1299 respondents took place, 51.7% female and 48.3% male persons in all regions of Latvia.

2. Theoretical background

Hydrogen energy has become a widely adopted in many countries where hydrogen energy is used already on great extent. Before the introduction of hydrogen energy in many countries has been performed extensive scientific research on the different aspects hydrogen energy public acceptance, like on dynamic effects on the acceptance of hydrogen technologies extensive international comparison was performed by B. Heinz and G. Erdman (Heinz, 2008). In some other research hydrogen has been researched as the energy source for the 21st century (Johnston, 2005), as well as different aspects of it (West, 2010). Clark and Rifkin devoted their research on green hydrogen economy (Clark, 2006). Research on conversion of the United Kingdom gas system to transport hydrogen has been performed by P. E. Dodds and S. Demoullin (Dodds, 2013). On forecasts, scenarios, visions, backcasts and roadmaps to the hydrogen economy as extensive review of the hydrogen futures literature have worked W. McDowall and M. Eames (McDowall, 2006). On Iceland's hydrogen energy development has been made several researches as hydrogen energy is already part of Iceland's economy (Park, 2011). Research on hydrogen and fuel cell education in Europe different aspects has been performed by several authors and published in several research results, a lot of attention to education aspects is devoted by M. Reijalt (Reijalt 2010). M. Ricci, P. Bellaby and R. Flynn for many years devote their research to public knowledge and perceptions as well as acceptance of hydrogen and on the public involvement on paths to sustainable energy (Ricci, 2008; 2010). It has been performed scientific research on possibilities to be green with hydrogen (Zimmer, 2012). Research results in several countries on social acceptance of hydrogen energy concluded that more information and society education is needed (Wüstenhagen, 2007). Good results on public education and real hydrogen energy implementation in last years has been done in Poland – it is mentioned also in academic research that Poland is turning to hydrogen economy (Stygar, 2013). Many applications of hydrogen energy in Norway take place in recent years, but research on public attitude was made by several authors (Tarigan, 2012). Several scenarious and plans have been evaluated and examined on hydrogen use in economy (Upham, 2014) as well as future energy (Sovacool, 2010). In many researches has been stated question on public understanding of hydrogen as part of economy (Sherry-Brennan,

2010). In several countries public is informed on different levels and research confirms the attitude toward hydrogen in many countries, also in USA (Krause, 2013), also in several states of USA (Besley, 2010) and (Martin, 2009). In the Netherlands a lot of achievements have been reached in use of hydrogen energy and public knowledge and acceptance have been researched by several scientists (de Best-Waldhober, 2011), (Achterberg, 2010). Public opinion on hydrogen energy research is devoted also to security issues (Saffers, 2013). Several public views are met and analysed (Kontogianni, 2013). Public opinion on hydrogen acceptance has been studied also in Turkey (Apak, 2012), in China (Lu, 2013).

3. Research results

3.1. Energy resources in Latvia

Latvia is one of those countries strongly dependent from imported energy resources. The most significant local energy resources used are fuel-wood and hydro energy (Daugava HPP cascade). Solid fuel, oil products and electricity are imported from several countries and supply regions, but there is only one supplier for natural gas – Russia. The split of energy flows shows the relatively high dependence from energy import – only 33% of total energy consumption is covered by local energy resources. The large part of the fuel for the centralized heat supply to regions and cities are imported in Latvia – 63% of the natural gas, 3% of oil products, 0.6% of coal and the rest 33% is only local biomass (Ministry…, 2013). The share of fossil fuels in transport sector is growing year by year and is above 99% (Steinberga, 2013). Information on fuel consumption in Latvia in 2009–2012 is stated in Table 1.

Table 1. Fuel consumption in Latvia in 2009–2012

Oil products (fuels) in tons	2009	2010	2011	2012
Gasoline	241227	28154	19882	18573
Gasoline bio (E5)	80347	260143	235177	209416
Diesel	661113	644871	642993	674822
Biodiesel (100%)	1179	1723	865	722
LPG	19751	21544	27026	40627
Total	1002438	954712	925078	943438

Source– Information from The State Revenue Service

The traffic with average daily flow intensity 25 thousand vehicles per day in typical street canyons (Brīvības, Valdemāra, Čaka-Marijas) located in Riga city center is major air pollution source (Steinberga, 2013). The number of days when particle PM10 concentrations exceeds EU ad Latvian guidelines and annual average concentration on nitrogen dioxide are two main air quality problems arising from internal combustion engine propelled vehicles in Riga. Switch to electro-mobility and electro-hydrogen vehicles could solve air pollution problems in Riga.

3.2. Europe Union Road Map 2050

The leaders of the European Union and the G8 in 2009 announced an objective to reduce greenhouse gas emissions by at least 80% below 1990 levels by 2050 – Roadmap 2050: a practical guide to a prosperous, low-carbon Europe, a discussion of the feasibility and challenges of realizing an 80% GHG reduction objective for Europe, including urgent policy imperatives over the coming five years (European Commission, 2009). It also shows how the main sectors responsible for Europe's emissions – power generation, industry, transport, buildings and construction, as well as agriculture – can make the transition to a low-carbon economy most cost-effectively.

Road transport needs to decarbonize 95% by 2050 to achieve EU overall commitment of 80% abatement. About 25% of decarbonization can be achieved with energy efficiency but majority needs to come from fuel shift. It is uncertain if conventional combustion engines will be able to fulfill requirements by a potential EURO VII norm or beyond. Result is that European cities focus on getting newest diesel engines until 2015 but, beyond that, seems to demand powertrains with lower zero emissions (electric and electric-hydrogen) (FCH…, 2012).

Operators and policy makers wonder how to balance lower emissions with potentially increased costs and decreased performance. Only the hydrogen, e-bus and trolley buses have the potential to drastically reduce well-to-wheel emissions and only the hydrogen, e-bus and trolley buses can achieve zero local emissions (FCH…, 2012). Perceived noise of a fuel cell hybrid is more than 3 times lower than that of a conventional diesel. The hydrogen fuel cell bus is the only articulated bus expected to decrease in TCO until 2030 (FCH…, 2012). Total Cost of Ownership, based on 12 years' bus lifetime, 60 thousand km annual mileage.

3.3. Hydrogen is fuel for the Sun why not for us?

Why hydrogen technology? Hydrogen is a very simple element, but at the same time it is very powerful. With the help of Hydrogen and Fuel Cell it is possible to produce cleaner energy by reducing Greenhouse gas emissions as well as get the solution for renewable energy recourses. Important reasons while it is necessary are because accidents in centralized networks happen more often, the price of fossil energy resources is growing up, and burning of fossil fuels is polluting environment.

The United States Department of Energy (DOE) postulated key components for transition to Hydrogen Economy (United…, 2002):

- hydrogen is "The Freedom Fuel": provides independence and an environmental choice;
- hydrogen solves foreign oil dependency and improves the environment;
- hydrogen is everywhere—"it's right in our backyard";
- a hydrogen economy includes other fuels and hydrogen is an ongoing business today;
- hydrogen is safe;
- hydrogen is a long-term energy solution;

- hydrogen is the "man on the moon" equivalent for this generation.

Hydrogen produced through non-fossil fuel sources by using the different forms of sustainable energy sources, such as solar, hydropower, wind, nuclear, etc. (so-called green energy based hydrogen production), is considered to be a prime fuel in meeting energy supply and security, transition to hydrogen economy, environmental betterment, and social, societal, sectoral, technological, industrial, economical and governmental sustainability in regions and countries (FCH…, 2012). Thus, green energy based hydrogen system can be one of the best solutions for accelerating and ensuring global stability and sustainability. Therefore, the production of hydrogen from non-fossil fuel sources and the development and application of green energy based hydrogen energy technologies become crucial in this century for better transition to hydrogen economy (United…, 2012). Hydrogen is the safest fuel, comparing with gasoline, methane, propane, on all measures by Fire Risk "Radar Chart" (buoyancy, lowest flammability limit, diffusion) (United, 2012). The advantages of hydrogen economy have been researched in many countries.

3.4. Selected examples on recent implementation of hydrogen technologies in transport

Norway (Fuel…, 2013**).** Hydrogen Highway between Stavanger and Oslo in Norway is 600 km with 5 filling stations and was opened on May, 2009 (project realized 2005–2009, coordinator HyNor). The hydrogen is produced by the electrolysis of water using electrical power generated by sustainable wind energy. The road is undergoing tests using 30 hydrogen sports cars (Mazda), 13 hydrogen cars and four hydrogen-powered buses from Toyota.

Italy (HyER …, 2013). The High V.LO-City project in San Remo – five buses hydrogen buses will be ready for operation by 31 January 2014 in 2 lines: on one line (La Brezza–Villa Helios), 3 fuel cell buses will fully substitute the trolleybuses currently operating, while on the second line (Sanremo–Taggia), the fuel cell buses will constitute half of the fleet. A mobile refuelling station will be used in the first half of 2014, which will enable a direct full operation of the buses once delivered. By mid-June 2014, the fixed refuelling station shall be ready for operation while the whole infrastructure shall be ready by mid-September 2014. Electrolysis will build at least 60% of the hydrogen required. For the remaining 40%, tube trailers will be used. The next step will be that part of the hydrogen initially delivered by tube trailer will be produced on-site by solar energy.

Belgium (HyER HyLIGHTS, 2013). In Antwerp, 5 buses are planned to be delivered beginning of January 2014. They are currently in testing phase. The buses will be operated at different lines in the city of Antwerp and in the surrounding villages. The hydrogen is produced by the international chemical group Solvay as a by-product from the existing chlore-alkaline production. The hydrogen refuelling station will be located at the premises of Solvay in the harbour of Antwerp and will be operational by the time the buses are delivered.

Scotland (HyER …, 2013). In Aberdeen, the High V.LO-City project is linked with the HyTransit fuel cell bus project, is planning to operate 10 hydrogen buses

from February 2014; build a state of the art hydrogen production and refuelling facility and a dedicated maintenance facility for the buses. The hydrogen production/refuelling facility will be constructed and operated by BOC, with support from Linde and Hydrogenics. With hydrogen production on-site, there is no need to transport hydrogen to the facility. The hydrogen will be produced by electrolysis on-site, compressed and then dispensed, using only electricity from wind power.

Public survey in all regions of Latvia was conducted to get information on public knowledge on hydrogen energy as well as on attitude towards hydrogen energy. Respondents were selected by mechanical sample to ensure random selection of respondents. Public opinion survey in Latvia was conducted in all regions in first quarter of 2013. The questions were stated taking into account experience of public surveys in other countries. In the survey in Latvia there were included 16 questions and statements, respondents were asked to evaluate in scale 1–10, where 1 – do not agree, 10 – fully agree. For data processing indicators of central tendency or location (arithmetic mean, mode, median) and indicators of variability (range, variance, standard deviation, standard error of mean) were used. 1299 respondents participated in the survey (respective 51.66% female and 48.27% male) from all regions of Latvia.

Table 2. Main statistic indicators of responses on statements on public knowledge on hydrogen in energetics

		I have been aware of the advantages of using hydrogen technology	I have learned about Hydrogen energy during primary or high school	I am informed about hydrogen technology application use and demonstration projects in the economy	I am informed about hydrogen technology application use and demonstration projects in the transport sector	I am aware that the carmakers develop electric cars with hydrogen as an fuel for electricity
N	Valid	1172	1045	1096	1101	1117
	Missing	127	254	203	198	182
Mean		4.36	3.08	3.48	4.19	4.68
Std. Error of Mean		0.087	0.088	0.084	0.088	0.091
Median		4	2	3	4	4
Mode		1	1	1	1	1
Std. Deviation		2.983	2.847	2.780	2.927	3.048
Variance		8.898	8.108	7.731	8.568	9.288
Range		9	9	9	9	9
Minimum		1	1	1	1	1
Maximum		10	10	10	10	10

Evaluation scale 1–10, where 1 – fully disagree, 10 – fully agree
Public survey by Dimants J., Sloka B., Kleperis J., 2013, n = 1299

Data of table 2 indicates that society in general in Latvia is not well informed on different aspects of hydrogen use in economy, mostly the average evaluations of respondents were low, especially mode (most often met evaluation) for all statements was the lowest possible (mode was 1), but with wide variability indicated by different indicators of variability (range, variance, standard deviation and standard error of mean). It means that society mostly is lacking information on hydrogen energy use in

different fields of economy. The highest evaluations of respondents were on statement "I am aware that the carmakers develop electric cars with hydrogen as fuel for electricity" has the highest arithmetic mean of respondent's evaluations: 4.68. For this statement half of respondents gave evaluations less than 4, half of respondents gave evaluations higher than 4 (described by median). It reflects that part of society had some information on hydrogen use in cars, but still information on practical use of hydrogen energy has not reached public on reasonable level to accept hydrogen energy for practical use and more information on good applications of hydrogen energy in other countries have to be distributed on understandable and acceptable level for society. The experience of other countries on regular information of success stories, especially demonstration of respective devices has to be developed.

Distribution of respondents on evaluations for the statement "Hydrogen in energetics is safe if all safety standards are met" in different regions of Latvia are included in table 3.

Table 3. Distribution of responses on statement "Hydrogen in energetics is safe if all safety standards are met" by region of living

Evaluation	Number of respondents by region of living						Total
	Riga	Near Riga	Kurzeme	Zemgale	Vidzeme	Latgale	
1	9	3	9	18	5	2	46
2	1	2	2	3	4	3	15
3	4	3	5	3	5	2	22
4	3	4	10	5	6	2	30
5	33	15	26	34	18	15	141
6	22	6	21	7	18	13	87
7	47	21	39	16	26	22	171
8	44	40	41	25	33	37	220
9	42	12	23	25	21	30	153
10	72	41	60	44	29	45	291
Total	277	147	236	180	165	171	1176

Evaluation scale 0–10, where 0 – do not have information about issue, 1 – fully disagree, 10 – fully agree.
Public survey by Dimants J., Sloka B., Kleperis J., 2013, n = 1299

The results of the survey indicate that the full range of the evaluation scale is covered: people in all regions have different opinions on safety of hydrogen energy but more respondents are on higher evaluations. Share of respondents who gave lower evaluations (5 or less) are less in all regions of the country. To indicate relationships on different statements by regions of the country it was conducted correlation analysis. The results of correlation analysis on different statements in survey by region are stated in table 4.

Table 4. Correlations on statements by region of living

		I'm interested in renewable energy	I have been aware of the advantages	I have learned about hydrogen energy during primary or high school	I am informed about hydrogen technology application use and demonstration projects in the economy	I am informed about hydrogen technology application use in the transport sector	I am aware that the carmakers develop electric cars with hydrogen as fuel for electricity	Society in general would support the use of hydrogen energy
Region of living	Pearson Correlation	-0,047	-0,096**	-0,130**	-0,074*	-0,099**	-0,146**	-0,009
	Sig. (2-tailed)	0,095	0,001	0,000	0,014	0,001	0,000	0,741
	N	1262	1163	1037	1087	1092	1108	1220

Source: Public survey by Dimants J., Sloka B., Kleperis J., 2013, n = 1299

The results of correlation analysis have indicated that there is no statistically significant correlation on statements of the survey and region: in all regions evaluations are alike and statistical significance is low.

The main statistic indicators on statements on public information sources on hydrogen economy are stated in table 5.

Table 5. Main statistic indicators of responses on statements on public information sources on hydrogen in energetics

		Government must work on the development of renewable energy policies	Universities and research institutes must carry out research on renewable energy topics to develop and promote renewable energy	Public institutions should cooperate with scientific and private institutions in order to develop, implement and promote renewable energy technologies
N	Valid	1221	1228	1224
	Missing	78	71	75
Mean		8,53	8,81	8,80
Std. Error of Mean		0,052	0,045	0,049
Median		9	9	10
Mode		10	10	10
Std. Deviation		1,815	1,563	1,724
Variance		3,294	2,443	2,973
Range		9	9	9
Minimum		1	1	1
Maximum		10	10	10

Evaluation scale 0–10, where 0 – do not have information about issue, 1 – fully disagree, 10 – fully agree

Public survey by Dimants J., Sloka B., Kleperis J., 2013, n = 1299

The respondents gave indications on necessity to get more information on hydrogen use in different spheres of everyday life.

4. Conclusions

1. Wide applications of hydrogen energy in different fields around the world is reflected in scientific publications, but could be more information about good practice, challenges and problems also for general public use.

2. Different international activities on cleaner energy sources are on agenda already for decades, but still there is a free place to make more efforts to use cleaner energy sources.

3. There are accepted legislative documents for implementation of cleaner energy sources use in Latvia including use of hydrogen energy.

4. Public awareness of hydrogen energy in Latvia generally can be evaluated as comparatively low, higher acceptance is for part of society with better education.

5. Society in general supports implementation of renewable energy technologies in Latvia and would be interested to receive more information in the media about the use of hydrogen experience in other countries.

6. Society in general agrees that hydrogen technology demonstration project might be suitable activity to increase public awareness about hydrogen energy.

7. Society in general supports the introduction of hydrogen energy industry.

8. There results in regions are different, but there are no significant differences on evaluations by region.

9. Hydrogen safety issues have been recognized, though, in average, the majority of respondents totally agreed that "Hydrogen power is safe when all safety standards are met".

Acknowledgments

Jānis Kleperis got the financial support of the European Regional Development Fund project No. 2010/0294/2DP/2.1.1.2.0/10/APIA/VIAA/009

References

1. Achterberg, P., Houtman, D., van Bohemen, S., Manevska, K. (2010). Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands // International Journal of Hydrogen Energy. Vol. 35. No. 12: 6075–6083.

2. Apak, S., Atay, E., Tuncer, G. (2012). Renewable hydrogen energy regulations, codes and standards: Challenges faced by an EU candidate country // International Journal of Hydrogen Energy. Vol. 37. No. 7: 5481–5497.

3. Besley, J. C., Baxter-Clemmons, S. (2010). Analysis of South Carolina hydrogen and fuel cell workers views and opinion leadership behavior: A waiting opportunity? // International Journal of Hydrogen Energy. Vol. 35. No. 16: 8407–8416.

4. de Best-Waldhober, M., Paukovic, M., Brunsting, S., Daamen, D. (2011). Awareness, knowledge, beliefs, and opinions regarding CCS of the Dutch general public before and after information // Energy Procedia. Vol. 4: 6292–6299.

5. Cabinet of Ministers (CM), Republic of Latvia (2009). Regulation No.644 "Procedures for Implementation of Projects Financed by the Climate Change Financial Instrument, the Submission and Examination of Reports Thereof" (approved on 25.06.2009, in force since 18.07.2009) http://www.lvif.gov.lv/?object_id=299 [01.09.2013].

6. Clark II, W. W., Rifkin, J. (2006). A green hydrogen economy // Energy Policy. Vol. 34. No. 17: 2630–2639.

7. Direct Hydrogen Fueled Proton Exchange Membrane Fuel Cell System for Transportation Applications, DOE/CE/50389-502 (1997); Fuel Cell Technologies Office Multi-Year Research, Development and Demonstration Plan (DOE USA, 2012). – http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/[08.09.2013].

8. Dodds, P. E., Demoullin, S. (2013). Conversion of the UK gas system to transport hydrogen // International Journal of Hydrogen Energy. Vol. 38. No. 18: 7189–7200.

9. European Commission. (2009). First Carbon Leakage List, adopted December 24, 2009. – http://ec.europa.eu/clima/policies/ets/cap/leakage/index_en.htm [09.09.2013]

10. FCH JU launches its study on urban buses: Urban buses: alternative powertrains for Europe: A fact-based analysis of the role of diesel hybrid, hydrogen fuel cell, trolley and electric powertrains, November, 2012. – http://www.fch-ju.eu/news/fch-ju-launches-its-study-urban-buses-alternatives-power-trains-europe [15.08.2013].

11. Fuel Cell Technologies Office Multi-Year Research, Development and Demonstration Plan (2012). – http://www1.eere.energy.gov/hydrogenandfuelcells/mypp [05.09.2013].

12. Fuel cells and hydrogen in Norway. Fuel Cells Today, 2013. – http://www.fuelcelltoday.com/media/1838763/fuel_cells_and_hydrogen_in_norway.pdf [12.09.2013].

13. Heinz, B., Erdmann, G. (2008). Dynamic effects on the acceptance of hydrogen technologies–an international comparison // International Journal of Hydrogen Energy. Vol. 33. No. 12: 3004–3008.

14. Hydrogen Production: Overview of Technology Options. US Department of Energy, Fuel Cell Technologies Office, 2013. – http://www1.eere.energy.gov/hydrogenandfuelcells/roadmaps.html [23.08.2013].

15. HyER HyLIGHTS – Monthly Update November 2013. – http://www.hyer.eu/publications/newsletters/hyer-newsletter-november-2013/november-newsletter-editorial [16.09.2013].

16. HyER Highlights: Riga City Council explores deployment of hydrogen applications (March 21, 2013). – http://www.hyer.eu/news/hyer-highlights/riga-city-council-explores-deployment-of-hydrogen-applications [10.09.2013].

17. Institute of Physical Energetics. (2012). Energy Efficiency Policies and Measures in Latvia. – http://www.odyssee-indicators.org/publications/PDF/latvia_nr.pdf [10.09.2013].

18. Johnston, B., Mayo, M.C., Khare, A. (2005). Hydrogen: the energy source for the 21st century // Technovation. Vol. 25. No. 6: 569–585.

19. Kontogianni, A., Tourkolias, C., Papageorgiou, E. I. (2013). Revealing market adaptation to a low carbon transport economy: Tales of hydrogen futures as perceived by fuzzy cognitive mapping // International Journal of Hydrogen Energy. Vol. 38. No. 2: 709–722.

20. Krause, R. M., Carley, S. R., Lane, B. W., Graham, J. D. (2013). Perception and reality: Public knowledge of plug-in electric vehicles in 21 U.S. cities // Energy Policy. Vol. 63: 433–440.

21. Lu, J., Zahedi, A., Yang, S., Wang, M., Peng, B. (2013). Building the hydrogen economy in China: Drivers, resources and technologies // Renewable and Sustainable Energy Reviews. Vol. 23: 543–556.

22. Martin, E., Shaheen, S. A., Lipman, T. E., Lidicker, J. R. (2009). Behavioral response to hydrogen fuel cell vehicles and refueling: Results of California drive clinics // International Journal of Hydrogen Energy. Vol. 34. No. 20: 8670-8680.

23. Matters relating to the mechanisms under the Kyoto Protocol: Review of the joint implementation guidelines, UN Climate Change Conference in Warsaw, November 8–16, 2013. – http://unfccc.int/meetings/warsaw_nov_2013/in-session/items/7871.php [20.11.2013].

24. McDowall, W., Eames, M. (2006). Forecasts, scenarios, visions, backcasts and roadmaps to the hydrogen economy: A review of the hydrogen futures literature // Energy Policy. Vol. 34. No. 11: 1236-1250.

25. Ministry of Economy if Latvia; Energetics; Fossil fuels. – http://www.em.gov.lv [15.09.2013].

26. Park, S. (2011). Iceland's hydrogen energy policy development (1998–2007) from a sociotechnical experiment viewpoint // International Journal of Hydrogen Energy. Vol. 36. No. 17: 10443–10454.

27. Reijalt, M. (2010). Hydrogen and fuel cell education in Europe: from when? And where? To here! And now! // Journal of Cleaner Production. Vol. 18. Supplement 1: 112–117.

28. Ricci, M., Bellaby, P., Flynn, R. (2008). What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence // International Journal of Hydrogen Energy. Vol. 33. No. 21: 5868–5880.

29. Ricci, M., Bellaby, P., Flynn, R. (2010) Engaging the public on paths to sustainable energy: Who has to trust whom? // Energy Policy. Vol. 38. No. 6: 2633–2640.

30. Riga City Council. (2013) International Conference "Hydrogen Technologies for Sustainable Development of Cities", March 20, 2013 materials. – http://www.rea.riga.lv/component/content/article/15-aktualitasu-arhivs-2013/625-dienaskartiba-inovativas-udenraza-tehnologijas [20.09.2013].

31. Roadmap 2050: a practical guide to a prosperous, Low-carbon Europe: April, 2010 (Technical Analysis); Roadmap for moving to a low-carbon economy in 2050. – http://ec.europa.eu/clima/policies/roadmap/index_en.htm; http://www.roadmap2050.eu/attachments/files/Volume1_fullreport_PressPack.pdf [18.09.2013].

32. Saffers, J. B., Molkov, V. V. (2013). Hydrogen safety engineering framework and elementary design safety tools // International Journal of Hydrogen Energy, In Press, Corrected Proof, Available online in Science Direct 17 July 2013.

33. Sherry-Brennan, F., Devine-Wright, H., Devine-Wright, P. (2010). Public understanding of hydrogen energy: A theoretical approach // Energy Policy. Vol. 38. No. 10: 5311–5319.

34. Sovacool, B.K., Brossmann, B. (2010). Symbolic convergence and the hydrogen economy // Energy Policy. Vol. 38. No. 4: 1999–2012.

35. Steinberga, I., Bikshe J. Jr., Kundzins, K., Kleperis, J. Bikshe, J. (2013). Evaluation of Local Scale PM Pollution Levels in Typical Street Canyon in Riga // Journal of Environmental Protection. Vol. 4: 956–963.

36. Stygar, M., Brylewski, T. (2013). Towards a hydrogen economy in Poland // International Journal of Hydrogen Energy. Vol. 38. No. 1: 1–9.

37. Tarigan, A. K. M., Bayer, S. B. (2012). Temporal change analysis of public attitude, knowledge and acceptance of hydrogen vehicles in Greater Stavanger, 2006–2009 // Renewable and Sustainable Energy Reviews. Vol. 16. No. 8: 5535–5544.

38. United Nations (UN) 2000. Climate Change. – http://www.un.org/climatechange/ [01.09.2013]

39. United States Department of Energy. (2002). A National Vision of America's Transition to a Hydrogen Economy – to 2030 And Beyond, Based on the results of the National Hydrogen Vision Meeting Washington, DC November 15–16 2001 (DOE, 2002). – https://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/vision_doc.pdf [18.09.2013].

40. Upham, P., Carney, S., Klapper, R. (2014). Scaffolding, software and scenarios: Applying Bruner's learning theory to energy scenario development with the public // Technological Forecasting and Social Change. Vol. 81: 131–142.

41. West, J., Bailey, I., Winter, M. (2010). Renewable energy policy and public perceptions of renewable energy: A cultural theory approach // Energy Policy. Vol. 38. No. 10: 5739–5748.

42. Wüstenhagen, R., Wolsink, M., Bürer, M.J (2007). Social acceptance of renewable energy innovation: An introduction to the concept // Energy Policy. Vol. 35. No. 5: 2683–2691.

43. Zimmer, Z., Welke, J. (2012). Let's go green with hydrogen! The general public's perspective // International Journal of Hydrogen Energy. Vol. 37. No. 22: 17502–17508.

VANDENILIS – ENERGIJOS ŠALTINIS: IŠŠŪKIAI LATVIJOS REGIONAMS (VIEŠOSIOS NUOMONĖS TYRIMŲ REZULTATAI)

Biruta Sloka[1], Jānis Kleperis[2], Justs Dimants[3], Ilze Dimanta[4], Jānis Kleperis Jr.[5]

[1, 3, 4, 5] Latvijos universitetas, [2] Latvijos žemės ūkio emės ūkio ir miškų mokslų akademija

Received 24 12 2013; accepted 03 03 2014

Santrauka

Daugelyje šalių vis dažniau atsiranda vandenilio energija. Pavyzdžiui, JAV, Didžioji Britanija, Taivanas, Portugalija, Ispanija, Slovėnija, Rumunija, Lietuva bei kt. suformavo vandenilio ekonomikos programas. Pokyčiai vyksta vandenilio, kaip energijos šaltinio viešajame transporte, šildyme bei kitose ekonomikos srityse. Šio straipsnio tikslas – pateikti visuomenės nuomonę apie vandenilio energiją Latvijoje. 2013 m. pirmą pusmetį atlikta apklausa visose šalies regionuose. Rezultatai parodė, kad vandenilio klausimu visuomenė neturi pakankamai informacijos. Apklausos rezultatai skyrėsi regionuose, nors dauguma respondentų visiškai sutiko, kad vandenilio energija yra saugi ir atitinka visus saugos standartus.

Raktiniai žodžiai: vandenilio ekonomika, viešoji nuomonė, rinkodaros tyrimai, nuostata.

JEL kodai: M30, M31.