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OPPORTUNITIES FOR HYDROGEN MARKETING – PUBLIC OPINION ANALYSIS

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Abstract

Increase of oil prices as well as problems in supply of fossil energy resources have led to development and use of renewable energy resources, including hydrogen energy. Popularity of renewable energy is growing in with each passing year. There are multitudinous successfully projects and more often companies and different societies start to implement renewable energy projects to manage efficient financial resource spending as well as reduce the impact of energy suppliers. Hundreds of good practice are examined and developed world wide, including operation of university campus, public transport, operation of villages, etc. Paper examines the readiness of acceptance of renewable energy resources and in this case – hydrogen for energy supply of Academic Centre. In the survey were questions on respondent's, attitudes, behaviour, some environmental knowledge as well as information on socio-economic characteristics of respondents, including, questions about the project acceptance, scientific value and safety issues. The main conclusion is that the main results shows acceptance for the project. Methods used for analysis: scientific publications research, evaluation of practical knowledge transfer and marketing tools application evaluations using

questionnaire. For data processing and analysis indicators of central tendency or location and variability, crosstabulations were used.

Introduction

Due to fluctuating oil prices, depletion of world's fossil resources, global warming and local pollution, geopolitical tensions and growth in energy demand, the renewable energy technologies and effective use of fossil fuels have became more important than at any time in history [1]. The faculties of natural sciences imply implementing innovative building technologies, such as a double facade made of green plants reducing temperature fluctuations in direct sunlight as well as wind generators of vertical flow on the roof. Integrated energy system depending on heat and power supply can be used to access the market potential of technologies [2]. Combined hydrogen heat and power system would be consistent accession for the already proposed construction goals. Hydrogen can be generated from a variety of energy resources, such as imported resources (gasoline, natural gas), and local resources (methanol, ethanol, biogas, water, geothermal, Sun and wind). The supply is endless and, depending on the production process, will not rob the earth of any more non-renewable sources [3]. Hydrogen can be used in stationary and mobile applications without damaging emissions especially using fuel cells [4]. Fuel cells is an enabling technology, and have high efficiencies and potentially sustainability with lower negative externalities than current energy systems, which has made them attractive future option in micro, stationary and automotive applications [5]. Within the context of hydrogen economy, the lack of infrastructure remains unsolved for large scale [6]. Hydrogen as a sustainable alternative energy solution for mobile and stationary applications has generated widespread interest on hydrogen energy [7]. Paper examines the readiness of acceptance of renewable energy resources and in this case – hydrogen for energy supply of Academic Centre. In the survey were questions on respondent's, attitudes, behaviour, some environmental knowledge as well as information on socio-economic characteristics of respondents, including, questions about the project acceptance, scientific value and safety issues. The main conclusion is that the main results shows acceptance for the project. Methods used for analysis: scientific publications research, evaluation of practical knowledge transfer and marketing tools application evaluations using questionnaire. For data processing and analysis indicators of central tendency or location and variability, crosstabulations were used.

Ideas on the Future of the University of Latvia Campus

By 2023, the University of Latvia is going to create a modern learning infrastructure in Riga district Tornakalns, with five study blocks and all the necessary facilities for active student life. The Campus total capacity will be about 20 000 people. Currently the connection to central city communications is planned for the new Campus, therefore hydrogen resource available on-site will therefore be natural gas. From renewables the Sun, Wind and water will be available and suggestions will be elaborated to organise in the Campus local collection of biological wastes. The fuel conversion system will be used to convert the locally available feedstock to a usable biogas. Anaerobic digestion system will be used to convert the organic feedstock and wastewater that University of Latvia campus will produce. Electricity will be used to power the

Academic Centre of Natural Sciences (include Biology, Chemistry, Geography and Earth Sciences – research laboratories, lecture-rooms, professor rooms etc., 200 researchers and professors, 2000 students. Feedstock that will continuously run the combined hydrogen and heat power plant will be municipal solid food waste, produced by University of Latvia campus city. According to The Ministry of Environmental Protection and Regional Development prepared State waste management plan for 2006-2012, the amount of municipal solid waste (MSW) generated by one person is 0.53 kg/day (biologically degradable waste). In the campus about 20 000 people will be daily, but factor of 0.2 was used to take into account people that do not eat on the campus territory. A conversation rate for degradable waste to biogas is from 50-70%, but biogas contains approximately 55% methane [8]. Based on experimental data [9], 0.12 tons of methane are produced from 1 ton of MSW. Accordingly, 0.064 kg methane will be produced daily per one person; 1024 kg CH_4/day. Fuel cell power plant DFC 300 [9] requires 1139 kg natural gas/day. Power distribution and electricity will be maintained centralized in the University of Latvia Campus. Currently the connection to central campus electricity communications is planned and it will be elaborated to organise connections to fuel cell system requirements. Leak detection equipment and automated system shutdown will be implemented, as well as catalytic oxidizers and ventilation, preventing hydrogen build up. Sensors for gas detection will be installed near and in the systems. Alarms will be incorporated in case of failure. Emergency switch will be easily accessible in the case of failure. 80 kg of hydrogen is stored in special Dynetek storage tanks with pressure 450 bars, then passed to dispenser when needed. If pressure drops to 300 bars, compressor starts to work again. Unlike conventional fossil fuel combustion plants where fuel quality and prior preparation is of little or no concern, the inputs, quantity and quality to the fuel cell are of great importance. The basic inputs are methane (from natural gas or biogas), water, and air. The outputs are DC electricity, water, and exhaust gases consisting primarily of heated carbon dioxide and water vapour. The power of the chosen device (DFC300) is 300 kW. As the building is only in a project phase, all figures above are based purely on predictions and calculations. However precise the calculations might be, there is still a profound necessity for the system to be highly flexible, and that has also been accounted for in the present section as well as in the technical design section. Luckily it is not that difficult, as the residual electricity can be fed back into the grid earning Ls 0.0115 per kWh [10]. Power system is safe if operated with the proper handling. System will be closed and available for viewing only selected parts together with selected specialists. Design system for Latvia is designed and will be built according to European material Hydrogen standards. Main electricity uses are computers, lighting, air conditioning, laboratory equipment, kitchen appliances of the café. The new faculty building is expected to have about 300 computers, mostly desktops (150 for university staff, 150 for computer classes).

Experience of World University Campus

Existing research provides important insights about determinants of hydrogen support and refuelling facilities. The increase of fossil fuel consumption is frequent problem in the world, for example, the University of Birmingham operates a fleet of 110 vehicles for delivery and other duties. To solve these problem electrical and hydrogen vehicles were introduced in the university campus to decrease fossil fuel consumption [11]. Also a commercially available lead-acid battery electric scooter was converted to a hydrogen fuel cell battery hybrid scooter. It was proved that hydrogen fuel cell battery hybrid scooter gave better energy efficiencies and speeds compared to battery and petrol powered scooter alone [12]. Different studies have examined the application of hydrogen to public and private transportation systems, based on customers and potential user opinions. Some studies have focused on measuring levels of hydrogen application acceptance and to identify determinant factors likely to support this green technology. Across these studies, variables related to socio-demographic factors, knowledge and attitudes appear to relate to hydrogen support and acceptance reported by the public [13]. In 2007 a clean energy research facility consisting of a 5kW photovoltaic system and 2.4 kW hydrogen-fuel cell system was build to investigate these energy production technologies at Pamukkale University in Denizli, Turkey [14]. Complete thermo economical analysis of an integrated power plant for co-production of electricity and hydrogen via pyrolysis and gasification processes fed by various coal and mixture of coal and biomass was applied to existing large steam power plant in Italy. The results showed that hydrogen cost, primarily, is affected by the total plant capital costs [15]. Social survey was carried in 2009, California, USA to learn consumer attitude on hydrogen vehicles. Hydrogen vehicles were tested and drivers questioned after test-drive. More then 90% would consider travelling 5-10min to find hydrogen fuelling station, more than 80% left with a positive overall impression of hydrogen [16]. Different analysis shows, that hydrogen refuelling stations and their supporting decentralized refuelling infrastructure diffusion over a long-time period can be estimated thru different scenarios and government incentives can play a significant role in development process [17]. Also educational part is significant element during renewable energy technology implementation. Numerous European educative initiatives targeted at children, students and other citizens to train them with active learning [18]. Unreached energy efficiency is significant problem for all kind of buildings. The study to analyze the energy efficiency of Los Angeles Community College City Campus was done to evaluated sustainability of the campus. It was discovered that campus could reduce its current annual energy consumption by 18.2% by improving energy efficiency. The study also concluded that the campus would need to install a 4601 kW solar PV array to meet remaining total campus energy demand [19]. It is hard to predict technology development. One of methods is five forces of competition, which analyses potential market entrants, buyers – to customers, substitutes, suppliers and competitors [20].

Before technology implementation it is important to make sure that society will accept technology. Gaining technology acceptance is critical in modern organizations [21]. By targeting one of groups it is possible to learn readiness and acceptance of technology. Target group for the survey of authors covers potential consumers including personal, professors, students – academia that will work together in the new campus. It can be assumed that consumer's perception toward government policy is directly influenced from his or her own experience related to the government policy. Also personal experience affects risk perception and benefit perception, which determine whether or not a person will accept product [22]. It is significant to encourage hydrogen development thru the prism of potential consumer. The change of hydrogen power paradigm is required to reach sustainable economic feasibility today, not in 50 years or next century [23]. A significant paradigm shift is now under way as major change in the way government policy makers and industry leaders are looking for clean fuels and renewable energy for their own nation-states [24].

The European Commission has adopted two proposals today that will mark a step forward in the development and marketing of clean and safe hydrogen vehicles The first is the setting up of the Fuel Cells and Hydrogen Joint Technology Initiative, an ambitious industry-led integrated programme of Research, technology development and demonstration activities [25]. Any attempt to understand and plan for a future transition to a hydrogen energy system must rely on some understanding of the processes of technological systems [26]. Social marketers attempt to bridge the education-policy divide by creating incentives, or rewards that encourage and reinforce behaviour change. However, these efforts face the not inconsiderable difficulty of making deferred and uncertain rewards as attractive as immediate pleasures [27]. Philosophy and a business strategy, supported by a technology platform, business rules, processes and social characteristics, engages the customer in a collaborative conversation in order to provide mutually beneficial value in a trusted & transparent business environment [28]. It would be difficult to promote hydrogen, if distributions have had two independent systems, like petrol vs. hydrogen [29]. In authors situation hydrogen system can be integrated in existing system and gradually moved to independency. The lack of hydrogen infrastructure remains unsolved for macro level, but in micro level like University of Latvia campus integrated hydrogen power system can provide infrastructure demanded.

Empirical Research Results

University as Organization should choose economically viable long term energy consumption by promoting sustainable development as well as science development. That is possible, renewable energy technologies will be integrated in the campus energy system. The faculties of natural sciences imply implementing innovative building technologies to provide with electricity Academic Centre of Natural Sciences (include Biology, Chemistry, Geography and Earth Sciences – research laboratories, lecture-rooms, professor rooms etc., 200 researchers and professors, 2000 students. Social-economical survey via questionnaire was performed in February and March, 2012 to explore readiness of the society to use renewable technologies in the University campus. All respondents are related to University of Latvia (students, professors, researchers, and possible future students, etc.). Faculties intended to locate in Academic Centre of Natural Sciences participated in the survey. In the survey were questions on respondent's environmental knowledge, attitudes, behaviour as well as information on socio-economic characteristics of respondents. Including, questions about the project acceptance, scientific value and safety issues. Some descriptive statistics (arithmetic mean, mode, median and indicators of variability) are reflected in table 1.

As the survey results show (table 1), most of the respondents are very positive (with surprisingly high evaluations) for renewable technology implementation in University of Latvia Academic Centre of Natural Sciences (Mean = 8.49, Std. Error of Mean = 0.107, Mo = 10, Me = 9.00). Also appreciated statement: Could hydrogen be used for electricity, heat production, and for energy storage in these renewable energy technologies? (Mean = 7.60, Std. Error of Mean = 0.106, Mo = 10, Me = 8.00) this answer shows good level of knowledge among respondents. Survey participants agreed that access to renewable energy technologies in the campus area during studies is an important part of student practical training – one of highest evaluations (Mean = 8.30, Std. Error of Mean = 0.099, Mo = 10, Me = 9.00). Statement about respondent knowledge level on hydrogen usability as energy resource has been evaluated above average (Mean = 6.57, Std. Error of Mean = 0.140, Mo = 10, Me = 7.00). Safety is considered as most concerning issue do to the results for statement: I am positively convinced for hydrogen energy safety. It has been evaluated in average (Mean = 6.44, Std. Error of Mean = 0.120, Mo = 5, Me = 7.00) that means hydrogen safety issues still are topic for discussion in society. By opinion of respondents, government incentives must be attracted for renewable energy technology implementation in University of Latvia Academic Centre of Natural Sciences (Mean = 7.65, Std. Error of Mean = 0.122, Mo = 10, Me = 8.00).

Table 1

Main statistical indicators of responses on the project acceptance, necessity and safety issues in Latvia

		Renewable energy techno-logies should be imple-mented in University of Latvia Academic Centre of Natural Sciences	Could hydrogen be used for electricity, heat production, and for energy storage in these renewable energy techno-logies?	Access to renewable energy technologies in the campus area during studies is an important part of student practical training	I am infor-med for hydro-gen usa-bility as energy resour-ce	I am posi-tively con-vinced for hydro-gen energy safety	Government incentives must be attracted for renewable energy technology implemen-tation in University of Latvia Aca-demic Centre of Natural Sciences
N	Valid	364	359	363	364	362	364
	Missing	0	5	1	0	2	0
Mean		8.49	7.60	8.30	6.57	6.44	7.65
Std. Error of Mean		0.107	0.106	0.099	0.140	0.120	0.122
Median		9.00	8.00	9.00	7.00	7.00	8.00
Mode		10	10	10	10	5	10
Std. Deviation		2.037	2.013	1.878	2.678	2.291	2.336
Variance		4.151	4.051	3.527	7.171	5.250	5.456
Range		9	9	9	9	9	9
Minimum		1	1	1	1	1	1
Maximum		10	10	10	10	10	10

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

Source: Survey performed by authors in February and March 2012, n=364

It can be concluded that in average academia and students expressed positive attitude towards hydrogen energy and demonstrated good knowledge level about hydrogen technologies and are willing to accept and support technology implementation in University of Latvia Academic Centre of Natural Sciences. For almost all statements most chosen evaluation was the highest – 10, characterised by mode, except for the statement "I am positively convinced for hydrogen energy safety", where the modal evaluation was 5. For this statement the full range of responses were covered (except 0, it means that all respondents had information on analysed issues and expressed their attitude. Table 2 reflects distribution of the answers for statement: Renewable energy technologies should be implemented in University of Latvia Academic Centre of Natural Sciences.

Table 2

Distribution of answers for statement: *Renewable energy technologies should be implemented in University of Latvia Academic Centre of Natural Sciences* by faculty

Evaluation scores	Faculty represented					Total
	Faculty of Biology	Faculty of Physics and Mathematics	Faculty of Geography and Earth Sciences	Faculty of Chemistry	Riga Technical University	
1	4	0	0	1	0	5
3	1	0	0	1	0	2
5	2	2	4	5	0	13
6	1	3	0	3	0	7
7	8	8	1	6	0	23
8	7	11	12	13	0	43
9	9	7	9	14	0	39
10	46	17	31	33	1	128
Total	**78**	**48**	**57**	**76**	**1**	**260**

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

Source: Survey performed by authors in March 2012, n=260

Table 3 reflects distribution of the answers for statement: *Renewable energy technologies should be implemented in University of Latvia Academic Centre of Natural Sciences*. Results shows that gender distribution in answers for this statement are 52.6% female and 47.4% male. Total valid answers were 361. Females most often evaluated the statement higher than males.

Table 3

Gender Distribution of responses on statement *Renewable energy technologies should be implemented in University of Latvia Academic Centre of Natural Sciences* by gender

Evaluation scores	Gender		Total
	Female	Male	
1	5	3	8
3	1	4	5
4	3	2	5
5	10	9	19
6	8	6	14
7	13	19	32
8	25	32	57
y	35	17	52
10	90	79	169
Total	**190**	**171**	**361**

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

Source: Survey performed by authors in March 2012, n=361

One of most positive evaluated statements was the importance of student access to technology for educational purposes. Interesting to point out that actual students and future students strongly agree more often than academy and teachers – see Table 4. This could mean that practical training is more important from student point of view, than academia.

Table 4

Distribution of responses on statement: *Access to renewable energy technologies in the campus area during studies is an important part of student practical training* by position

Evaluation scores	Current status						Total
	Student	Academy	Pupil	Teacher	Parent	Other	
1	1	0	0	0	0	1	2
2	1	0	0	0	0	0	1
3	0	0	3	0	0	0	3
4	2	0	4	0	0	0	6
5	6	0	9	0	1	0	16
6	8	0	2	0	1	0	11
7	23	1	6	1	0	1	32
8	33	1	12	4	2	2	54
9	25	2	12	2	3	1	45
10	65	1	26	3	4	0	99
Total	**164**	**5**	**74**	**10**	**11**	**5**	**269**

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

Source: Survey performed by authors in March 2012, n=269

Some descriptive statistics on physical related statements about hydrogen as energy carrier and CO_2 binder are reflected in table 5.

Table 5

Descriptive statistics on statements related to physical knowledge about hydrogen

		Hydrogen as energy carrier can be used to accumulate Solar and wind energy	Hydrogen can be used to bind CO_2
N	Valid	258	259
	Missing	12	11
Mean		1.57	1.52
Median		2.00	2.00
Mode		2	2
Std. Deviation		0.639	0.501
Variance		0.409	0.251
Range		7	1
Minimum		1	1
Maximum		8	2

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

Source: Survey performed by authors in March 2012, n=259

The statement Hydrogen as energy carrier can be used to accumulate Solar and wind energy have got extremely low evaluation (Mean = 1.57, Std. V = 0.140, Deviation = 0.639, Mo = 2, Me = 2.00). Results prove that most of respondents do not have enough knowledge on hydrogen as energy carrier best practices in the world and physics related knowledge for hydrogen thus previous answers were given without physics effects.

Conclusions

Hydrogen usage in stationary and mobile applications without damaging emissions is highly regarded. Hydrogen technologies have potential to convert fossil fuel systems to renewable systems.

Public acceptance and knowledge expression is significant to implement renewable energy projects.

Main results of survey show that majority of the respondents are very positive for renewable technology implementation idea in the University of Latvia Academic Centre Of Natural Sciences.

Teaching staff and students have expressed good knowledge level about hydrogen technologies and are willing to accept and support technology implementation in the UL Academic Centre of Natural Sciences.

Nevertheless many respondents are highly concerned about safety issues of the renewable energy technology. This means that safety education must be implemented and discussed more with society.

Students and future students strongly agree that access to renewable energy technologies in the campus area during studies is an important part of student practical training.

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