Effects of serious game EnerCities on energy-related attitudes and behaviours

Deliverable D9.3

Final version

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COLOPHON

Report of IEE2007-project EnerCities

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CONTENT

1. INTRODUCTION

1.1. Focus of this document

This document (deliverable D9.3) describes the results related to specific research activities to measure the differences of energy-related awareness, attitudes and self-reported behaviours between students who played EnerCities and students who did not. Research activities are performed by Qeam BV (EnerCities consortium member; http://www.Qeam.com) with the support of University of Twente (http://www.UTwente.nl) and the EnerCities consortium partners. Research approaches and results are also worked out in papers (Knol & De Vries, 2010; Knol & De Vries, 2011; De Vries & Knol, 2011) altogether representing deliverable D9.4.

Chapter 1.2 introduces the project EnerCities and the online serious game EnerCities. Chapter 2 gives high-level information regarding household energy consumption and conservation. Reflections about games on sustainability and energy saving are given in chapter 3. Chapter 4 discusses the research activities and results and specifically the measured effects of EnerCities gameplay on energy-related awareness, attitudes and self-reported behaviours. The last chapter points conclusions.

1.2. Online serious game EnerCities

Project EnerCities offers an online computer game to educate young people about energy-related aspects (e.g. energy consumption, energy savings, renewable energy, energy & environment). European rollout of the computer game - accompanied with an education toolbox - was facilitated among more than 50 education institutions. Events were organized to share experiences. The duration of the project was 36 months in order to maximize the rollout and the usage of the project's infrastructure. The project is co-funded via the European Commission Intelligent Energy Europe programme (http://ec.europa.eu/energy/intelligent).

Home page Screenshot of level 2

Figure 1 Screenshots of EnerCities game

The serious game EnerCities challenges players to build a sustainable city. It runs online (http://www.EnerCities.eu) and on Facebook (http://apps.Facebook.com/EnerCities) and is available in six EU languages. The game starts with a small village and a small piece of land to build on. A drag-and-drop interface lets players build structures (e.g. residential and industrial areas, renewable / non-renewable energy sources,

green zones) to expand the city. The gamer needs to balance *People*, *Planet* and *Profit* while supplying the growing city with sufficient electricity, implementing energy conservation and CO_2 emission measures and minimizing fossil fuel use. Each player's decision influences the scores for people, planet and profit. When done well, players receive more potential city space to expand their city and to utilise extra available game options. The game allows players to execute several strategies and see the results of their actions on the long term. The duration of the game is approximately 15-45 minutes, depending on the player's strategies. Playing the game on Facebook gives players additional functionalities to share scores and experiences with Facebook friends. In this way, involving the player's social network could lead to intensified competitions among youngsters to break the EnerCities high scores.

EnerCities was awarded the title of "Best Learning Game 2010" by the European platform "ENGAGE Quality Awards"; this platform "recognise[s] excellent contributions from teachers, educational practitioners, game developers and producers to the quality of game-based learning". The award for Best Learning Game focuses on "digital games for teaching and learning that stand up to methodological, didactical and technical standards". In addition, the Dutch game industry awarded EnerCities with the title "Best Online Game 2010".

2. HOUSEHOLD ENERGY CONSUMPTION AND CONSERVATION

2.1. Energy consumption in our society

The current energy consumption in our European society (EU27) is approximately 1170 Mtoe (million tonnes of oil equivalent) on a yearly basis (figure 2; Eurostat, 2010). Figure 3 gives a projection of the energy requirements in the EU27 per fuel type (right) and a projection of the energy intensity of the EU27 in relation to GDP carbon intensity of the generated energy (left). Projections show that the energy requirements will grow substantially, especially those generated by renewable energy sources and gas. Although renewable energy kicks in, the carbon intensity of our energy consumption for the coming years lowers minimally.

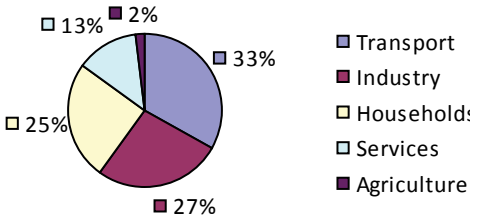


Figure 2 Total energy consumption distribution in 2008 of the EU27 countries (Eurostat, 2010)

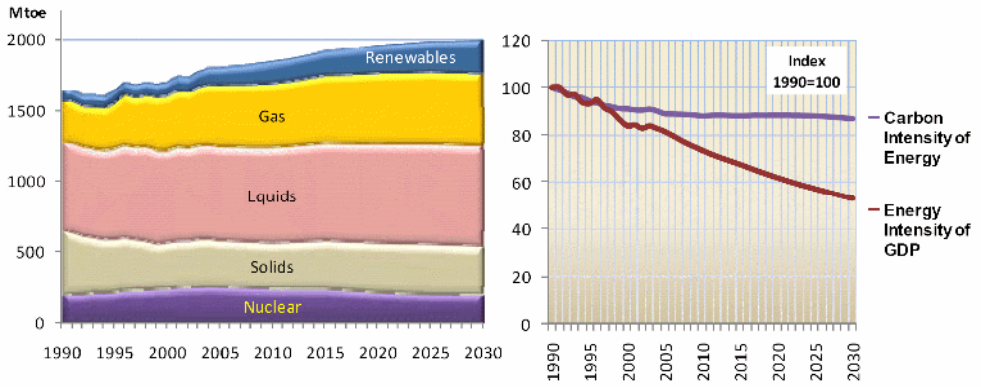


Figure 3 Energy requirements of EU27 by fuel (left figure) and energy and carbon intensity indicators of EU27 (right figure) (European Commission, 2008)

Renewable energy and reduction of energy consumption, and thus CO_2 emissions, have become focal points of energy and environmental policies worldwide. On a European level, the ambition is to substantially invest in and stimulate energy efficiency, as evidenced by Member States' expressed commitment to achieve a 20 % reduction in the consumption of primary energy by 2020 (European Commission, 2006a).

2.2. Household energy conservation

A considerable part of the total energy consumption, approximately 25 %, is related to household consumption (figure 2). Figure 4 (above) that during the period of 1998 to 2008 the electricity consumption per dwelling for electrical appliances and lighting increased in almost all EU27 countries. Explanations can be found in the increased availability of electrical appliances in each home. These trends counteract the overall energy efficiency improvements in the household sector during that same period, achieved for instance in space heating, water heating and cooking (figure 3; below).

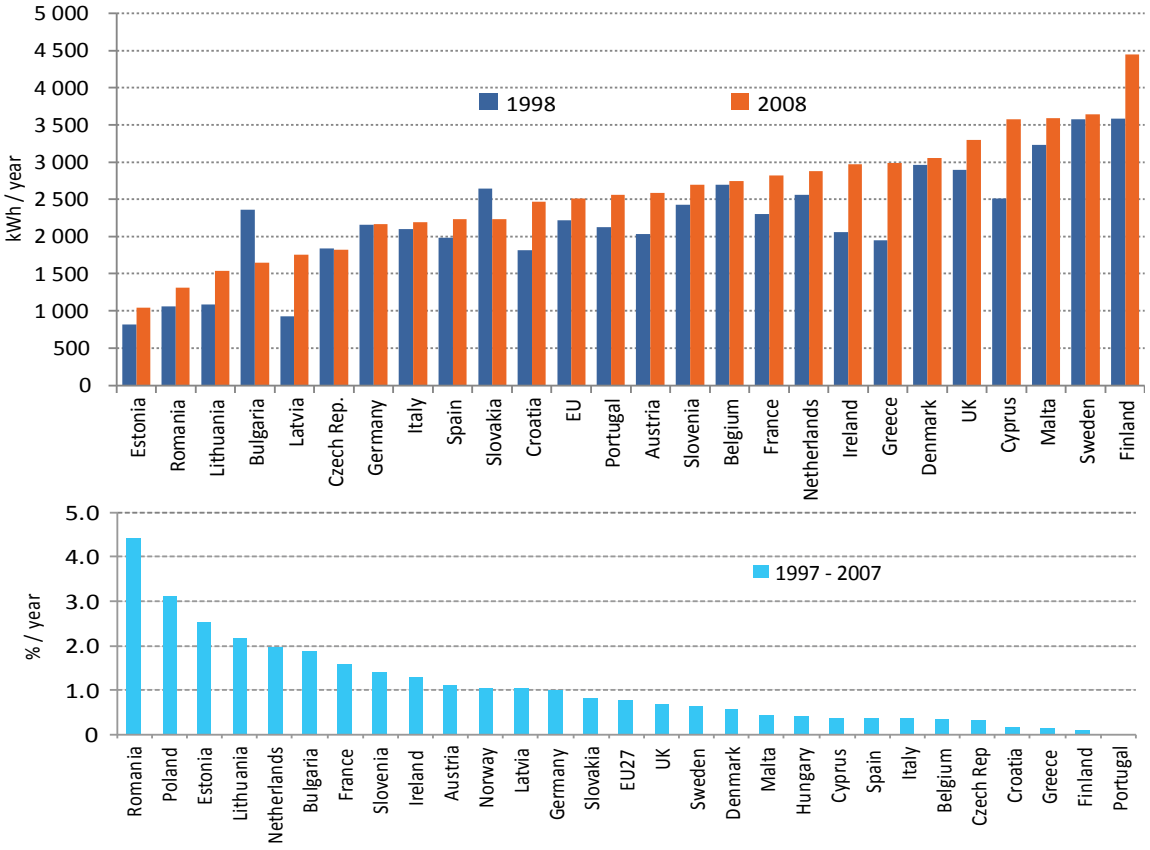


Figure 4 Above: electricity consumption per dwelling for electrical appliances and lighting (Odyssee, 2011); below: energy efficiency improvements in the household sector (Odyssee, 2011)

Focusing on household appliances and domestic lighting are cost-effective ways to achieve energy savings at household level (Bertoldi et al., 2000). Electricity consumption for standby in the residential sector in EU27 amounted to about 43 TWh in 2007 (Bertoldi & Atanasiu, 2009). It is suggested that this equivalent to a share in total residential electricity consumption of 5.4 %. Although current and future technology (e.g. double-paned windows, insulation technology, and energy efficient lighting) may reduce energy consumption by an estimated 30 % (Bertoldi et al., 2000), we should not overlook the role of consumer behaviour and psychology (cf. Herring, 2006). Influencing consumers to change their behaviour has a substantial energy-saving potential. In fact, some researchers suggest that focused attempts to do so may result in an energy reduction of at least 10 % (Darby, 2000; cf. Abrahamse et al., 2005).

2.3. Educate and inspire youngsters about sustainability and energy saving

In order to stimulate household energy conservation, education of youngsters is a very sound strategy, focusing on increasing awareness of the role of energy in our society and energy consumption at home, and influence their (future) energy-related behaviours (e.g. European Commission, 2004, 2006b). Policymakers therefore increasingly focus on youngsters to stimulate awareness of sustainability and energy saving. This is in line with policy and educational developments under the title “Education for Sustainable Development” (ESD) (Wade & Parker, 2008).

At schools across Europe substantial attention is devoted to sustainability, renewable energy and energy efficiency. Some projects are initiated locally, while others are more embedded in regional, national or European initiatives or frameworks like the initiative U4Energy (figure 5), funded by the European Commission Intelligent Energy Europe Programme. This pan-European competition for both primary and secondary schools includes three competition categories: energy efficiency measures at school, best pedagogical actions to raise awareness on efficient energy use, and best awareness raising campaign on energy efficiency. Besides regular education programmes, new and innovative educational concepts are being developed to reach youngsters and involve them in sustainability and energy efficiency (e.g. Gustafsson et al., 2009). One of these concepts is serious gaming.

Figure 5 Home page U4Energy; http://www.U4Energy.eu

3. COMPUTER GAMES ON SUSTAINABILITY AND ENERGY SAVING

3.1. Digital natives

A considerable part of the energy consumers of tomorrow are today's secondary school students. Media channels and institutes, e.g. schools, offer excellent possibilities to inform and inspire youngsters about sustainability and energy saving. Nevertheless, non-interactive media channels and traditional education programmes to some extent seem to mismatch with the information-processing styles, communication and social routines of today's young people. Having grown up in a world of internet, mobile phones, online social networks and computer games, they are seen as 'digital natives' (Bennett et al., 2008). For example, Roberts & Foehr (2008) report that 15- to 18-years olds from the United States played computer games for approximately half an hour per day in 2004, and recent figures show an increase to more than an hour (Rideout et al., 2010). This is why education institutes would like to find ways to modernise their methods and instruments for knowledge transfer, students' skill development and enhancement.

3.2. Computer games and serious games

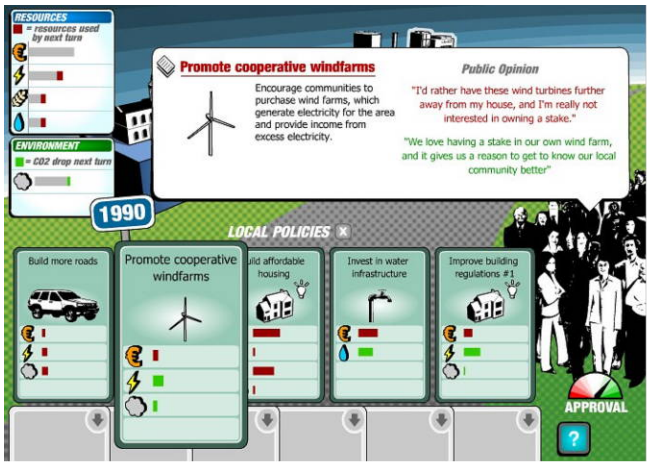
Serious games, being a specific segment of computer games, seem to be suitable learning tools due to their engaging character (e.g. Annetta, 2008; Ratan & Ritterfeld, 2009). Defined as "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (Zyda, 2005; p. 26), they go beyond traditional 'game-based learning' (Prensky, 2007) in that they also have the ambition to incorporate fun and enjoyment in the gaming experience while the learning elements are less overtly positioned in the game. An effective serious game should take into account intrinsic motivational ingredients like challenge, curiosity, fantasy, and control (Rieber, 1996). Table 1 gives an impression of the difference between computer games for entertainment and serious games.

Aspect	Entertainment games	Serious games
Task versus rich experience	Rich experiences preferred	Problem solving in focus
Focus	To have fun	Important elements of learning
Simulations	Simplified simulation	Assumptions necessary for workable simulations
Communication	Communication is often perfect	Should reflect natural (i.e. non-perfect) communication

Table 1 Differences between entertainment games and serious games (Susi et al., 2007)

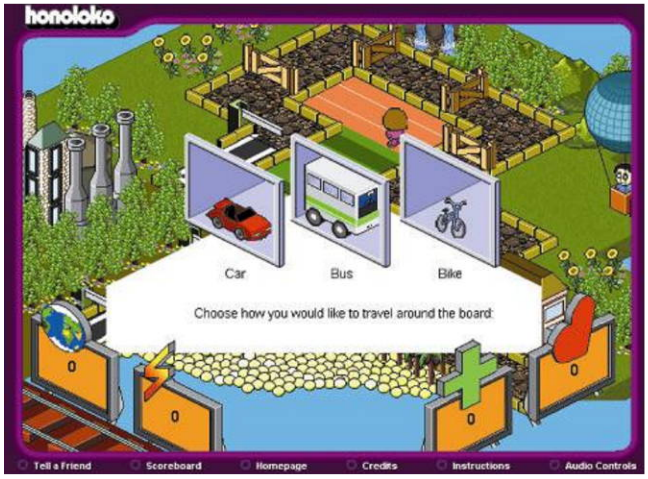
3.3. Examples of computer games on sustainability and energy saving

Computer games dealing with sustainability, energy efficiency and renewable energy have multiplied in recent years. Examples are BCC Climate Challenge, CEO2 Climate Game, Honoloko, MiniMonos, Stop Disasters!, and Turn it All Off (figure 6). Appendix 1 gives more information about these (available) games.



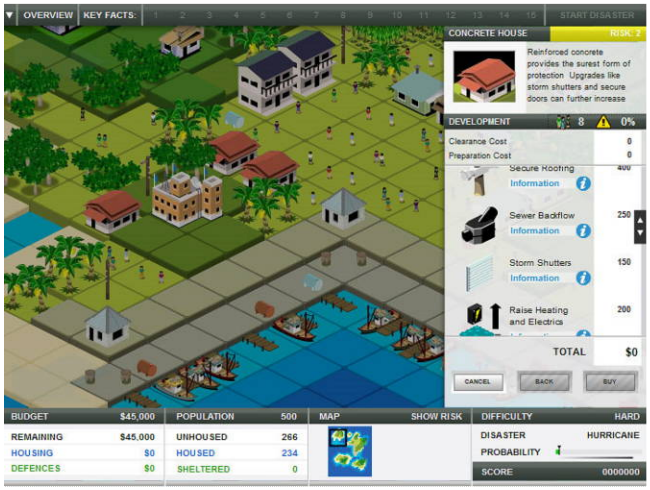
BBC Climate Challenge

CEO2 Climate Game

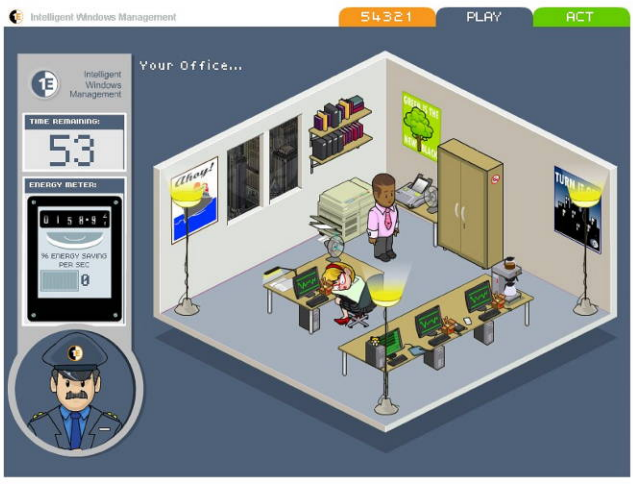


Honoloko

MiniMonos



Stop Disaster!



Turn It All Off

Figure 6 Screenshots of various computer games dealing with sustainability, renewable energy or energy efficiency

All these games have the ambition to inspire youngsters about social, economic and technological challenges related to sustainability, renewable energy or energy efficiency. In our view, many of these games have not sufficiently emphasised fun and enjoyment aspects in their game concepts. Ideally, however, fun and enjoyment should be paramount if games are to be influencing awareness, attitudes and behaviours. This indicates also the need for criteria to evaluate these game-based learning tools (Liu & Ding, 2009).

4. EFFECTS OF ENERCITIES GAMEPLAY

4.1. Theory of Planned Behaviour

Attempts to change energy-related behaviour of youngsters via a game-based interventions like EnerCities have their roots in theories like the Theory of Planned Behaviour (TPB, Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980). TPB postulates that *Behaviour* / *Behavioural Intentions* are governed by the interplay of a number of different psychological constructs. First among these is the *Attitude Towards Focal Behaviour* and constitutes the degree to which this particular behaviour is valued: positively or negatively. Another influential variable is the *Subjective Norm:* the degree to which people think their social environment likes or wants them to perform the particular behaviour. Finally, whether or not behaviour will actually be performed also depends on the degree to which people believe they are able to perform the focal behaviour: *Perceived Behavioural Control*. In short, a positive attitude towards a particular behaviour in combination with positive subjective norms and a higher degree of perceived control will likely positively influence a person's intention to perform that behaviour, and increase the likelihood that the behaviour will be performed (figure 7).

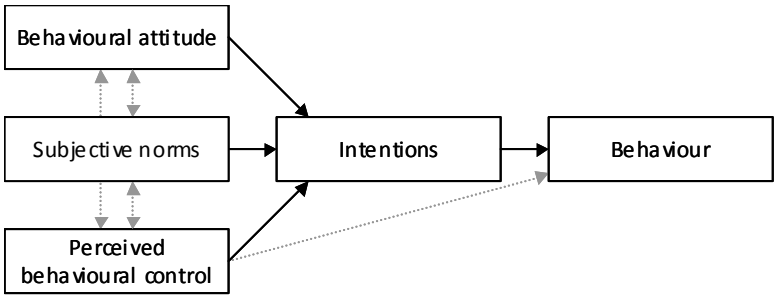


Figure 7 Schematic presentation of main parts of the Theory of Planned Behaviour

4.2. Research design and participants / respondents

Main purpose of the EnerCities' research is to measure an effect of EnerCities game on the energy-related attitudes and self-reported behaviours of youngsters. In other words: does EnerCities change the energy-related attitudes and self-reported behaviours of the EnerCities players? To test the intervention effectiveness of the game a between-participant design was adopted. Thus, measurements of attitude and behavioural intensions as a result of the intervention (in the so-called experimental group) are compared to measurements in the control group.

Looking at the every day life setting of youngsters, several specific energy-related behavioural (intention) variables form the core of the analysis: e.g. lowering the thermostat, turning off lights when leaving an unoccupied room, switching off the computer when it is not in use, standby, buying household appliances that are more energy efficient, and taking shorter showers. These main dependent variables were chosen taking into account the Theory of Planned Behaviour (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980). Attitudes towards behavioural intentions, social norms and perceived behavioural control were measured.

During the experiment experimental and control groups were mostly created at the level of individual schools joining the EnerCities initiative. Teachers who indicated to use the EnerCities game in the classroom or during a special event were asked to involve control group students e.g. by splitting the participating class in half or from parallel classes in the same cohort / year or from classes one year lower or higher than the class joining

the experimental groups. Teachers were strictly instructed not to mention EnerCities to the control group students in order to minimize bias effects. Additionally, it was requested to make the two groups as homogeneous as possible in terms of number of students, age, gender composition or education level. Questionnaires were composed in six European languages (Dutch, English, German, Greek, Slovenian, and Spanish) and placed on http://www.EnergyQuestionnaire.eu. Both, students from the experimental and control group filled in the same online questionnaire. The online questionnaire was so organised that control group students noticed minimally the fact that EnerCities was used as an experimental tool. Appendix 2 presents the questionnaire and related aspects like a screenshot of the homepage of the questionnaire and images used in the questionnaire.

Table 2 Number of questionnaire respondents (with valid data) (left) and respondents participating in the control and experimental groups (right)

Country	Questionnaire respondents*			Control and experimental group respondents		
	Overall respondents (unfiltered, unsorted)	Respondents with valid data (filtered, sorted)	Percentage of respondents with valid data	Control group respondents (filtered, sorted)	Experimental group respondents (filtered, sorted)	Percentage of experimental group respondents from total
Germany	33	-**	-	-	-	-
Greece	89	68	76,4%	34	34	50,0%
Netherlands	370	313	84,6%	166	147	47,0%
Slovenia	172	121	70,3%	26	95	78,5%
Spain	112	85	75,9%	49	36	42,4%
UK	110	64	58,2%	53	11	17,2%
Totals	*886*	*651*	73,5%	*328*	*323*	*49,6%*

* Data collection period: February 2011 – May 2011

** At the time of data analysis the German data set was not fully available yet.

From February 2011 towards the end of May 2011, data had been collected from more than 800 respondents from various European countries. However, some respondents (both from the experimental and control group) had stopped answering questions well before reaching the end of the questionnaire. In addition, some respondents had filled out parts of the questionnaire with invalid data (e.g., scoring each single item the same), and a few had filled it out multiple times. After omitting these, 653 cases remained, 325 related to the experimental group and 328 being part of the control group (table 2).

The sample used for our analyses comprised 36 % females and 64 % males. The average age was 16.40 years (*SD* = 3.21). The country distribution of the experimental group respondents was: Greece 10,5 %, Netherlands 45,5 %, Slovenia 29,4 %, Spain 11,1 %, and UK 3,4 %. Characteristics of the control group: 39 % females / 61 % males; average age 16.51 (*SD* = 2.89); country distribution: Greece 10.4 %, the Netherlands 50,6 %, Slovenia 7,9 %, Spain 14,9 %, and UK 16,2 %. In general, the experimental and control groups are similar in terms of gender, and average age. In the experimental group Slovenian respondents are stronger present than in the control group.

4.3. Playing games on energy saving or renewable energy

Observations during the rollout of EnerCities showed that for teachers (mostly secondary schools and vocational education) gaming in the classroom and serious gaming are (still) new phenomena. This is in line with the study of the National Foundation for Educational Research (2009). It found that in a survey of 735 teachers (secondary schools) in 2009, 30 % said they had used games (designed primarily for entertainment) in the classroom for educational purposes and 58 % would be willing to do so in the future.

Table 3 Respondents' reaction on the question what kind of computer game dealing with the topic energy saving or renewable energy have they played, including differences between EnerCities players and non-EnerCities players.

"Green" game usage among students who never played EnerCities*	"Green" game usage among students who played EnerCities**
95,5 % never played an energy game	92,9 % never played another game
0,4 % ElectroCity	3,1 % ElectroCity
0,3 % BBC Climate Challenge	0,6 % BBC Climate Challenge
0,5 % other games	1,2 % other games
3,3 % unable to specify a played game	2,2 % unable to specify a played game

* N = 757; average age 18.3 years; 33 % female / 67 % male

** N = 322; average age 15.1 years; 45 % female / 55 % male

Table 3 indicates that a widespread usage of some sort of game dealing with the topic energy saving or renewable energy by secondary school graduates who never played EnerCities is not common yet as reported by Knol & De Vries (2011): only a fraction (4.5 %) of the respondents indicated that he/she had played some sort of game dealing with the topic energy saving or renewable energy. These findings are similar to those in the group who did play EnerCities (figure 8).

Figure 8 Students playing EnerCities (Athens, Greece and Nijmegen, the Netherlands)

4.4. Effects of EnerCities on environmental and energy awareness

We tested the differences in awareness concerning environmental and energy-related issues between the experimental group and the control group. To test whether playing the EnerCities game had increased awareness about energy conservation issues, as opposed to the control condition in which the game had not been played, scores on five awareness items were inserted in a multivariate analysis of variance: 1) I am

interested in learning more about energy saving and 'green' energy; 2) I am concerned about the environment; 3) I am aware of the linkages between economy, energy usage and environment; 4) I am aware that environment is more important than economy; and 5) I am aware that I should lower my own energy usage. This resulted in a significant multivariate effect (F (5, 647) = 6.58, p < .001). Table 4 shows that for each of the five items a higher awareness score was found for the experimental group compared to the control group. Univariate tests, also displayed in table 4, indicated that for each item this difference was highly significant. These results clearly show that playing EnerCities increases the awareness on energy-related and environmental-related issues.

Table 4 Means and standard deviations of environmental awareness for the experimental and control group, and significance of their differences (7-points scale; higher scores indicate more positive awareness)

	Experimental Group*		Control Group*		Significance	
	M	*SD*	*M*	*SD*	*F (1, 651)*	*P***
I am interested in learning more about energy saving and 'green' energy	5.02	1.79	4.38	1.89	19.67	< .001
I am concerned about the environment	5.35	1.55	4.82	1.62	18.54	< .001
I am aware of the linkages between economy, energy usage and environment	5.00	1.51	4.39	1.53	26.36	< .001
I am aware that environment is more important than economy	5.06	1.56	4.59	1.73	13.25	< .001
I am aware that I should lower my own energy usage	5.24	1.79	4.81	1.72	9.76	< .002

* Experimental Group N = 325; Control Group N = 328; data gathering period: February 2011 – May 2011

** p < .05 is significant

4.5. Effects of EnerCities on energy saving attitudes

To test the intervention effectiveness of the game on energy-related attitudes, measurements of the following attitudes of the experimental and control group were compared: 1) Attitude towards saving energy at home; 2) Attitude towards switching off lights in unoccupied rooms; 3) Attitude towards turning off TV instead of using standby; and 4) Attitude towards taking shorter showers.

Table 5 shows the research results and indicates that playing the EnerCities game resulted in higher attitudes towards performing specific energy-related behaviours as indicated by a significant multivariate test of significance (F (4, 648) = 2.76, p < .03). The univariate tests showed participants' attitudes towards saving energy at home, towards turning off the TV, and towards taking shorter showers significant differences (table 5).

No significant differences regarding attitude towards switching off lights in unoccupied rooms were found. However, this attitude is already relatively high in both the experimental and control condition. This could be related to the salience of energy efficient lighting as a result of the discussions in popular media in recent years about the inefficiency of incandescent light bulbs, and the resulting phasing out of these light sources. Possibly, this may have caused higher a-priory attitudes towards light regulation as a means to reduce energy, leaving little room for an additional increase by means of our experimental manipulation.

Table 5 Means and standard deviations of attitudes towards energy-related behaviours for the experimental and control group, and significance of their differences (7-points scale; higher scores indicate more positive awareness)

	Experimental Group*		Control Group*		Significance	
	M	*SD*	*M*	*SD*	*F(1, 651)*	*p*
Attitude towards saving energy at home	6.19	1.16	5.96	1.30	5.59	.018
Attitude towards switching off lights in unoccupied rooms	6.31	1.11	6.18	1.11	2.06	Ns**
Attitude towards turning off TV instead of using standby	5.95	1.28	5.73	1.44	4.44	.036
Attitude towards taking shorter showers	4.82	1.71	4.41	1.82	8.90	.003

* Experimental Group N = 325; Control Group N = 328; data gathering period: February 2011 – May 2011

** Ns is not significant

4.6. Self-reported energy-related behaviours

A multivariate analysis of variance was conducted, with the following four self-reported energy-saving behaviours as dependent variables: 1) Switching off lights in unoccupied rooms; 2) Turning off the TV instead of using standby; 3) Taking shorter showers; and 4) Switching off my PC after use. EnerCities experience was labelled as independent variable. The analysis showed a significant multivariate effect of EnerCities experience (F (4, 647) = 5.60, p < .001, Wilks' Lambda = .98). Univariate tests revealed that all four self-reports were significantly higher in the experimental condition compared to the control condition (see table 6).

Table 6 Means and standard deviations of self-reports on energy-saving behaviours (7-points scale; higher scores indicate higher occurrence of behaviours)

	Experimental Group*		Control Group*		Significance**	
During the past two weeks I have saved energy by…	*M*	*SD*	*M*	*SD*		*p*
… switching off lights in unoccupied rooms	5.90	1.76	5.58	1.80		.02
… turning off the TV instead of using standby	5.17	2.19	4.80	2.29		.03
… taking shorter showers	4.16	2.18	3.42	2.09		.001
… switching off my PC after use	4.92	2.20	4.42	2.19		.002

* Experimental Group N = 325; Control Group N = 328; data gathering period: February 2011 – May 2011

** Ns. = not significant

4.7. Mediation effect of attitudes on self-reported energy-related behaviour

To test whether attitude towards energy saving mediates the effect of the experimental manipulation on reported energy-related behaviour (see Theory of Planned Behaviour and figure 7), a series of regressions was conducted based on the approaches of Baron & Kenny (1986). First, a regression test was performed with the

proposed mediator, attitude, as a dependent variable and EnerCities experience as independent variable. This resulted in a significant B-weight of 0.25 (see left part of table 7), indicating that playing EnerCities caused students to report more positive attitudes towards saving energy. Next, a regression analysis was conducted with self-reports on performing energy-related behaviours as dependent variable and EnerCities experience as independent variable. The test shows a direct effect of dependent variable on the independent variable (B = 0.33; see middle part of table 7), indicating that playing EnerCities caused students to report that they perform energy-saving behaviours more often.

Inserting attitude towards energy saving as an additional variable in a regression test shows significant effect of attitudes on the dependent variable (B = 0.49), and resulted in a decrease in the B-weight of the direct effect from 0.33 to 0.25 (see the right part of table 7). The results of a subsequently performed Sobel test showed the indirect effect (i.e., the effect of the manipulation on behaviour via attitudes) to be significant (Sobel z = 2.51, p < .05). The analyses presented here indicate that attitude towards energy saving operates as a 'mediator' on the self-reported energy behaviours (see bold arrows in figure 9). This is in line with the Theory of Planned Behaviour.

Table 7 Results of a test for mediation, with EnerCities experience as independent variable, Reported energy behaviours as dependent variable, and Attitude towards energy saving as proposed mediator.

	Effects on Attitude towards energy saving		**Direct effects on Reported energy behaviours**		**Indirect effects on Reported energy behaviours**	
Predictors	*B*	*t*	*B*	*t*	*B*	*t*
EnerCities experience	0.25	2.57**	0.33	2.50*	0.25	2.50*
Attitude towards energy saving	-	-	-	-	0.49	11.36***
Gender	0.39	3.93**	0.18	1.59^{NS}	0.02	0.16^{NS}
Subjective norm	-	-	0.41	11.47***	0.30	9.03**

* p < .05. ** p < .01. *** p < .001. Regressions testing the direct effect on the mediator incorporate *Gender* as additional predictor, those testing direct and indirect effects on the dependent variable incorporate *Gender* as well as *Subjective norm* (consistent with TPB, Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980).

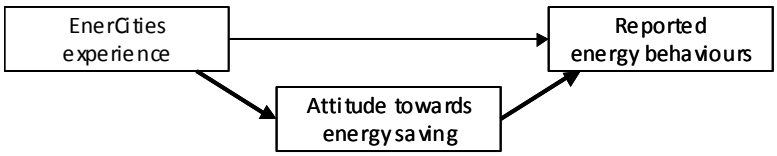


Figure 9 Attitude towards energy saving as 'mediator' on the self-reported energy behaviours

When focusing from research perspective on changing actual behaviour rather than self-reported behaviour, other factors should be taken into account in order to measure if self-reported behaviour correlates to the actual energy-behaviour at home like the degree to which behaviour is repetitive. Many studies have suggested that simple behaviour that occur in the household, such as light regulation and waste recycling, tend to become habitual when they are frequently performed (e.g. Ouellette & Wood, 1998; Aarts & Dijksterhuis, 2000) and are difficult to control by consciously formed intentions (De Vries, Aarts, & Midden, in press).

5. CONCLUSION

This document (deliverable D9.3) describes the results related to specific research activities to measure the differences of energy-related awareness, attitudes and self-reported behaviours between students who played EnerCities and students who did not. Approaches and results are also published in Knol & De Vries (2010), Knol & De Vries (2011) and De Vries & Knol (2011). Research activities are performed by Qeam BV with the support of University of Twente and the EnerCities consortium partners.

Energy saving at home and youngsters

Focusing on household appliances and domestic lighting are cost-effective ways to achieve energy savings at household level. Additionally, influencing consumers to change their behaviour has a substantial energy-saving potential. Therefore policymakers increasingly focus on youngsters to stimulate awareness of sustainability and energy saving. This is in line with policy and educational developments under the title "Education for Sustainable Development".

Digital natives and computer games on sustainability and energy

Non-interactive media channels and traditional education programmes to some extent seem to mismatch with the information-processing styles, communication and social routines of today's young people. Having grown up in a world of internet, mobile phones, online social networks and computer games, they are seen as 'digital natives'. Serious games, being a specific segment of computer games, seem to be suitable learning tools on sustainability and energy saving due to their engaging character. Computer games dealing with sustainability, energy efficiency and renewable energy have multiplied in recent years. Fun and enjoyment should be paramount if games are to be influencing awareness, attitudes and behaviours. Gaming in the field of energy conservation and sustainability is not common among students, as evidenced in our study by extremely low percentages of reported use, despite of a range of games being currently available.

Effect of EnerCities on energy-related awareness, attitudes and behaviours

Important part of the EnerCities research is to measure an effect of the EnerCities game on the energy-related awareness, attitudes and self-reported behaviours of youngsters. The theory of planned behaviour is used as research framework. To test the intervention effectiveness a between-participants design was adopted: compare differences between EnerCities players (experimental group) and control group. From February 2011 towards the end of May 2011, data had been collected from respondents from several European countries. This resulted in useful 653 cases (experimental group: 325; control group: 328).

Data analyses showed higher environmental and energy-related awareness ratings for students who had played EnerCities compared to those who had not. Secondly, attitudes towards energy-related behaviours in the household were generally more positive for students who had played EnerCities compared to the control group members. Thirdly, all four self-reports on energy-saving behaviours, namely switching off lights in unoccupied rooms, turning off the TV instead of using standby, taking shorter showers, and switching off the PC after use, were significantly higher in the experimental condition compared to the control condition. Last, attitude towards energy saving appears to be the 'mediator' on the self-reported energy behaviours and in line with the theory of planned behaviour.

The mean scores on the attitude and self-reported behaviour ratings were rather on the high end of the scale. It seems that saving energy in the household is something that our target group takes quite to heart.

As elaborated in De Vries & Knol (2011), it is interesting to see that the virtual city-planning in EnerCities (macro level planning and action) can have effects on 'real world' micro level behaviours of the students, namely self-reported energy-related behaviours in the household. Apparently, members of our target group experienced little difficulty in connecting the one with the other.

Regarding our study we should not exclude the possible positive influences of other (social context) variables than the game itself on awareness, attitudes and self-reported behaviours like inspired teachers. However, it can be said that the EnerCities game operated in many cases as the eye-catcher to involve and inspire students.

Food for thought for policymakers, education-related actors and (serious) games developers

The positive effects of the exposure to the EnerCities game suggest that serious gaming has the potential to change public opinion and behaviours. Our results are relevant for various stakeholders, such as policymakers with regard to digital education and environmental education, school managers, and last but not least, teachers to put the use of game-based learning on sustainability in educational programmes high on the agendas.

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APPENDIX 1: COMPUTER GAMES ON SUSTAINABILITY AND ENERGY

List of computer games

Below a list of computer games dealing with sustainability, renewable energy and energy efficiency. It is based on Games4Change website, Serious Games Classification website, and Liarakou et al. (2011). Remark: some games could not be available online anymore.

3rd World Farmer	Earth Hour	Food Force	Plan it Green
Age of Ecology	Eco Agents	Garbage King	Power Up
Ayiti: the cost of life	Eco Saviors	Go Goat Go	PowerScout
Barrel Blaster	EcoVille	Green Planet	Stop Disasters!
BBC Climate Challenge	EfficienCity	Honoloko	Toxic Blaster
CEO2 Climate Game	ElectroCity	Hutnet Island	Transform it!
Catchment Detox	Energuy	MiniMonos	Trouble Shooter
Clim'Way	Energy City	Mission BluePlanet	Turn It All Off
Copenhagen Challenge	Energy Footprint	Mission Lighting	Water Alert
Darfur is Dying	EnergyVille	Operation Climate Control	WindRacer
Disaster Watch	Errand Run	Operation Resilient Planet	

Screenshots of computer games on sustainability and energy

EnergyVille

EcoVille

ElectroCity

Eco Agents

Clim'Way

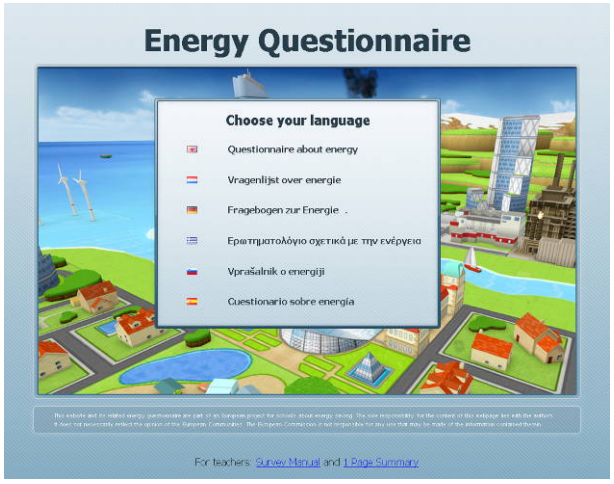
PowerScout

EfficienCity

3rd World Farmer

APPENDIX 2 : ENERCITIES ONLINE QUESTIONNAIRE

Screenshot of home page of EnerCities online questionnaire



Website : http://www.EnergyQuestionnaire.eu

Questionnaire

1	What is your email address?
2	Did you receive a survey code from your school? Yes / No / Don't know
3	Did you ever filled out this questionnaire before? Yes / No / Don't know
4	What is your age?
5	Are you male or female? Male Female
6	In which country do you live?
7	What is the name of your school?
8	What is the level of your current education?
9	Some statements. You can choose between "strongly disagree" and "strongly agree" Scientists protect citizens from possible environmental harm When scientists claim to minimize risks for me as a citizen, I believe that Scientists are concerned about the safety and health of people Scientists communicate openly about health risks for people Scientists can be trusted If we do not act now, we will experience an environmental disaster Nature is fragile and easily upset We are abusing the environment I do not believe that the environment has been severely abused by us People who say that we are near an environmental disaster are wrong People have to change their way of life to solve our environmental problems
10	What computer game on energy saving or "green" energy did you play? EnerCities on website

	EnerCities on Facebook BBC Climate Challenge ElektroCity Other None Don't know
11	What is your EnerCities User Name?
12	What is your Facebook User Name?
13	Some statements. You can choose between "strongly disagree" and "strongly agree" I am interested in learning more about energy saving and "green" energy I am concerned about the environment I am aware of the linkages between economy, energy usage and environment I am aware that environment is more important than economy I am aware that I should lower my own energy usage
14	Turning off lights when I leave an unoccupied room is something ... (scale: "strongly disagree" and "strongly agree") I do frequently I do automatically I do without having to consciously remember that makes me feel weird if I do not do it I do without thinking that would require effort not to do it that belongs to my daily routine I start doing before I realize I'm doing it I would find hard not to do I have no need to think about doing that's typically "me" I have been doing for a long time
15	During the past 2 weeks I saved energy at home by ... (scale: "strongly disagree" and "strongly agree") turning off lights when I leave an unoccupied room switching of my computer whenever I stop using it switching off the TV instead of putting it on standby taking shorter showers
16	In the future I intend to save energy at home by ... (scale: "strongly disagree" and "strongly agree") turning off lights when I leave an unoccupied room switching of my computer whenever I stop using it switching off the TV instead of putting it on standby taking shorter showers
17 / 18 / 19	Energy saving intentions: good / bad; pleasant / unpleasant; useful / not useful Saving energy at home is ... Turning off lights when I leave an unoccupied room is ... Switching off the TV instead of putting it on standby is ... Taking shorter showers is ...
20	Some statements. You can choose between "strongly disagree" and "strongly agree" My friends expect me to save energy at home My classmates expect me to save energy at home My housemates (like parents) expect me to save energy at home I am confident that I can save energy at home The decision to save energy at home is beyond my control Whether I save energy at home is entirely up to me Whether I save energy at home is entirely up to me

Various images used in the online questionnaire

In the online questionnaires images were used to make them more appealing and to lower the barriers for students to fill in the online questionnaire.

Image used for the question related to environmental awareness

Image used for question to test respondent about playing games about « green » energy etc.

Image used for the question dealing with environment and learning

Image used for the question about behaviour regarding turing of the lights

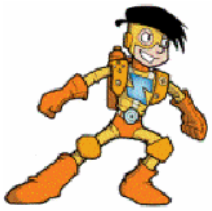


Image used for the question about future intentions regarding energy saving at home

Image used for energy saving intention question good / bad

Image used for energy saving intention question pleasant / unpleasant

Image used for the question dealing with peer influences and energy saving