LESSONS FROM TEACHING RENEWABLES: DOMESTIC AND CROSS-BORDER EDUCATION ACTION – LATVIAN SOLAR CUP

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ABSTRACT
From 2008 the education action – Latvian Solar Cup – is organized in University of Latvia. In this event, intended for pupils and students, the basics of one of the types of renewable energy – solar photovoltaic – are taught, and pupils from 5th to 12th classes are being taught, and students – those who teach. Lectures about renewable technologies are organized for pupils, and materials are distributed them for homework – to built up just a solar-powered vehicle. First Solar Cup became with an active participation of Czech colleagues (University of Ostrava) and their experience in organizing similar initiatives. Over the next few years the German colleagues from the University of Kassel (Germany) shared with their experience from German Solar Cup activities.
KEY WORDS: *renewable energy technologies, solar cup, education action, photovoltaics.*

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Introduction

Renewable energy resources and technologies are ready to meet our energy needs, probably only partly today and fully in the future (Hearps and McConnell, 2011: 58). They are cleaner and safer than coal, oil, also nuclear power. Use of them helps improve public health and energy security, as well as reduce the emissions of the primary global warming pollutant – carbon dioxide. Hydropower still represents the dominant source in renewable electricity generation, but has become less important during recent years. This technology accounted for 94 % of green electricity generation by 1990 while by 2008 its share had decreased to below 60 % (EU Working Document, 2011: 41). This is caused by strong development of emerging renewable energy technologies, such as wind, sun and biomass. However the Lithuania was the most dependent country between all 27 EU states of electricity import in 2010, and main reason of it was closing the Ignalina nuclear power plant (Paskevicius, 2011: 16). Net electricity import in Latvia constituted 12 % in 2010 (23 % in 2009) (CSB, 2010). Therefore the sooner we make the transition to renewable energy, the more our nations will benefit. Which prevents them from introduction? Renewable energy technologies are ready to be implemented,

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but increased public confidence, regulatory reforms, and a system of economic incentives for development of these resources are needed to make large-scale use of renewables a reality.

Education is an important first step in making this transition. Renewable energy is an ideal topic for middle and high school classrooms (Brown, 2008: 100). Renewable energy resources and technologies can be used to teach basic scientific principles: the Sun as renewable (in the scale of human life – infinite) source of Earth's energy, conversion of energy from one form to another, or electricity generation electricity storage and finally – a reasonable spending power. Natural science, physics, biology, chemistry teachers can incorporate activities on renewable energy into a unit on the environmental impact of energy use. Social studies teachers can select renewable energy activities that demonstrate how the marketplace and our political system govern the way energy decisions are made. But this applies not only to primary schools, as well as or even more importantly it is for future engineers in high schools. High schools struggle to get and keep students engaged in the study of science, while industry struggles to attract employees with advanced technical skills in renewable energy technologies. As it is mentioned by Brown (2008:100), progressive teachers and lecturers see a great opportunity to combine the growing national interest in renewable energy with research science and hands-on skills to provide a truly integrated, contextual curriculum to engage pupils and students:

- Renewable energy provides a political, economic and technical framework for the study of scientific concepts and methodology;
- Renewable energy utilization rests on the development of advanced technical skills in engineering research and design, electrical power production, storage, transmission and utilization, manufacturing, transportation modeling, urban planning and design;
- The translating of scientific concepts into working physical models offers unparalleled opportunities for students to practice creative and critical thinking, and to problem-solve in a tangible context.

In this article we summarize the experience in organizing Latvian Solar Cups for pupils from Latvia's schools in period from 2008 to 2011.

1. Goal and objectives of Latvian Solar Cup

The goal of activity is to understand the Sun as an energy source and an energy resource, as well as to acquire primary knowledge about technologies to collect energy from the Sun and to put it in use. Next objectives are set and realized every year in one-day event, which usually falls on a Saturday in mid-May:

1. To gain knowledge about the energy from the Sun and ways to harvest it, the fundamentals of photovoltaic devices, the implementation of renewable energy technologies in Latvia, Europe, the World.
2. To design and build car/boat/plane small prototype which can perform following tasks:
   - 2.1 In the Speed Class the car must drive the given distance (8–10 m) as quick as possible using only currently (on the competition day) available Sun energy;
   - 2.2 Cars in the Strength Class must drive the given distance with relief (artificial grass with small hills, 6–8 m) as quick as possible using only currently available Sun energy;
   - 2.3 The boats must move as quickly as possible the distance (10–20 m) in specially arranged pool using only currently available Sun energy;
   - 2.4 The plane must stay in the air at least 10 seconds or has to make the furthest flight after running start on horizontal ramp, using only currently available Sun energy.

2. Practical realization

The one of the first tasks of the Solar Cup organization has to figure out workable tasks for pupils aged from 12 to 18 years. Organizing 1st Latvian Solar Cup we were modest, and the student team, consisting of up to 3 participants were given only the task to build a small toy car, whose engine is powered by solar battery. To create a vehicle which could then participate in the race should use a constant size solar cells. Since the solar cells are already experiencing a third, even fourth generation, each of which has its own special technology and the different technical parameters, it is clear that all partner teams should have the same type and same area solar cells. Photovoltaics is a technology for converting light directly into electricity (renewables are Ready, 2003). Most photovoltaic cells have two layers of "semiconductor" material – the same material used in computer chips. When light hits the photovoltaic cell, electrons travel from one layer to the other, creating a voltage (or charge) that can power an electrical device. Photovoltaic cells (also called PV or solar cells) were first developed to power space satellites. Technical advances have steadily increased PV cell efficiencies, and their cost has dropped significantly. Solar cells are widely used in calculators and for remote power applications not connected to an electricity grid (such as rural villages, communications relays, and emergency lights, signs, and telephones). They are not yet economically competitive for large-scale electricity generation.

No one measure can not be organized without the financial investment, and, reflecting on the event-building tactics, we decided that the most important thing is to invest in solar cells, small electric motors and fans. Purchased parts are shared equally by each team, which has applied for, and sent to their addresses. Encapsulated solar modules SOL2 are made of interconnected photovoltaic solar cells, which convert sunlight into DC voltage to power electronic circuits and projects. A solar module may be used alone, or two or more modules can be wired together in series or in parallel (or both) into larger "solar panels" to increase the useful voltage or current. Just as with batteries, modules wired together in series will increases the voltage, and modules wired together in parallel will increase the available current. When even more power is needed, solar panels may be similarly expanded into „solar arrays". Solar cells and modules are great for charging batteries, powering miniature motors and small circuits, science fair demonstrations and projects, or just experimenting with the possibilities. Four our pupils we chosed 2 cells from Velleman for one team with total area 120–125 cm^2. Specifications of one SOL2 photovoltaic solar cell (Velleman) are next:

- cell technology: polycrystalline silicon;
- working output voltage: 0.5 V DC;
- current: 800 mA;
- connections: red and black wire leads;
- dimensions: 6.5 cm x 9.2 cm x 0.5 cm;
- encapsulated.

Main participants are pupils from schools (average age 12–18 years), but students and adults are welcome as well and will participate in a separate class. A team is formed from 1–3 participants, to apply the team needs a Team Name (also distinguishing marks for groups are welcome – motto, flags, caps, shirts etc.). In the first Latvian Solar Cup the solar cars created by pupils took part in the speed and power tracks, but in the second and next Solar Cups also solar boats and solar planes participated. Description of tracks:

Speed Track:

Orientation – from South to North; laminate surface 8 m long, 0.5 m wide (from 6 standard floor sheets); wood laths bounded both sides of track (see figure 1):

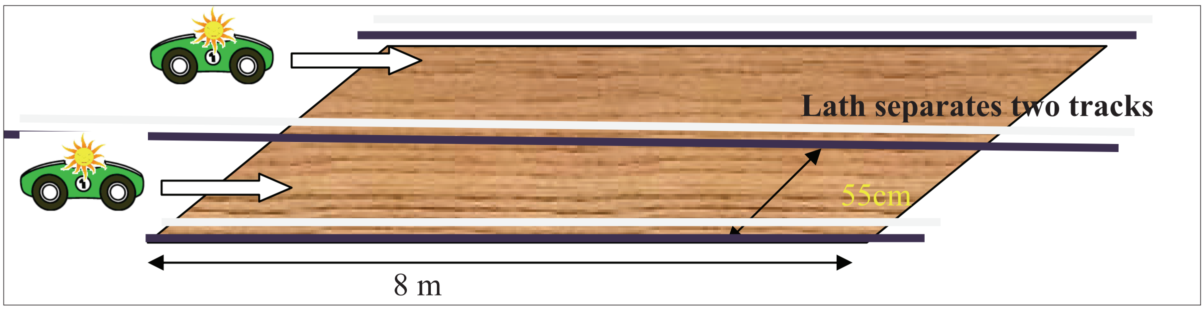

Figure 1. Organisation of Speed Tracks in Solar Cups
Source: Contest Regulations, Institute of Solid State Physics, University of Latvia

The Force Trace:

Orientation – from South to North; artificial grass surface (wires 2 cm high) 6 m long and 50 cm wide with 2–3 humps (10–20 cm high); both sides of Trace are bounded with vertical wood laths (see figure 2):

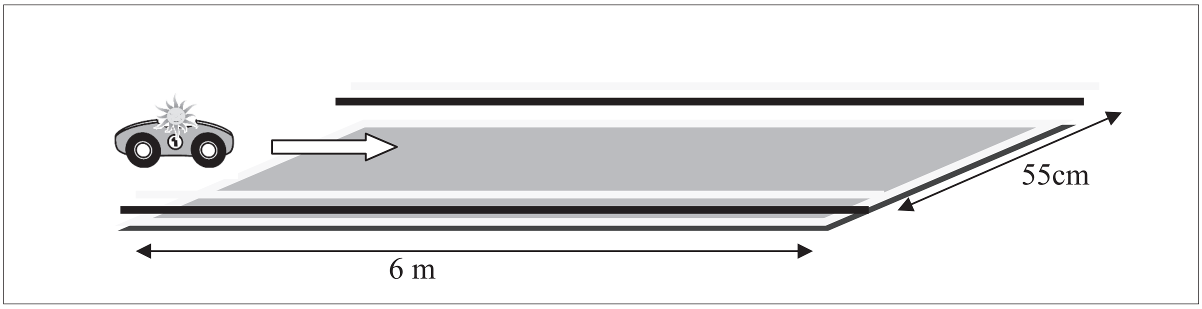

Figure 2. Organisation of Force Trace in Solar Cups
Source: Contest Regulations, Institute of Solid State Physics, University of Latvia

The Water Trace:

Orientation – from Southwest to Northeast; the pool (artificial river) with film inlay and deepness 30–60 cm, length 6 m and the width 2 m. The Sun boat needs a couple of hooks – one in the bow and second – in the tail, to use a string, if the problem will arise with reciprocal motion (see figure 3):

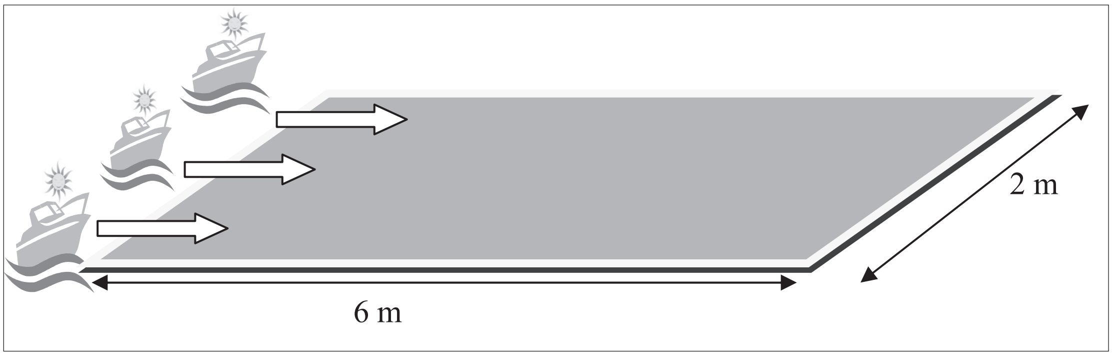

Figure 3. Organisation of Water Trace in Solar Cups
Source: Contest Regulations, Institute of Solid State Physics, University of Latvia

The Air Trace:

The orientation is free. Possible variants depending on the ability of participating models (will be evaluated just before the competition):

- The Sun plane starts vertically – the time is fixed when defined height is reached (6–8 meters).
- The Sun plane needs the runway – it will be arranged directly on place.

The process of Start and Competition:

- The Sun vehicle (boat) is laid on the Start just before the start line with covered Sun panels (from distance).
- After starting signal the cover is removed;
- If vehicle (boat) does not begin to move, it can be pushed slightly with one finger;
- The time is fixed between two events – when the front of vehicle is crossing the start line and when the tail of vehicle is crossing the finish line.

Dividing the Sun vehicles and Sun boats:

The Judges team is dividing the vehicles and boats in classes:

- A – Folk Class: the vehicle or boat is using Solar panels with active area not exceeding 125 cm^2 and does not use electronics;
- B – Master Class: The tuning of Solar Panels is made (concentrators etc.) or electronics is used to store Solar energy (before competition the stored energy must be discharged);
- C – Extra Class: The active area of Solar panels exceeds 125 cm^2, hydrogen is used to store the solar energy and more extras);

The competition takes place sequentially – Folk Class, Master Class, and Extra Class starting with Speed Trace, then Force Trace, then Water Trace and finishing with Air Trace. During the time when the tracks are not used for competition they can be used for trial experiments;

- Two drives will be allowed for every vehicle (boat, plane), and the best results will be judged.
- Awards will be for the best 3 places in all Tracks and Classes.

The Place of Latvian Solar Cups 2008–2011 trditionally is the Car Parking place of Institute of Solid State Physics, University of Latvia (address: Latvia, Riga, Kengaraga Street 8). In case of rain the solar cars only will compete in the Vestibule of second floor, the lighting will be arranged with six 300 W halogen lamps situated 1.5 m above the track. However, the chosen date of the Latvian Solar Cup race – Saturday in mid-May – is usually sunny in Latvia, as it shows by long-time meteorological observations.

Participants and results

Latvian Solar Cup events are normally involved 80–120 participants (maximum 80 teams) from 35–60 schools, aged between 12 and 18 years. The younger participants had up to 4 years. Each year, the Sun Cup is also an international event – either a team from a foreign country or a lecturer from abroad. An excellent teacher and lecturer at the first Latvian Solar Cup was Professor Bohumil Horák from Ostrava University, Czech Republic (Horák, 2008).

University of Kassel (Germany) Professor Jürgen Zick participated in Latvian Solar Cup events two times – 2009 and 2011 (Hessen Solar Cup, 2011). He told that this kind of events are taking place in Hessen for more than ten years – every year to organize competition of solar boats, solar ultra-light mobile, remote-controlled solar-Mobile or Solar Robots; it is the issue of "energy revolution now" involving German pupils, students.

Let describe just one of our events, the Latvian Solar Cup 2009. On the 16th May the 2nd Latvian Solar Cup took place at Institute of Solid state Physics of University of Latvia. Organized events included lectures and races. Totally 120 participants were divided in 59 teams (applied 86), there were also teachers, parents and fans. Pupils came from different schools in Latvia: Riga (Agenskalna National Gymnasium, the Riga School of Crafts, Jugla Secondary School, Riga 64th Secondary School, Riga 84th secondary school, pupils from Riga Pupils Castle, Riga State 1. Gymnasium, the Riga State Technical School, , Gymnasium of Nordic languages and technical innovation group TJN Annas-2/RTU); from country – A.Upītis Skriveru Secondary School, Auce Secondary School, Blome Elementary School, Liepaja 5th Secondary School, Jaunjelgava School, State Jelgava Gymnasium, Malpils Secondary School, Preili National Gymnasium, Priekuļi Secondary School, Saldus Gymnasium, Sigulda State Gymnasium, Smiltene Centre College and Smiltene Gymnasium. Lectures were started with academic speech of director of Institute of Solid state Physics (ISSP), Andris Šternbergs, overview oh Hessen Solar Cup by Professor Jürgen Zick. It was followed the lecture on organic photovoltaics by new researcher of ISSP Andrew Tokmakov and the presentation about Latvian solar testing plantation in Physical Energetic Institute – lecturers Martins Vanags and Janis Blums. Although Saturday morning began with a great Sun, when lectures ended, the Sun was hiding in the clouds. Sun's missing then was the key to why the solar planes stood on the land, and why the speed of solar cars and boats was low. During the race of solar cars the participants were divided into three classes – Folk Classs, Master

Class and Extra Class. The races were on the speed track (distance 7.5 meters long), power track (6 m long artificial grass covering of the hills) and solar boat race in water (6 m long pool). Even in cloudy conditions, winners beat speed track in less than 4 seconds (from students – Tinky team from Sigulda State Gymnasium, albeit for a slower solar car it took almost 2 minutes. In the power track only two teams finished all way – it took 9 seconds for winning team and 1 minute 19 seconds for second place. The water race received much agreement from participants, but in cloudy conditions, only a few teams fought for the award-winning sites.

Close of the Latvian Solar Cup event was the award ceremony, which awards students with different various prizes, which were brought upon sponsors: ISSP, University of Latvia, Latvian Academy of Sciences, Latvenergo, Latvian Council of Science, Riga Energy Agency, Riga City Council Education, Culture and Sports Department, VISC ESF project "Dabaszinātnes un matemātika", Publisher company Lielvārds, Ltd. Perpetuum Nova Science, Journal "Ilustrētā Zinātne", Ltd. Viessmann, Ltd. Rīgas Piensaimnieks, L'Oreal and Ministry of Environment.

There were also questioning arranged in each Latvian Solar Cup summarizing all recommendations to organizers.

Conclusions and Summary from evaluations of participants

It is important to understand that solar car, boat or another device is not simple, but system containing several important parts. We must begin by understanding each part of the system and setting realistic goals as to what can be done in the same time that lies ahead. Lofty goals are great, but if they are set unrealistically high, the project may not be completed in time. One the other hand, if we choose a very simplistic approach, there may not be enough challenges to hold interest for the team.

In order to not only physical race of solar cars and solar boats, but also intellectual contribution to develop young researchers, it would be useful when Solar Cup race could begin with descriptions from each Team of their research building up their model: energy capacity, available speed, payload, another capabilities or functions. From the beginning it always useful to make experiments with solar cells to see who will come out.

The sun shines during the day and the intense summer than in winter, the wind blows differently, depending on the time and place. On the other hand, the plug at any time day or night "blindly" plugged into the socket. To run the TV, computer, fridge, heating pump, the toaster or hair dryer, no matter when and for how long. This leads to the central question: How can the consumption and production of electricity at any time be brought into balance? What can we do to achieve a full supply of renewable energies? What is the role of the conscious use of energy in everyday life? How can electrical energy be stored? How can we orient our personal consumption at the supply of renewable energies? How to drive our cars without ejecting CO_2 and without gasoline and diesel fuels? It is not about science fiction. To develop meaningful utopias and displayed! Get creative with your pupils and students! Find out what everyone can do now is get closer to target the "100 % renewable energy"?

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More information about Latvian Solar Cups: http://www.cfi.lu.lv/saules-kauss/

ATSINAUJINANČIŲ IŠTEKLIŲ PAMOKOS: VIETINIŲ IR KITŲ ŠALIŲ MOKSLEIVIŲ MOKYMAS – LATVIJOS „SAULĖS TAURĖ“

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Santrauka

Nuo 2008 metų Latvijos universitete rengiami mokymai Latvijos „Saulės taurė“. Renginyje, kuris skirtas mokiniams ir studentams, kalbama apie vieną iš atsinaujinančių išteklių – saulės fotogalvaninę energiją. Studentai moko 5–12 klasių mokinius. Mokiniams vedamos paskaitos, užduodami namų darbai: sukurti vien saulės energija varomą transporto priemonę.

Iš pradžių „Saulės taurė“ vyko aktyviai dalyvaujant Čekų kolegoms (Ostravos universitetas), remiantis jų patirtimi organizuojami panašūs renginiai. Vėliau kolegos iš Vokietijos Kaselio universiteto dalijosi patirtimi iš Vokietijos „Saulės taurės“ renginių.

PAGRINDINIAI ŽODŽIAI: *atsinaujinančios energijos technologijos, „Saulės taurė“, mokymo iniciatyva, fotogalvanika.*

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