# THE USE OF THE WATER ELEMENT IN THE ENERGETICS OF MICRO-URBAN DEVELOPMENT IN SLOVAK REPUBLIC AND TAIWAN R.O.C.

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## Summary

Currently Taiwan and Slovakia import over 90 % of energy consumables annually. Population is concentrated in the major cities which are facing energy deficiency issues. The unregulated development of micro-urban areas is underestimated in both cases so are the energy issues bound with them. Centralized energy sources require long distance wires to support remote areas. Hydro energy is so far the most common, stable and efficient renewable resource in use. Water turbine’s efficiency has gone up to 96 %. Proposed new multi-purpose small hydro type is one of the preliminary small scale systems that could be precisely tailored to micro-urban demands. It could stand by for direct use if needed and also use various types of working mediums (e.g. compressed gas, steam, water).

**Keywords:** Renewable resources, Micro-Hydro, Water Turbines, Micro-Urbanism

## 1 Introduction

There are various scales on how the concept of energy independence should be researched. Most of the recent research proposals that consider energy issues of the human dwellings are mainly dealing with macro-urban scale, which is the centre of many questions from different sectors including the energy one as well. This work represents recent results from a bilateral research project, dealing with investigation and comparison of the hydro-potential within the micro-urban structures in Slovak Republic and Taiwan R.O.C. The effort in this paper is to show the possible use of hydro-potential in micro-urban scale as one of the major presumptions for creating autarchic micro-urban structures, with their own internal grid. The energy-urban model from the *Fig. 1* shows centralized energy efficiency distribution circles calculated by the losses in wiring, which also shows how the proposed model could create far more symbiotic energy coexistence between the city scheme surrounded by micro-urban regions and ensure coherent sustainable integration of surrounded micro-urban structures as the city grows instead of an unpleasant urban sprawl. Furthermore, the idea that considers a suitable use of the hydraulic energy, supported by the various applications of a new model of multipurpose micro-urban turbine proposal as a practical part of this research in possible conglomeration with other renewable energy resources is presented.

## 1.1 Landscape and urban hydro potential similarities

The Slovak Republic and Taiwan R.O.C. have both similarities in geomorphologic landscape structures and urban divisions that create notable energy potential premises. Large population difference makes also good prognosis study potential. Currently Taiwan imports over 99 % [1,2] and Slovakia almost 90 % [3] of energy consumables annually. Sustainable development is a priority factor in the European Union as well as in Taiwan R.O.C. So far Taiwan successfully applied coastal wind turbines and is engaging solar power as additional energy sources. In this work, the City is introduced as the macro-urban unit that historically evolves whether under some regulations or sporadically. As the city is constantly growing so is growing its general consumption. Water power plants are used in large scale facing possible earthquakes and typhoon failures [4], but it covers only 6 % [5] of the energy from renewable resources in contrast to 16 % [6] of Slovak Republic rate. In Taiwan development of small scale hydro-power plants for local farmers applying water from irrigation canals or reservoirs thus becoming more interesting like the example of the Hsikou hydro power plant [7] project located in Tainan – South-Western Taiwan owned by Farmland Irrigation Associations. The Slovak Republic lacks wind power, but there is a great potential in geothermal and biomass energy. Solar and hydro energy are both currently donated by government programs for development. Hydro-energy in Taiwan is mainly managed by the government TPC (Taiwan Power Company|) [8]. In Slovakia although the Italian Energetic Giant ENEL group [9] covers most of the energy, the market is more open to individuals (37 private companies). Most of Taiwan´s hydro-power projects need revitalization as they were built in 70s–80s or even during the Japanese occupation period and if it comes to small modern hydro-power plants, Taiwan is still in the learning phase [10]. Small scale hydro-power-plants are seen to be economically viable, easily manageable, resist natural disasters in wider scale and they can boost local businesses in farmlands across the country and since the water supplies for irrigation systems are relatively stable, so is the production of energy which is different from the volatile wind or solar energy. Small scale hydro also resists natural disasters as well. As a matter of fact, Taiwan´s Water Resource Agency in Economic Revitalization Policy – Project to Expand Investment in Public Works [11] promotes repairs, improvements and research in irrigation systems. Information to the private sector about non impact locations for small scale hydro--power plants are provided too. The Slovak Republic on the other hand promotes small scale hydro-power plants. Regulatory Office for Network Industries (ÚRSO) issued in the year 2011 final decision for 30 hydro-electric power plants. 200 small hydro-power plants projects were approved also the new concept of using hydro energy potential on the Slovakian rivers until 2030 from 9. 2. 2011 [12] was issued counting with a development of more than 368 new small hydro-power plants with 160 MW and 797 GWh of annual energy production. Private companies and local public initiatives in Slovak Republic are developing projects for revitalization of historical small scale hydropower plants like in the village “Lubochna” for instance. In Slovakia hydro energy has a long tradition, there were more than 1000 small hydro-power plants listed in inventory of water works from 1930, currently the number of small hydro-power plants is around 180 and rising, all plants are in active service, most of them managed by individual owners.

# 2 Urban Ideas for implementation

## 2.1 "Efficiency electric power grid circles"

In the urban scheme of Slovak Republic the city macro-urban structures surrounded by micro-urban structures creating a micro-urban region *(Fig. 2 right)* could be still clearly observed.

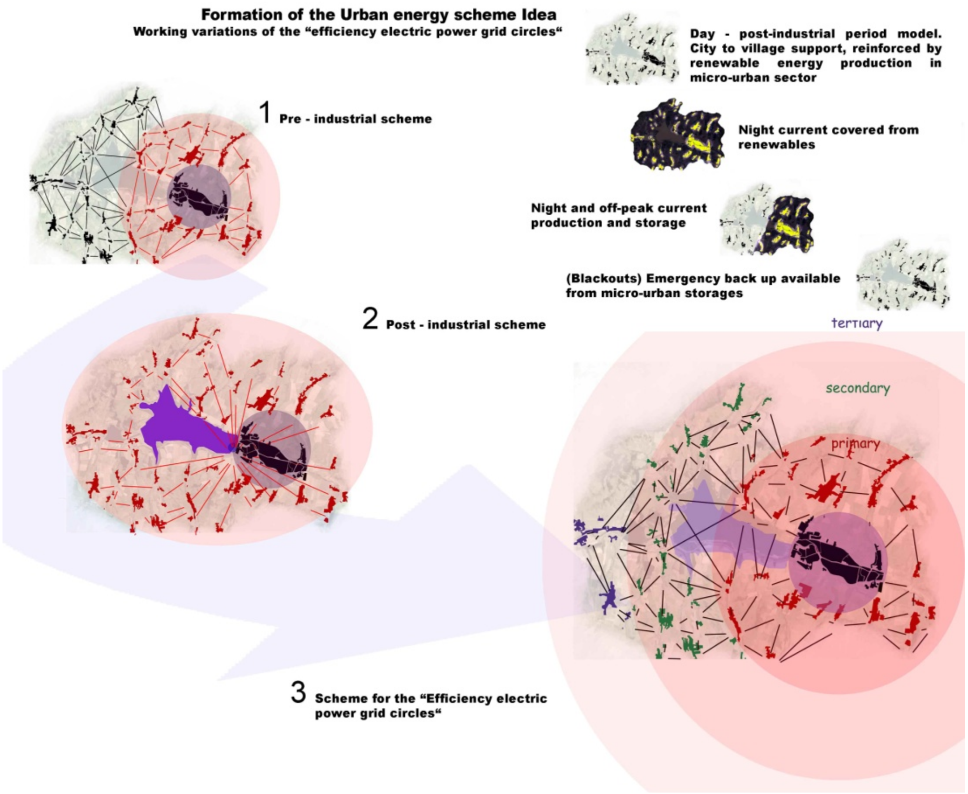


***Fig. 1*** *Origin of the "Efficiency electric power grid circles"*

Many citizens are moving in those dwellings around the city as they can reach the city anytime they need, but also having their private space. Life in micro–urban structures starts to expand rapidly. On the other hand, Taiwanese undreadably merged micro-urban and macro-urban scheme *(Fig. 2 left)* this does not give the people chances for choices and thus many are moving into already densely populated cities. If it comes to any kind of change in urbanism, it is always easier to implement the new ideas in small groups than move huge masses or change a system that people are used to for many years. The case in Slovak Republic is quite the same as was in Taiwan before Japanese occupation era, during and after the cities grew unnaturally fast, mostly without clear urban attention; nowadays, nowadays it is hard to track back the micro-urban cores or villages surrounding mega urban structures which became a major issue in energy distribution. Black outs are common issues in wider city regions. Dealing with micro-urban development in smaller communities usually on the town or village level is not unusual: 100 % – energy self-sufficient village – "Feldheim" (Germany) [13] or GEN – Global eco-village network [14] grouping all the eco-villages all around the globe are just a pioneering projects showing feasibility. Each village is a historical settlement and has some energy potential coming from its location. Research focused on micro-urban energy potential *(Fig. 4)* should be in this century embedded in the strategic plan for each village as it is a source for many future developments, but mostly for possible autarchic existence.

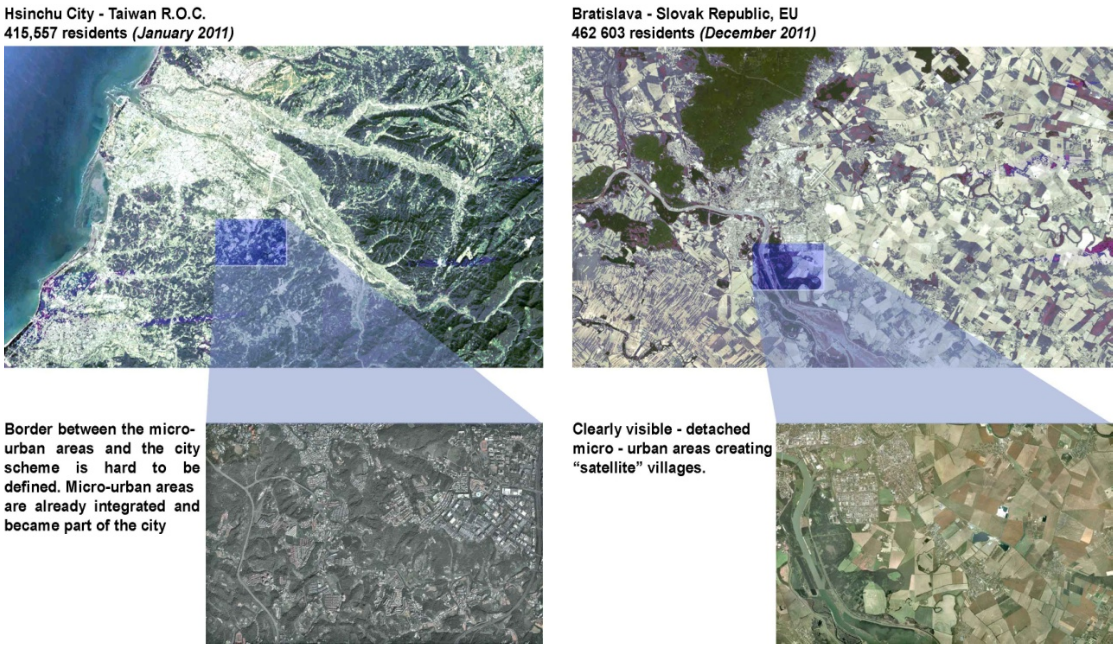


***Fig. 2*** *Selected examples for differences in micro-urbanism for both study areas.*

Making the community involved understand the technology used around could be the key for success in all sustainable models. The way how to reach the energy self-sufficient community might be feasible by introducing tailor-made multirole technology for everyday basic personal use. The fact is that almost all the systems for renewable energy conversions are already in general awareness and as a matter of fact some systems like personal photovoltaic or micro-hydro are already commercially available in quite a large scale. The price of personal scale renewable systems, which will be commercially available, could be another convincing factor. The key might be distribution system between the centralized source owned by city or government and local power plants owned by individuals in micro-urban structures. As the city grows, the centralized energy regulation has become more difficult, but is the city the only urban unit that is involved? Pre-industrial revolution models show cities supplied by chains of villages. This model could be feasible today as well, but the traded goods will be energy in the terms of energy supplies. According to the *Fig. 1, 3*, if macro-urban scale impact is concerned, these micro-urban structures – villages consisted of micro-urban units – mostly individual dwellings could create the LCPG – *Local Community Power Grid.* According to the *Fig. 1* villages surrounding the city are called the "satellite" villages. These "satellite" villages form circles with radius equals to efficient distribution distance in low voltage wiring that is calculated by the energy losses in wires which usually represents 10 % [15] from the overall energy distribution. In case of energy overproduction in the LCPG, direct support of the city, energy storage for later use or the emergency scenarios like local black outs might be covered.

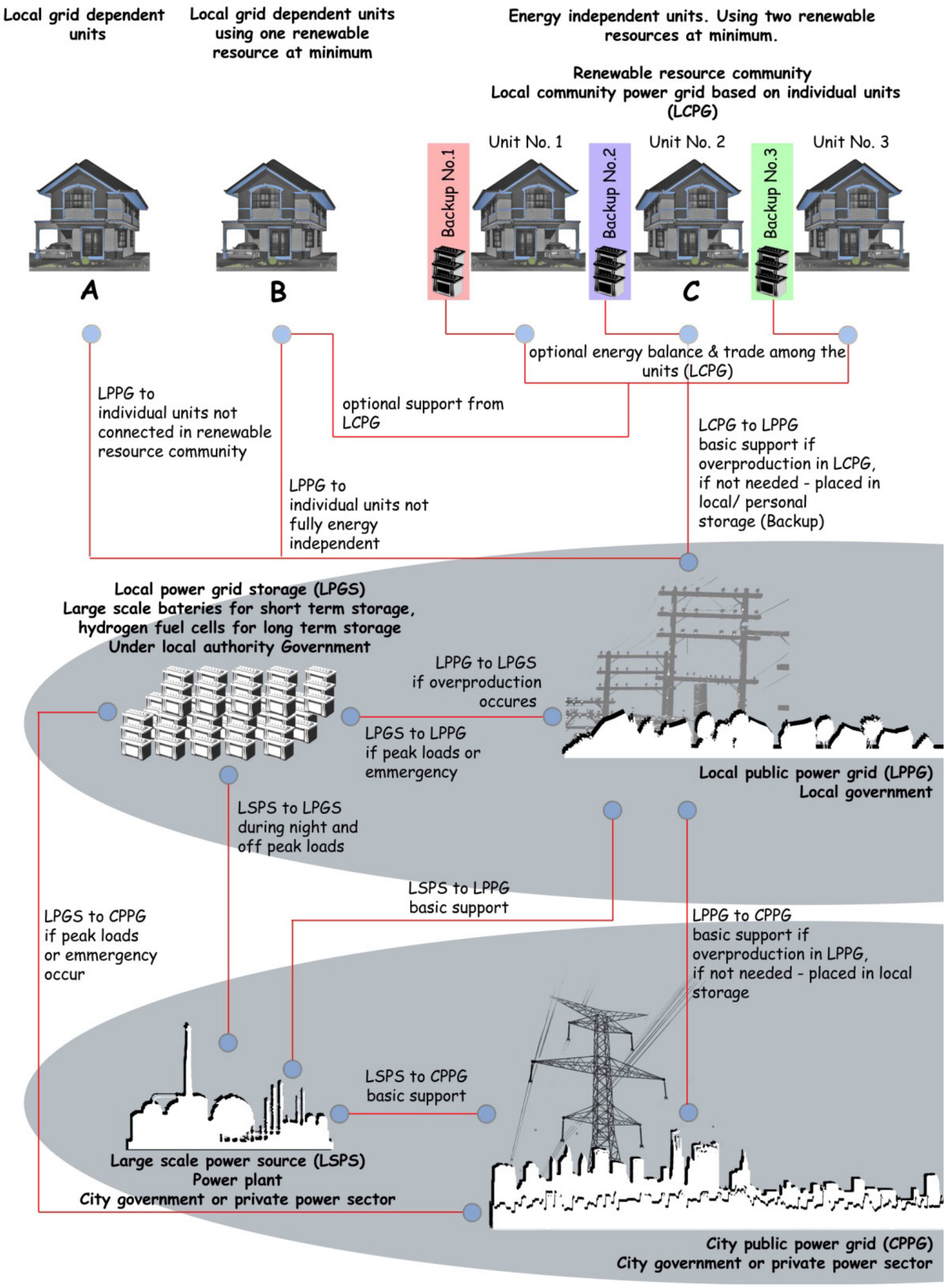


*__Fig. 3__ Distribution within the "Efficiency electric power grid circles", between the city and "satellite" villages.*

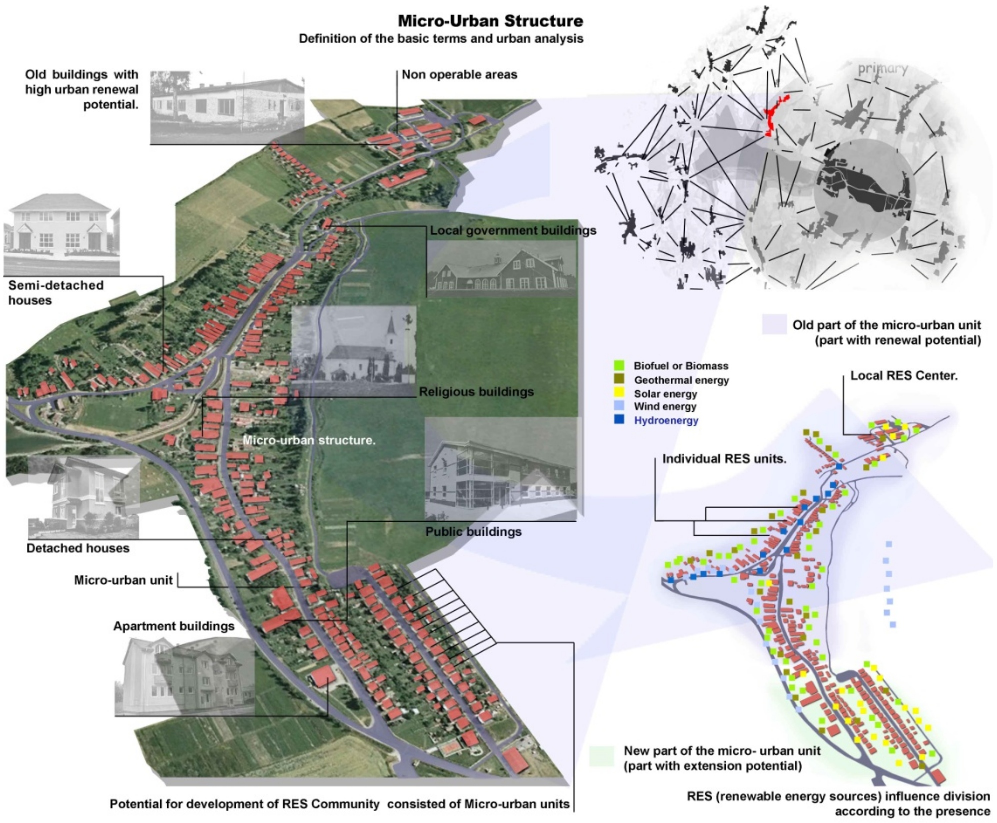


***Fig. 4*** *Preliminary study of micro-urban units division and the concept for RES in the micro-urban structure.*

Each circle produces energy for itself and trade energy among the villages on the same level. Additionally in case of energy overproduction, the primary circle usually includes largest villages and is the closest to the city centre so it plays the role of the direct city grid support ("opposite grid flow") with the lowest loses in wiring in emergency scenarios or off peak support, secondary, tertiary etc. are playing the role of backup and support for themselves and the primary one as well. All villages play the role of energy storages for short (batteries) or long term period (hydrogen power cells). Assuming that villages promote micro-urban renewable policy pictured in *Fig. 3*, individuals will be able to create micro-power stations from their house producing home energy from available renewable resources for their personal use or even under regulated development support LCPG from which it will be distributed to the next village or directly to the CPPG – *City Public Power Grid*. This community inclusion due to individuals may also contribute to boost the micro-urban trade and economy; even the high voltage wiring could change into low voltage as the distance shortens.

# 3 Micro-urban multipurpose turbine

## 3.1 Current stage of research

The experimental Micro-urban multipurpose turbine is successor of the 'UFO' micro-urban multipurpose turbine [16] that was originally designed for gas mode and lately adapted to water medium focused on high heads and small flow volumes as well, but runoff river systems due to larger application range in most of the micro-urban structures located on planes is also assumed.

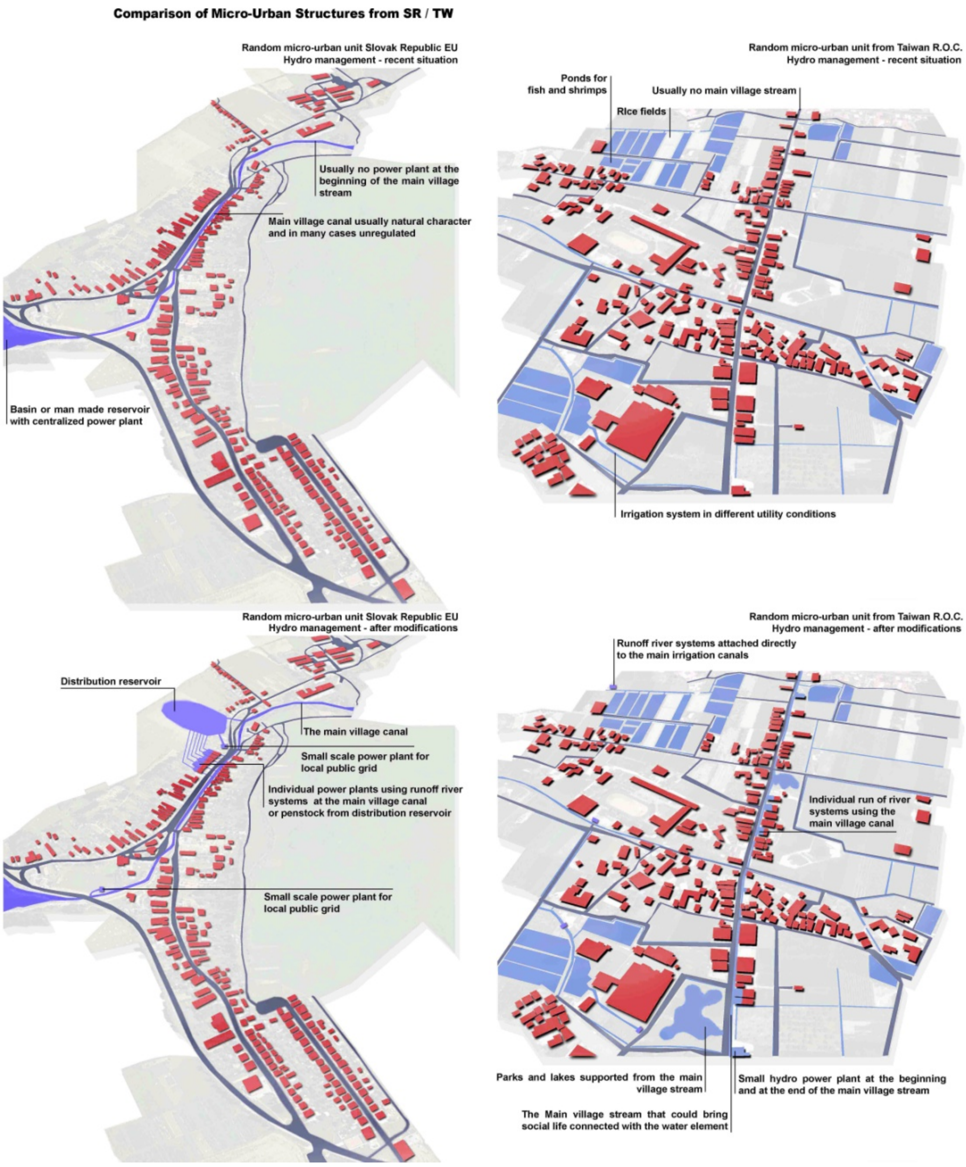


***Fig. 5*** *Hydrological research, concept for random village from Slovak Republic and Taiwan R.O.C.*

Further ongoing laboratory works on functionality research with improved demonstration model at a scale of 1:2 shown in *Fig. 6* are in progress and results and procedure is shown in the *Table 1*. Laboratory research showed that the turbine could be a possible match for the needs of micro-urban canals, reservoirs or irrigation system, but the precise urban and hydrological research as in *Fig. 5.* for this kind of area must be done first. In addition to gas and water mode, hot pressured steam mode and salty water are assumed for the future research too as the commercial model requires it. It is expected that within 2 years the device could be applied in real micro-urban sphere conditions mostly as a part of urban renewal project for at least selected recently non operable structures, which are located almost within each larger village across the both study areas.

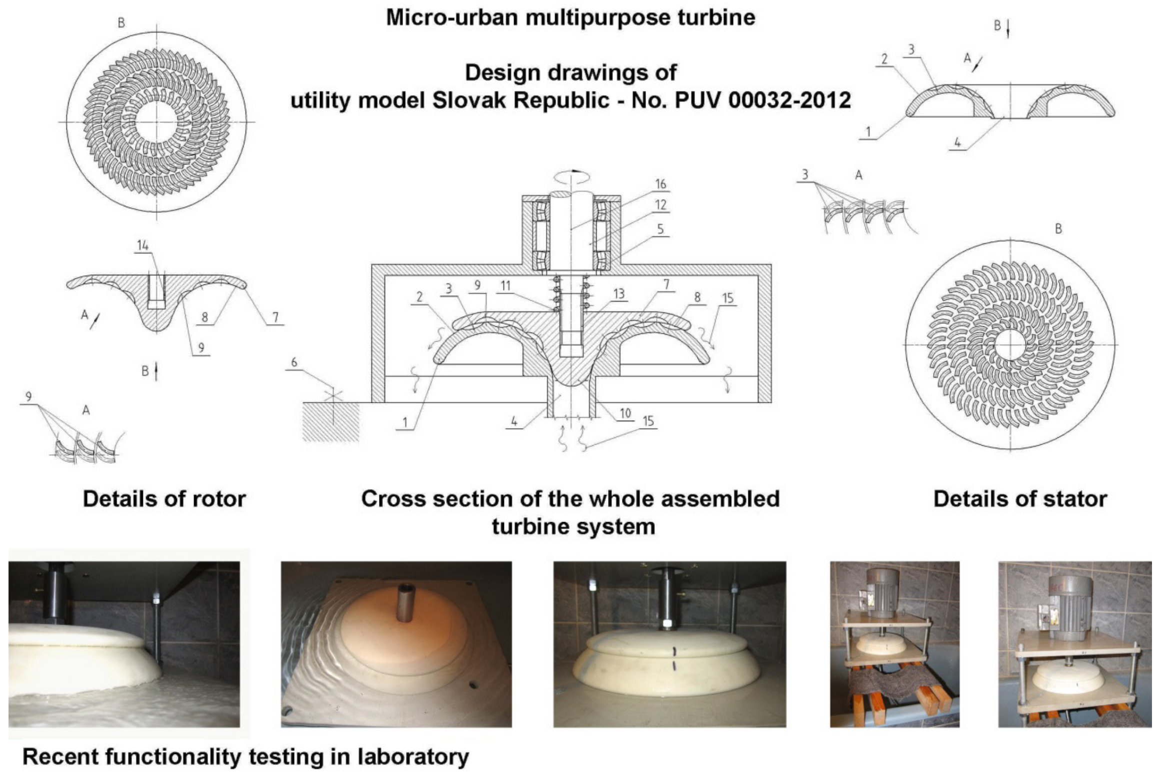


***Fig. 6*** *Design drawings of the micro-urban multipurpose turbine and pictures from recent functionality testing. (Legend: 1- Stator, 2 – semi-torus surface, 3 – stator canals in anticlockwise direction, 4 – inflow opening, 5 – bearings, 6 – surface, 7 – rotor, 8 – partial torus curve, 9 – rotor canals in clockwise direction, 10 – self stabilizing cone, 11 – buffer spring, 12 – shaft, 13 – shaft-to-rotor connection, 14 – opening for shaft-to-rotor connection, 15 – inflow and outflow of the working medium, 16 – axis of rotation).*

# 4 Conclusions

Both research involved countries posses remarkable similarities in hydro-potential connected with geomorphology, still waiting to be used. This potential is hidden also within the chains of small scale hydro-power plants owned by individuals. Application of the urban model presented above would mean decentralization of small energetic sources that might remarkably influence balanced development in economy, employment and last, but not least, it might affect the energy self-sufficient development policy of the both countries together with general awareness of renewable energy value. Use of the suitable device in micro-hydro power plants or directly in the micro-urban units whose means is to obtain the most feasible efficiency, one of the crucial parts in energy planning. However, basic water turbine principles are not varying, only improving in time. The proposed different design approach to water turbine development in this paper demonstrates that there are still undiscovered ways of water energy conversion that are worth to be researched, especially as a part of sustainability of the remote areas with unique genius loci atmosphere that should be kept for the future generations.

***Tab. 1*** *Example of a table (including tips for hotkeys of frequent styles)*

| **Turbine Functionality Tests** | | | | |
|---|---|---|---|---|
| **Type of test** | **Applied test medium (value)** | **Equipment** | **Defects** | **Results** |
| **Surface tests of stator and rotor no shaft, only behaviour of the medium in the canals was tested** | | | | |
| Gas mode | Compressed air (0,9 MPa) | Air compressor | Not applicable | Test positive |
| Water mode | Pressurized water (0,3 MPa) | Water pump | Not applicable | Test positive |
| **Stator to Rotor configuration testing, no shaft applied** | | | | |
| Gas mode | Compressed air (0,9 MPa) | Air compressor | Not applicable | Test positive |
| Water mode | Pressurized water (0,3 MPa) | Water pump | vibrations detected | Test negative |
| **Whole configuration without dynamo (short shaft (10cm), long shaft(20m))** | | | | |
| Gas mode | Compressed air (0,9 MPa) | Air compressor | Not applicable | Test positive |
| Water mode | Pressurized water (0,3 MPa) | Water pump | high vibrations detected | Test negative |
| Water mode | Pressurized water (0,3 MPa) | Water pump | low vibrations detected | Test negative |
| **Whole configuration without dynamo and buffer spring short shaft (10cm) applied** | | | | |
| Gas mode | Compressed air (0,9 MPa) | Air compressor | Not applicable | Test positive |
| Water mode | Pressurized water (0,3 MPa) | Water pump | vibrations detected | Test negative |
| **Whole configuration with 750 W dynamo included** | | | | |
| Gas mode | Compressed air (0,9 MPa) | Air compressor | Not applicable | Test positive |
| Water mode | Pressurized water (0,3 MPa) | Water pump | Not applicable | Test positive |

Note: produced energy was not measured during the feasibility tests as the applied dynamo only plays the role of shaft fixation that also helped to remove undesirable vibrations in water mode.

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