High-performance Sonitopia (Sonic Utopia): Hyper intelligent Material-based Architectural Systems for Acoustic Energy Harvesting

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Abstract. The rate of energy consumption in all over the world, based on reliable statistics of international institutions such as the International Energy Agency (IEA) shows significant increase in energy demand in recent years. Periodical recorded data shows a continuous increasing trend in energy consumption especially in developed countries as well as recently emerged developing economies such as China and India. While air pollution and water contamination as results of high consumption of fossil energy resources might be consider as menace to civic ideals such as livability, conviviality and people-oriented cities. In other hand, automobile dependency, cars oriented design and other noisy activities in urban spaces consider as threats to urban life. Thus contemporary urban design and planning concentrates on rethinking about ecology of sound, reorganizing the soundscape of neighborhoods, redesigning the sonic order of urban space. It seems that contemporary architecture and planning trends through soundscape mapping look for sonitopia (Sonic + Utopia) This paper is to propose some interactive hyper intelligent material-based architectural systems for acoustic energy harvesting. The proposed architectural design system may be result in high-performance architecture and planning strategies for future cities. The ultimate aim of research is to develop a comprehensive system for acoustic energy harvesting which cover the aim of noise reduction as well as being in harmony with architectural design. The research methodology is based on a literature review as well as experimental and quasi-experimental strategies according the paradigm of designedly ways of doing and knowing. While architectural design has solution-focused essence in problem-solving process, the proposed systems had better be hyper intelligent rather than predefined procedures. Therefore, the steps of the inference mechanism of the research include: 1- understanding sonic energy and noise potentials as energy resources, 2- recognition of transductor and other similar mechanisms, 3- developing an integrated, hyper intelligent and material-based system, 4- examining the productivity, performance and efficiency of proposed systems in commercial buildings and office departments of Tehran as case study. The results of the research show that high-performance Sonitopia concept might be helpful for adoption in contemporary architecture of developing countries such as Iran in order to better energy efficiency. It is intelligent energy systems (IES) enjoy electromechanical energy converters based on performance-oriented design in over-crowded architectural spaces. The results indicated significance of concentrating on smart, intelligent and recombinant materials in order to achieve higher performance and productivity.
1. Introduction

1.1 Energy Processing

1.1.1 Environmental pollution. Restrictions on energy and environmental issues is one of the most important concerns in the energy sector, because of the importance of this issue, different policies in order to secure energy resources and reduce environmental pollution have been adopted. Some of these policies include plans to support renewable energy sources and intelligent systems with high programmability to reduce energy consumption. For consumption There is also the potential to produce as much pollution, nowadays pollution has become one of the main challenges for management. So that Countries in addition to their domestic policies, follow this issue in the international realm. Europe Union Approved the 20-20-20 plan in 2007. The 2020 package is a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020. The package sets three key targets: 20% cut in greenhouse gas emissions, 20% of EU energy from renewables and 20% improvement in energy efficiency. [1] Construction and housing with more than 40% of energy consumption is the largest energy consumer in Iran. The energy consumption of buildings in Iran is more than 2.5 times the average global consumption and big cities like Tehran have high levels of air pollution which is caused by Fossil energy consumption. While more than 98 percent of the energy consumption of buildings in Iran are provided oil and gas products. shows that housing is one of the main reasons of Creating pollution. This section contains about 26.4% of carbon dioxide emissions. The following must be said that the buildings in Tehran Produces more than 40 percent of the carbon dioxide in the province. reducing energy consumption in the building and housing sector will have a significant impact on the total energy consumption of the country. Reducing energy consumption of buildings in terms of economic and environmental values is imperative. [2] Considering environmental issues began in the 1960s and its main focus was on industrial pollution due to the rapid growth of industrial economy. [3] In the late 1970s, trade issues and environmental issues peaked and Environmentalists protested the deplorable environmental situations of the development of trade, opposition and wide meetings were held around the world Which they say because of trade liberalization and increased exports, economic activity and also pollutive activities has spread and Inappropriate use of resources and energy increased. Pollution and environmental issues in crowded cities are not limited to a particular region And its effects will have a large-scale of impact. This pollution will impact Environment directly or indirectly, the direct impact includes the single major source of emissions and up to two to three stages However, in an indirect emission secondary sources, which are the primary sources of consumer, Create pollution. This pollution is mainly caused by man-made environments. Among the indirect pollution noise pollution in large cities can be noted, noise pollution can be infected with multiple sources. The sources in the city include noise pollution caused by traffic congestion, noise generated by unwanted noise pollution caused by mechanical machinery and equipment. Noise pollution can be divided into three parts: 1. Spherical or point 2. Linear cylinder or 3. Surface. Point sources of pollution such as presses, woodworking and turning, drilling or workshops, alone, cause noise pollution and increased load ambient sound environment. Alone causes noise pollution and increased load of ambient sound in the environment. the human nervous system reacts in different ways to an increase in noise level of the environment. for example, if a person regularly uses Loud noises, it will lose its hearing capillary cells and does cells will not replace and reproduce. Volume reduction in heart rate, breathing and pulse rhythm, drop in electrical resistance of the skin, reduction in skin temperature, impaired gastric peristalsis, the production of juice and saliva, dilated pupils, increased blood pressure and narrowing of the blood vessels are the different typed of respond that the nervous system gives to the increase in the ambient noise level. sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a transmission medium such as air or water. Humans can hear sound waves with frequencies between about 20 Hz and 20 kHz. Sound above 20 kHz is ultrasound and below 20 Hz is infrasound. Other animals have different hearing ranges. Soundproofing relates to the overall ability of a building element or building structure to reduce the sound transmission through it. Two types of sound insulation might be referred to – airborne sound insulation and impact sound insulation.
Airborne noises are transmitted by air and atmosphere. The radio, or people carrying on a conversation, are good examples of airborne noises. Impact noises propagate through solids and result from a shock on them. The footsteps of a person and the sound of an object falling on the floor are examples of impact noises. Sound is what we hear. Noise is unwanted sound. The difference between sound and noise depends upon the listener and the circumstances. Noise does not specify the type of sound and there are only vaguely heard audio source, in this case, due to unknown sources it will cause a noise traffic in certain areas. This may occur in residential buildings in dense urban context and in more important cases in office and commercial buildings which are very busy and productive in hours of noise traffic Monitoring and analyzing sound waves is investigated from several fronts which The three main branches can be noted as "Noise pollution control, sound source (energy production and other approaches), transmission and Transmission and separators ". Noise pollution may be intentionally or unintentionally form from one source of energy that will have devastating effects than other states. Sound waves produced by sources of energy for conversion into electrical energy have a direct relation The distance between the supply and sound absorbers. For example, for designing a sound into electrical energy converter in commercial construction to begin, attention should be payed to the potential in the building itself and then for the development and even saving energy Through facade to expand its relationship with the exterior transducers. Similar systems can be used as combined with electromagnetic or mechanical systems using a combination of smart materials (e.g., using the properties of polycrystalline). Recent advances in the field of micro-electronic processing and transmission of wireless sensor (WSN) has led to the use of this technology to be extremely common. In any case usage in industry, chambers of monitoring and control, urban traffic control systems and even get information on the health of a building structure are the cases of their often usage. [4] Configuration of the system consists of an external energy source (solar energy, heating energy, wind energy, sound energy and other resources), absorbing and converters, and in the final stage the design goal of using the system (production + save energy) that as a whole by an electronic system alone or in combination, guided and controlled. Expansion of the usage of this type of system is subjected to the potentials of points of use. noise Traffic in dense urban areas Both in terms of traffic and in terms of human will enhance the potentials in sound energy efficiency. The use of this potential may be provided at the same time and leads to energy savings and therefore its transferred to the municipal power. Among the strengths in the direction of sound energy efficiency in the urban context the following situations can be noted :1. Sound energy of urban traffic and local industry2. Sound energy from the crowd in the dense areas 3. Sound energy from the sound of the percussion movement of people on the surfaces (inside and outside)4. The reflected sound energy in the vicinity of dense tissue5. Artificial sound produced by enhancers.(fig1)

2. Research history

systems designed in Previous researches are often designed in a combination of several sources of energy and its main objective is the analysis of transmissions and the potential impact of the percussion sound of the user’s movements and other types of vibration. such as: Sound absorption coefficient of the collisions, the sound transmission coefficient. In such systems, which are mostly used as a therapeutic strategy for non-insulated buildings, non-isolated surface with Low sound absorption coefficient have the highest efficacy. This means that energy-absorbing and sound amplifiers beneath the surface collisions. with the increase in amount of energy transfer, from the Output Level, would have saved more energy in the ending point of the Converters and batteries. Examples of this type of system can be a combination of poly-crystal systems with oscillator and amplifier. These systems consist of terminals electrochemical (battery) that is charged by electric energy absorbers The type of electricity and voltage change from AC to DC by the oscillator device (using the piezoelectric properties), and in the end a Rectifier device will flow transmitters between the piezoelectric converter and the batteries. And will offer a uniform flow as electrical output either directly or stored in resource. Later, using nonlinear electronic circuits and energy-induced HS (SSHI) the efficiency in the production and conversion of sound energy into electrical energy increased. [5] In a nutshell this system, by shifting the voltage across the piezoelectric energy reduces the absorption from the absorber and its conversion speed. And this generates more energy in less time. Before The
main point was the usage of a feature of polycrystalline materials which its Property was used in the most of the Smart Sonic Systems as an absorber Which, by virtue of their special Property will produce energy. This type of material may have natural features in itself in order to produce energy or indirectly with a trigger or catalyst to achieve reaction stage. (fig 2.3)

| The potentials of acoustic energy | acoustic energy resulted from traffic | acoustic energy resulted from overloading | acoustic energy resulted from precision sound | acoustic energy resulted from recurrence and refraction | Producing synthetic sound (resonators) |
|----------------------------------|-------------------------------------|----------------------------------------|---------------------------------------------|------------------------------------------------------|--------------------------------------|
| acoustic energy source | Main road | auxiliary road | Location (separate compound) | plan | perspective |
| traffic population | | | | | |
| frequency | | | | | |
| time | | | | | |
| Utilizing population potential + traffic + user's perception + vicinity | | | Commercial building in crowded urban fabric exposed to very dense vicinity | Main road – auxiliary road | Very high number of user population |
| Utilizing population potential + traffic + user's perception | | | Commercial building in semi-crowded urban fabric exposed to dense vicinity | Main road – auxiliary road | High number of user population the building does not have vicinity from one front |
| Utilizing population potential – user’s perception | | | Commercial building in an urban fabric with average density and with less dense vicinity | Main road – auxiliary road | Fair number of user population the building does not have vicinity from two fronts |
| Utilizing perversion potential – installations | | | Commercial building in an urban fabric with less density and minimum vicinity | Main road | The building in an urban fabric with minimum noise pollution and with vicinity to one front |
| Utilizing perversion potential – installations | | | Commercial building in a non-conforming urban fabric no vicinity no noise pollution from external sources local access |

Figure 1. City potentials for the use of Acoustic energy sources [author]
3. Sonic energy

3.1 Intelligent systems

3.1.1 Energy generation. The quality of sound is determined by frequency. Measured in units of hertz (Hz), frequency is the number of complete cycles of vibration above and below the static pressure in a unit of time. The human ear detects sensitive frequency is approximately 1,000 hertz. Vibration is a periodic back-and-forth motion of the particles of an elastic body or medium, commonly resulting when almost any physical system is displaced from its equilibrium condition and allowed to respond to the forces that tend to restore equilibrium. This physical phenomenon is so-called the Wave. To get a rough picture of how we create sound waves we consider Pendulum as an example. A pendulum is defined as a mass, or bob, connected to a rod or rope, that experiences simple harmonic motion as it swings back and forth without friction. The equilibrium position of the pendulum is the position when the mass is hanging directly downward. Pendulums weight in its movement, pushes forward a thin layer of air molecules and This causes one a side of the weight to be a molecular density and in the other hand to be a molecular dilution. Dilution means the incrassation of the distance between molecules and density means the reduction of their distance. If we pull a rubber tire from its ends the length of it increases, the reason for this is that the distance between rubber molecules are increased in the mid portion and the molecules are Gathered in the ends of the rubber tire and so The distance between the molecules of the two ends decreases. Thus, in the middle molecular density and at both ends molecular dilution are caused [7]. Now, if we let go of the rubber molecules revert back to their original location. Perhaps one of the simplest solutions to the conversation of sound in to electric energy lies in a device called microphone. Microphones receive sound waves and convert them into electrical signals. Among the most important Microphones, dynamic microphones, tape and capacitive can be noted. In dynamic microphones a coil is glued to the rear of a membrane, and there is a strong magnet surrounding this coil. [8] When sound waves hit the microphone, the membrane moves to the rhythm of the sound waves, and the coil on its back moves along with it. The relative movement of the coil within its (stationary) magnetic gap induces a small signal voltage in this coil. There’s your microphone, a device that converts sound into an electrical signal. Among other examples used for the production of energy by sound speakers can be noted. a considerable point in energy generation using sonic is the direct conversion of sonic energy too electrical energy. [9] Among all the examples that even people have lived with the through ages, without considering the magnificent structure of sound and its potentials, energy transmission was from sonic form to Mechanical vibration. thus can be noted that the main way of converting sonic energy to electrical energy was through a mechanical interface, in conventional methods the goal was to achieve a mechanical vibration, In the piezoelectric material
by the vibrations of the material by the percussion type sounds and the properties of polycrystalline materials converts sound by a mechanical interface into pure electrical energy. Later on using convertors and Transformers eased the way of converting sonic energy into other typed of energy and Vice versa. Among these systems sonic engines can be noted. This engine has the ability to convert the wind energy to the sonic energy through a pipe resonator. Sonic engine means that by the aerodynamic effects converts wind power to sonic energy. In this way, instead of using mechanical movements as energy converters, systems such as Converters, transformers and heat refrigerators were used, which the main point in the process of energy conversion was the absence of mechanical interfaces in the reverse mechanism of the sonic system. [10](fig 4,5,6,7)

**Figure 4.** Schematic diagram of the prototype Smart Sonic System (sonic energy converter without mechanical inference)[10]

**Figure 5.** a. Engine that starts audio stream b. Eddy current c. Distribution of sound pressure in the pipe[10]

**Figure 6.** A variety of sound pressure at different points in the audio amplifier tube [10]

**Figure 7.** a. The pressure releases wavelength in different time periods b. Spectral analysis of frequencies[10]

4. Principles and approaches to reduction in noise pollution and energy production in architecture

4.1 Designing smart sonic systems (noise absorption and electrical energy generation)

Among all the different types of energy in the universe, from Non-renewable to renewable energy sources, Wind energy, solar, geothermal, wave and fossil fuels were used more often in architecture and other fields. In the meantime, sonic energy and its potentials in optimizing energy usage in architecture and constructions were less used. When an object vibrates creates an Unstable waveform state, when the waves are more distanced from its source of production, they are gradually destroyed and absorbed by the environment. The phenomenon that Stimulates the ear (with mechanical vibration) is called sound. And the space that this phenomenon happens is called and acoustic field. The main goal in design the following system is to aim to reduce noise pollution by absorbing Obstrusive sounds and using its potentials to optimize energy consumption in buildings. The following design has to main resources. 1. internal sound energy sources in buildings itself like the noise from Uninsulated
building installations and the movement of the users in the building and also the sound itself when the users are talking (In office and commercial buildings that have a lot of users at certain hours) 2. External sound energy sources which this sources are the main in the buildings energy supply. because of large facades these resources have a wide surface impact level. And the façade will be the most effective factor in absorbing sound energy by the designed system. Smart Sonic Facades will have a different from the traditional optimized smart thermal facades. Optimized sonic building forms are one of the factors which can interact with the building itself to multiply the sound Absorptions and can be used to optimize the process of generating energy. The Functional mechanism of the designed system Is as follows :1. Guided noise in crowded urban areas to building facades.2. absorption of the noise pollution which are guided to the facades by the optimized sonic forms and the smart sonic system placed in the 2nd layer of the system .3. and in the end absorbed Noise pollution is converted into electrical energy by the mechanical movement as a model for creating a magnetic field to produce electrical energy.

In short we have 3 types of Energy Conversion in the designed mechanism Sound energy into mechanical energy, mechanical energy into electromagnetic energy and electromagnetic energy into electrical energy, absorption and the guiding noise by the optimal sonic form (Such as conical forms part of the cone, the cone of hyperbolic paraboloid) will lead to the movement of the elastic membrane of the system and by that it will move the hydraulic jack , which the hydraulic jack itself has magnets in its end which by its forth and back movement in the main axel of the rotated coils will create an magnetic field which leads to generating electrical energy . the elastic membranes can be wet in order to improve the movement of sound. Because sound moisture has a direct relation with each other and the moisture in the membranes can help to guide the sound through the cone. The strength of the magnets and the number of turns of the coil is also an important factor in the design.(fig8,9)

5. Conclusion

Now days with the high potentials of sound energy in architectural design, it is a wise move to design architectural elements with the approach of using sound energy in it. absorption of noise pollution by the Smart Sonic System that is used in the exterior facades and also in interior parts will help us to achieve a more sound optimized design for our buildings. Using this system in double skin facades (exterior skin as an element for guiding the noise through the system and the internal skin for the absorption of the noise pollution) can help us archive the maximum amount of efficiency specially in the denser and Populated areas. Guided, absorption and energy production are among the principals of designing with the approach of using sound energy. Using this system with its different types and forms in the walls of the urban highways and using the potential of the sound energy which is often found in the modern and developing cities, can help us generate electrical energy by optimizing and its maximum efficacy levels. This can lead to the point that the building which are equipped with this design can harvest energy not only for themselves but in a larger scale. can produce so much electrical energy that can save and transfer them to the cities energy plant. Due to the increasing development of technology and industry in developing and developed countries, noise pollution will also increase with the Urban sprawl and this shows us this using this system is extremely Vital and important for creating an ideal Sonitopia.(fig10,11)
6. References

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