3. *Kurzweil R.* The Singularity Is Near. N.Y.: Viking, (2005).

4. *Martin A Makary, Michael Daniel.* Medical error – the third leading cause of death in the US, BMJ, (2016).

5. *Singatulin R., Ablyazov. K.* Personal Accompanying Remote-Noninvasite Medical System. International Journal of Advances in Computer Science & Its Applications. 2015. Volume 5: Issue 1. Pp. 34–36.

6. *Veshneva I., Singatulin R., Bolshakov A., Chistyakova T., Melnikov L.* Model of formation of the feedback channel within ergatic systems for monitoring of quality of processes of formation of personnel competences. International Journal for Quality Research, 2015. Volume 9. Num. 3. Pp. 495–512.

УДК 911

Nikolaos Karanikolas[1], Dimitra Vagiona[2]

GEOGRAPHY OF ENERGY. A WORLD IN TRANSITION

Abstract. *Geography and energy are two major scientific fields. From one side Geography is the science which answers fundamental questions of spatial behavior of all environmental and human phenomenon and from the other side energy is actually the «fuel» of economic and social development for many countries and regions especially after industrial revolution. In today's world energy came to be one of the major fields of development, success or even conflict between countries and societies. The division of energy producers and energy suppliers and the world with access to energy or not came to be one of the major problems of world nations.*

During the last decades' geography of energy is a result of the tiny mix of geography and energy science. Tiny, because of the very few publications in the field although it is seriously accelerating during the 21st century.

It is only after 1961, when the discussion about the role of geographers in the field of energy and the answers to common geographic questions like patterns and spatial understanding of the production, distribution and needs of energy came up to the foreground.

It is true that the world face fundamental changes in the patterns of energy production, distribution and use. International and national policies of the countries are driving energy transitions from «conventional» to «unconventional» fossil fuels (Farrell and Brandt, 2006; Greene et al., 2006) and from non-renewable to renewable energy resources (REN21, 2012). These changes follow a pattern behavior and a spatial analysis of the phenomenon is seriously needed.

In this paper the transition of energy forms and the spatial behavior of energy production and needs are discussed. The future of an -energy driven- world sets the background for new tools of analysis of the demand for energy from human race. A theoretical background of the field of geography of energy is also given.

Key words: *Geography of energy, energy landscapes, production and needs of energy.*

Introduction. It was after 1960 when the growth of energy demands and needs were first recognized among with the geographic characteristics about the role of spatial distributions and patterns of energy supplies, production and needs (John D. Chapman, 1961; Pryde, 1985; Frantal et al, 2014). Since then although many academics worked on the topic of Geography of Energy and many publications, journals and conferences came alive and realized about the complexity of energy char-

[1] Assistant Professor, Aristotle University of Thessaloniki, Faculty of Engineering, School of Spatial Planning and Development; e-mail: karanik@auth.gr.

[2] Assistant Professor, Aristotle University of Thessaloniki, Faculty of Engineering, School of Spatial Planning and Development.

acteristics and their impact on societies and wealth far beyond 1960's first thoughts (Karl Zimmerer, 2011; Dorian et al., 2006; Florini, Sovaccol, 2009).

Today the challenges of understanding the impacts of global energy use on the planet are widely discussed on the higher level of organizations like the G20 meetings.

The predictions for the future are sometimes dramatic about the consequences of our energy behavior and rarely more conservative. The truth is that energy needs are highly extending and many organizations publish the results of their models showing the needs climbing by more than one third to two thirds of today's needs (IEA, 2013). Most of the global demands are coming from emerging economies such as China, India, Indonesia and Brazil (Leach, 1992; Simon, 2005; IEA, 2012). On the other hand, developed economies like Northern Europe, U.S.A. and Canada are making a big and expensive turn to renewable way of energy production like wind farms, solar energy and other clean ways of energy production thanks to new technologies (Spinney et al., 2012; Van der Kroon et al., 2013; Warr et al., 2010; Bithas and Kalimeris, 2013).

Finally, the lack of energy to many regions like many Asian countries and sub-Saharan Africa leave billions of people without access to their energy needs.

Geographic applications on understanding spatial patterns and correlation of energy characteristics are also rising during the last decades (Pryde, 1985; Zimmerrer, 2011; Bridge, 2012). The relation between energy and geography is really strong and is often marked as common as «escape casual notice» (Pasqualetti, 2011).

Today and in the future, energy production and distribution is a complexed phenomenon influencing international relations, geopolitics, international and national policies or even local development. It is true that energy today holds a major key role on national and international conflicts around the world and even wars.

So what is the answer to the question what is geography of energy? What are the geographic characteristics of energy production, distribution and use?

Geography of Energy. The methodological frame of energy geography has to be established. This could be established as the study of energy development, transportation, markets or use patterns and their determinants from a spatial, regional or resource management perspective (Solomon and Pasqualetti, 2004; Solomon et al., 2004). The spatiotemporal analysis of energy production, distribution and use is widely referenced in many studies worldwide (Luten, 1961; van Zyl, 1968; Manners, 1971; Hauser, 1971; Cook, 1976; Spooner, 1981 & 2000; Calzonetti and Solomon, 1985). Also the aspects of energy chains and their impact from many scales and views is also published in many different aspects including economics (Zvoleff et al., 2009; Nguyen & Pearce, 2010; Kedron and Bagchi-Sen, 2011, Calvert and Mabee, 2016), cultural studies (Bridge, 2010, Spinney et al., 2012; Nadaï and Labussière, 2013), political sciences and economy (Huber, 2008; Neville and Dauvergne, 2012), political ecology (Andrews and McCarthy, 2013), history (Harrison, 2013), sociology (Dorow and O'Shaughnessy, 2013), environmental psychology (Devine-Wright, 2007), science and technology studies (Furlong, 2011; Bickerstaff, 2012), urban planning (Owens, 1986), regional science (Feder, 2004; Mabee and Mirck, 2011; Court et al., 2013), climatology (Li et al., 2011), GIS and remote sensing (Sabins, 2004; Wang et al., 2009; Horner et al., 2011; Calvert et al., 2013).

The truth is that geography of energy has to be studied from physical to human geographers to understand the impact of today's energy(civi)lization of humanity.

Cartographers are also playing an important role to these studies because of the major aspect of giving the accurate form of the spatial characteristics of energy on a map.

This work come to fill a lack of mapping all these characteristics in a global scale and a time series frame.

Energy Production. Physically speaking, energy is objects transferred to other projects or converted to different forms (Kittel and Kroemer, 1980). But energy comes from the ancient Greek work «Energeia» which means operation or ability and first time appeared in Aristotle's work in the 4th century B.C.

Today energy production comes in many and different forms and affect global economy. Many countries of the world stable and force their economies thanks to their energy production chains. The biggest production countries today are China, U.S.A., Russia, Japan and Germany. Fig. 1 shows the map of global energy supply in 2012. From this map and the diagram of Fig. 2 it is obvious that China, United States of America, India, Russia and Japan are the world leaders as energy suppliers.

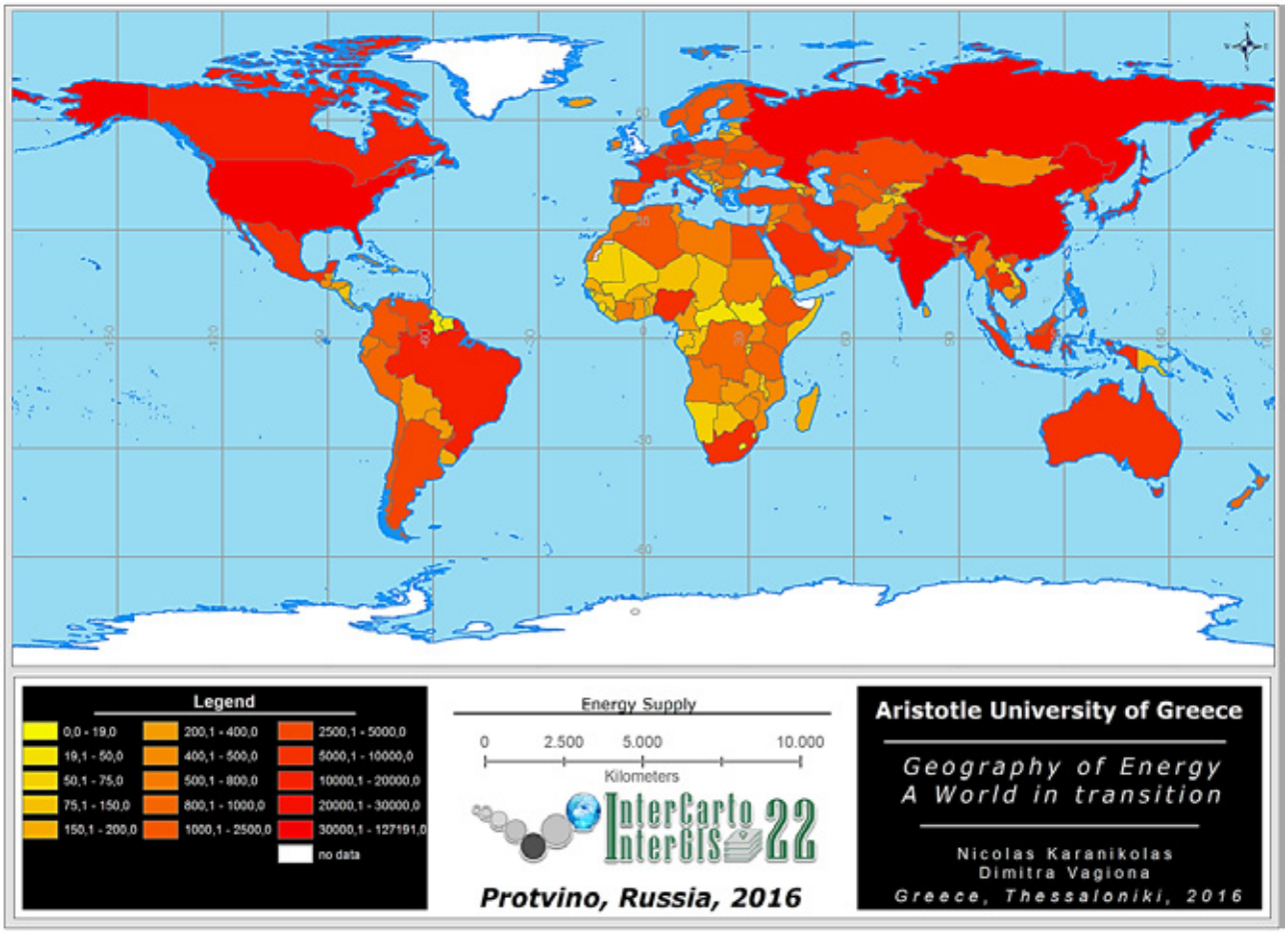

Fig. 1. Map of global energy supply

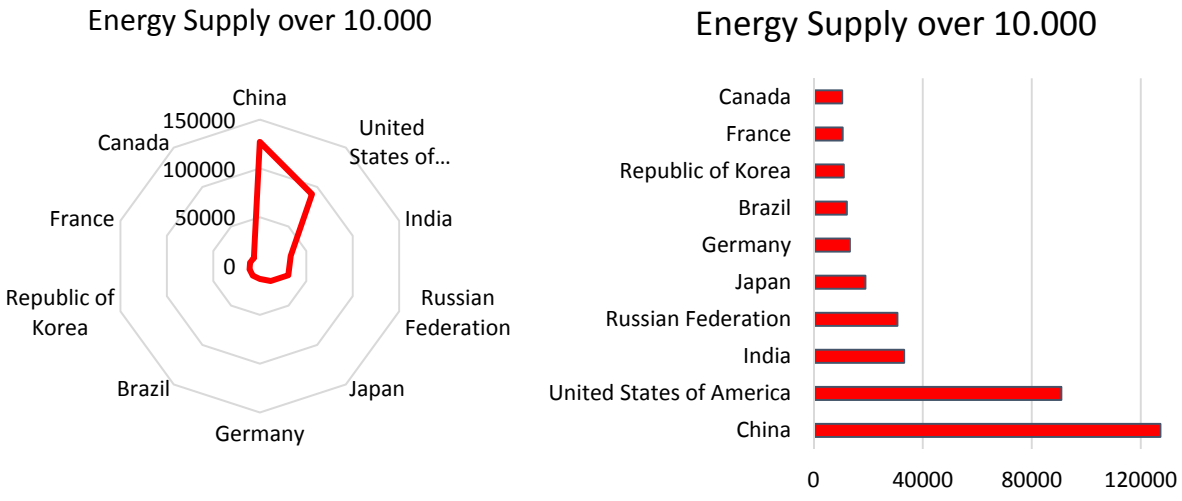

Fig. 2. Radar and bar diagrams of big suppliers

The geographic analysis of energy production is consisted of many maps and diagrams. In the context of this paper the use of a few examples will try to give the view of different aspects of this phenomenon.

One important turn in energy production is the turn in renewable ways of producing energy.

Map in Fig. 3 and diagram in Fig. 4 shows the world renewable energy production in 2013. Although it was expected to see developed countries as world leaders in this map, the truth is that many sub-Saharan countries like Namibia or Congo found to cover their needs only from renewable ways of producing energy. But the truth is not portrayed on this map and diagram. The basic difference between northern European countries and Canada with these countries is that they do not cover their needs. They may use renewable ways of producing energy but the cover of their needs is the minimum. The problem is that many households in these countries does not have access to energy suppliers to cover their needs. It is true that more than 2 billion people do not have any access to energy today. On the other hand, the renewable way of producing energy to these countries is something that have to get stronger so that greater percentage of the population will be energy-covered. So one proposal of this analysis is that a great need of helping the development of more renewable production of energy in Asia and Africa will be one of the world's great steps of the future. It is socially and environmentally fair to help these countries to produce great amounts of energy using renewable ways like solar energy which is maybe one of the best ways for these countries. Perhaps, more research is needed focusing on every country and taking into consideration their different geographical and geological characteristics.

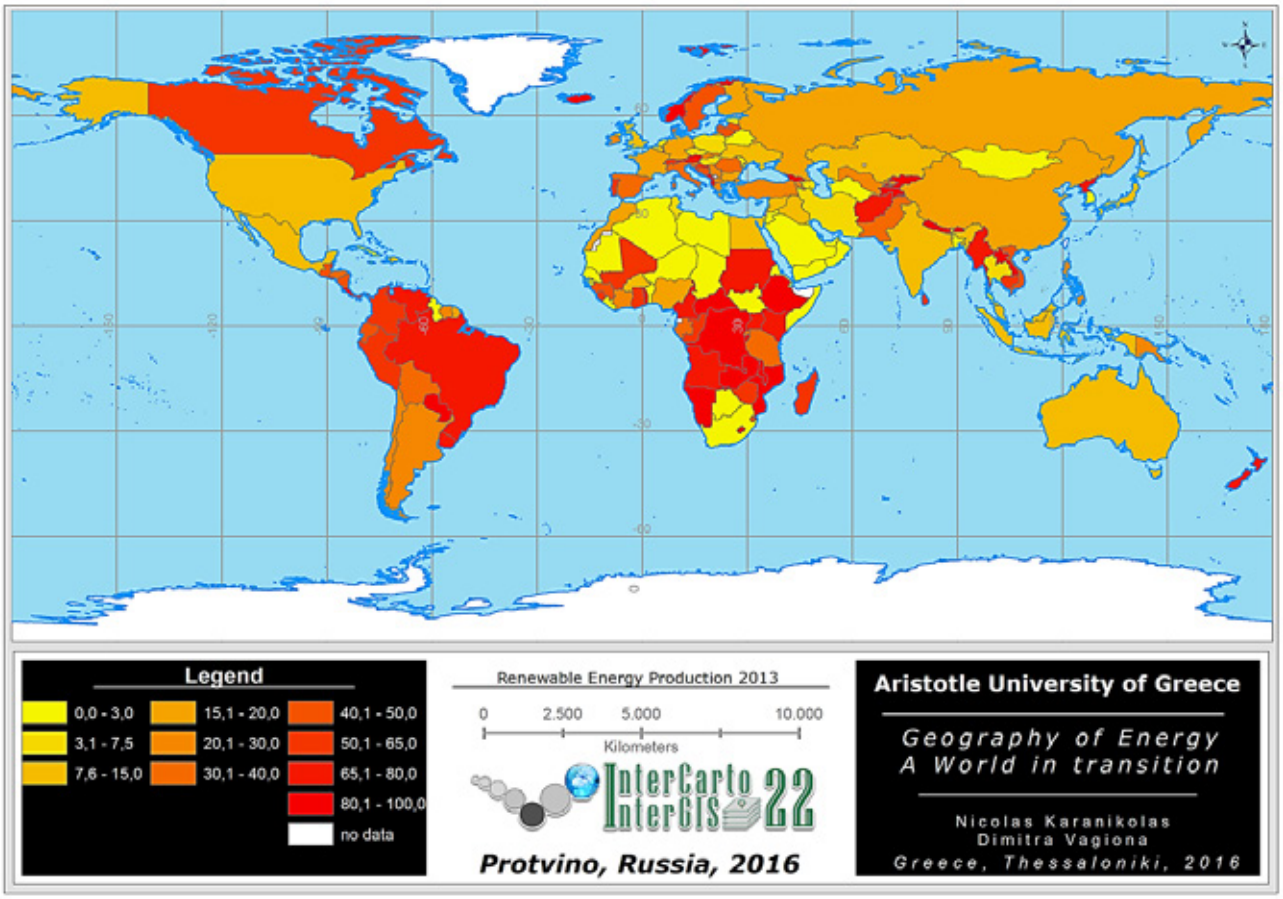

Fig. 3. Map of renewable energy production in 2013

Emissions and problems of today's energy production. One of the problems of the high energy needs of today's world is the problem of gas emissions. Emissions is today the first step to understand the impact of our non-renewable way of producing energy. In the context of this re-

search all the «classical» emissions like CO, CO2, NO, NO2, etc. are covered. There are also many data for other kinds of emissions like CH4, etc.

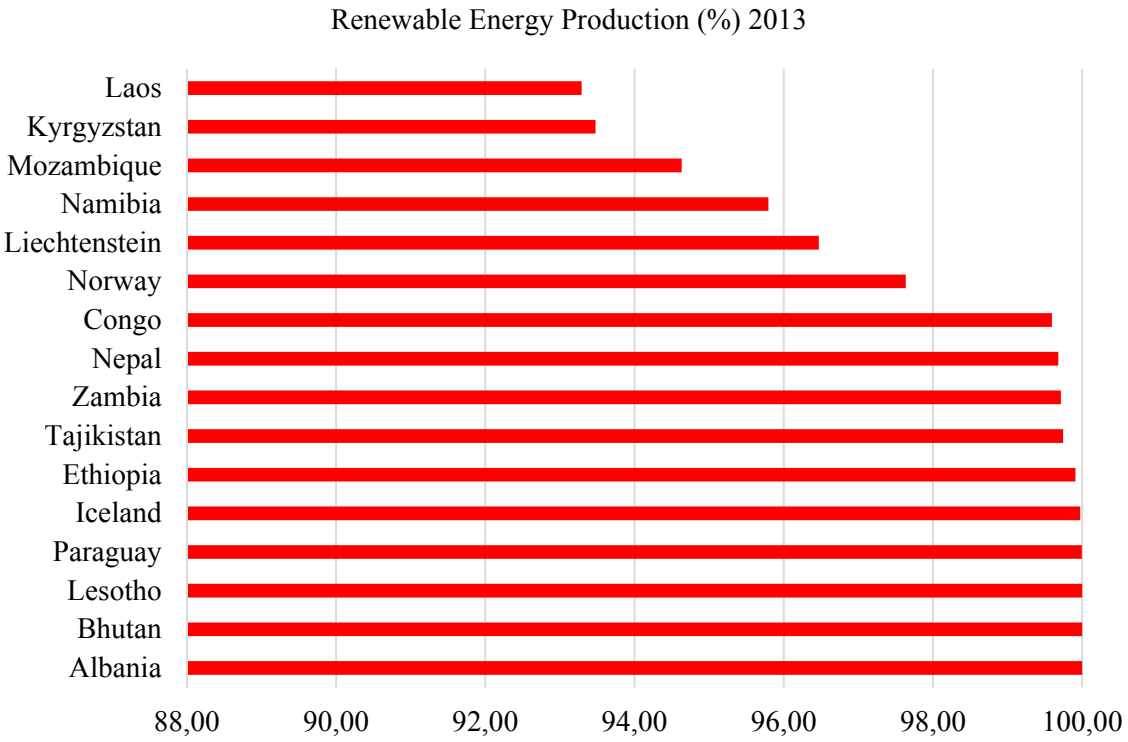

Fig. 4. Diagram of renewable energy production in 2013

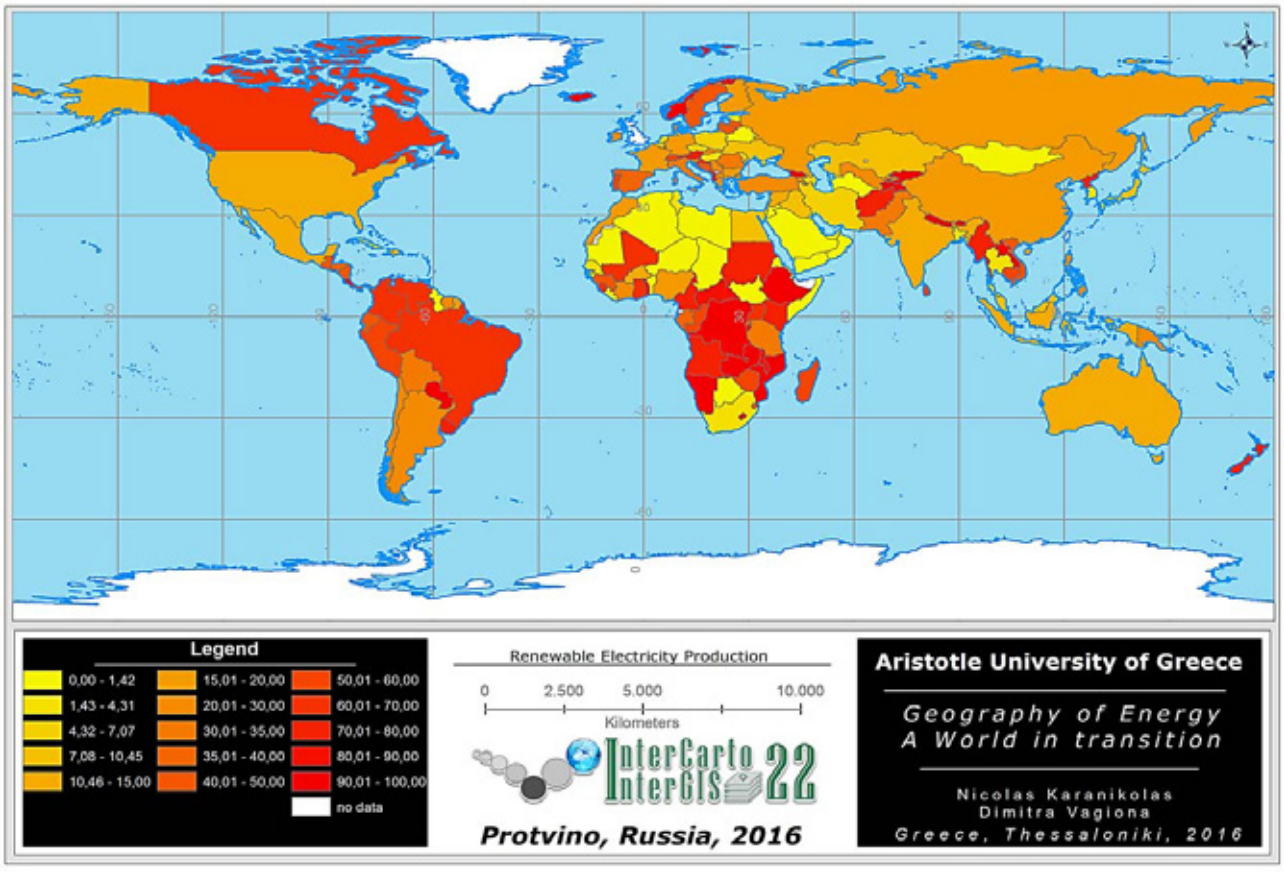

Fig. 5. Map of renewable electricity production

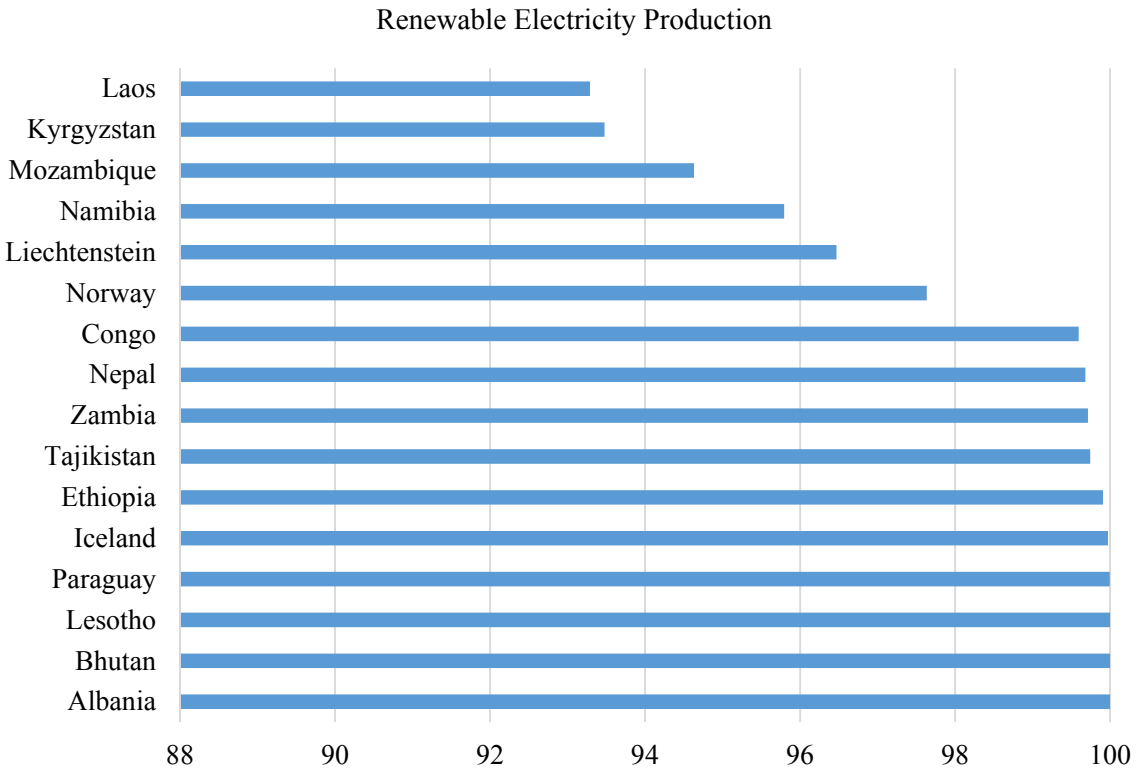

Fig. 6. Diagram of renewable electricity production.

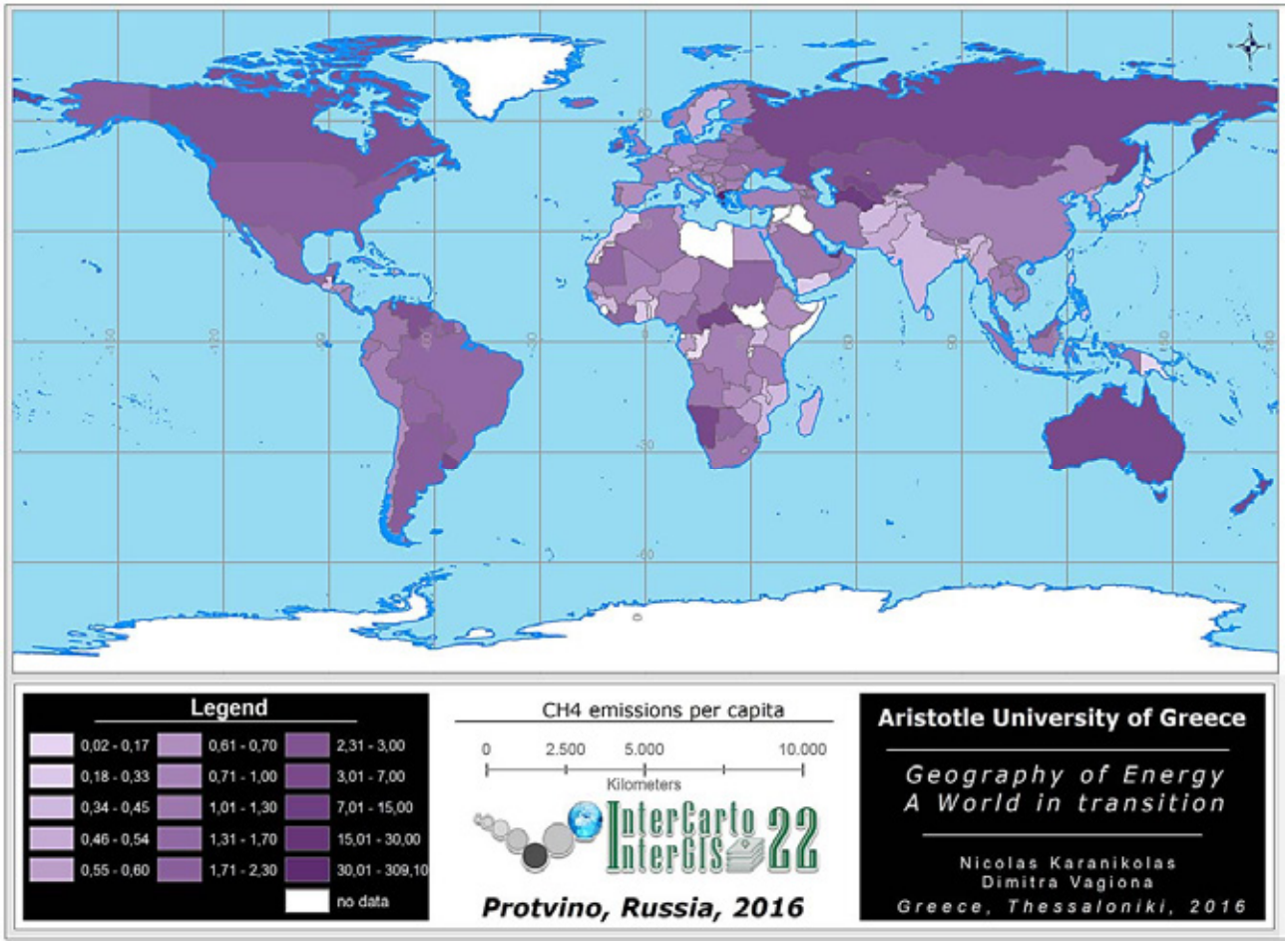

Fig. 7. Map of CH4 emissions per capita globally

Four different analyses have performed so that we can analyze the **emissions per country, per km2, per capital and per population**. From these analyses the results also give a different view of the problem. Of course big and developed countries like China, U.S.A. and Russia are the big pollutants of the world but using different approaches like the per capital analysis a different view of the emissions and pollutants is performed. This is because small countries like Greece, Mexico or Jamaica play a role as countries-pollutants. In Fig. 7 we analyze the CH4 emissions per capita and by using Fig. 8 we find that countries like Greece plays an important role on emissions.

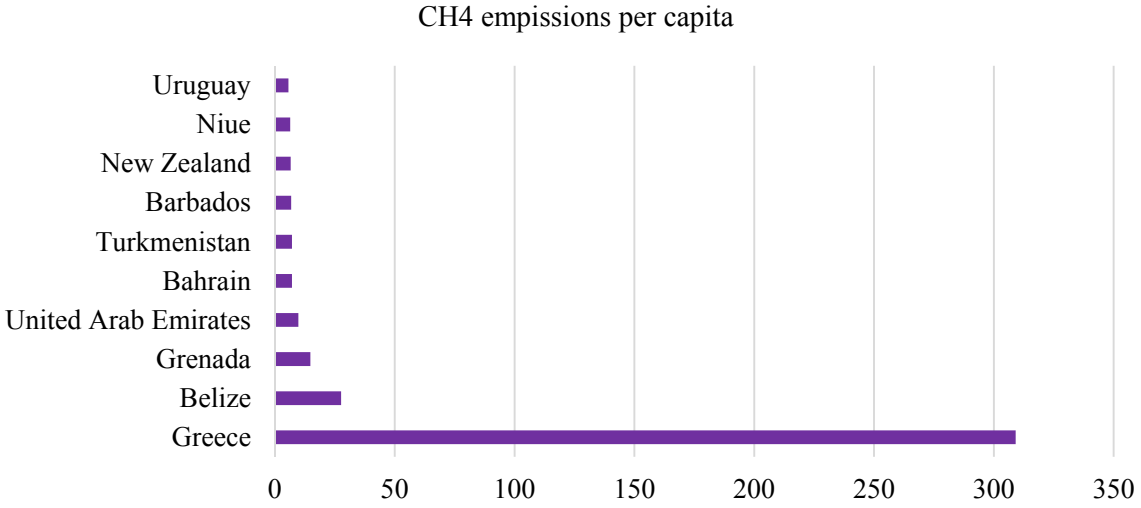

Fig. 8. Diagram of CH4 emissions per capita

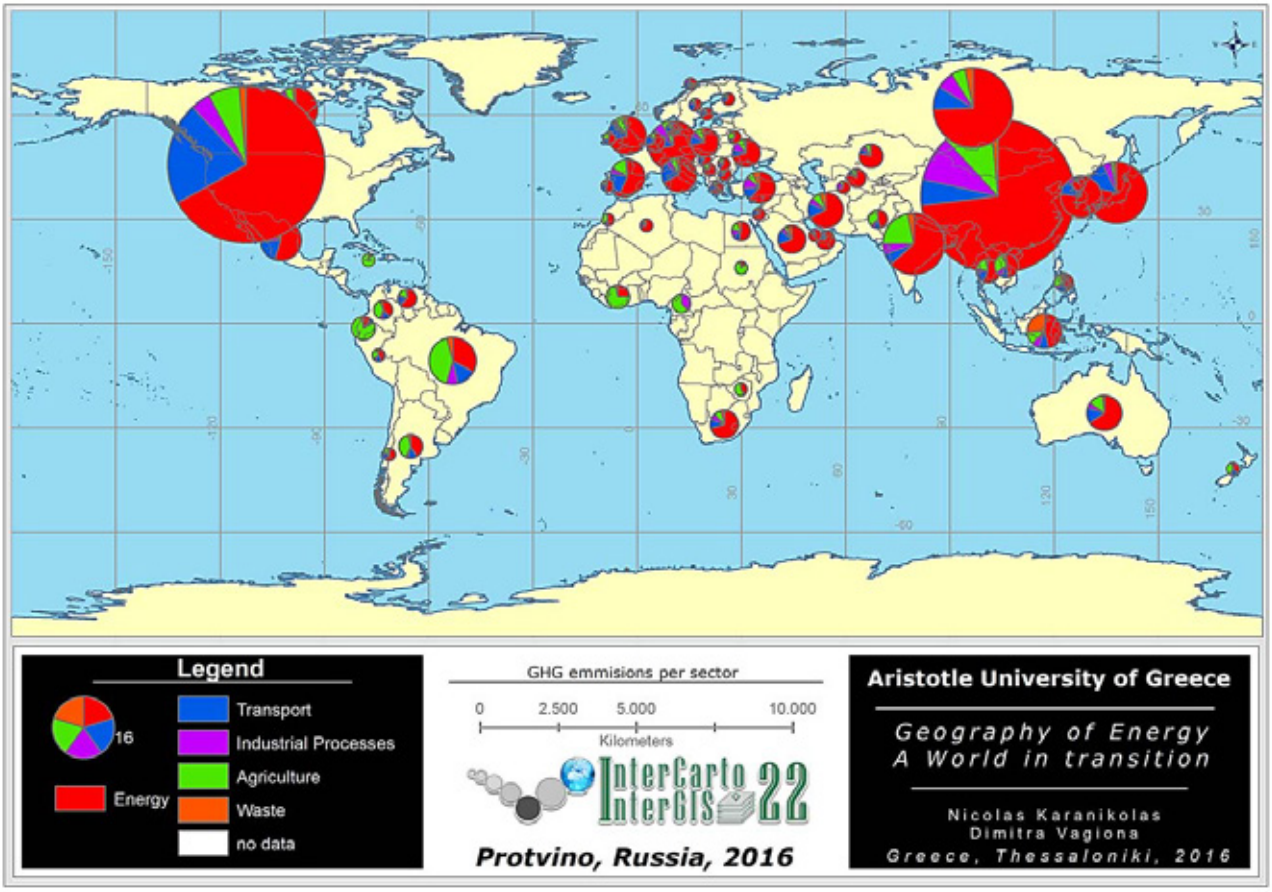

Fig. 9. Map of GHG emissions per sector

There are also more analysis maps like the totals emissions per sector which can help to understand the question of emissions according to their development model and stage. For example, emissions come more from energy needs, but USA has bigger transport needs and greater emissions on these needs than the rest of the world. There are also areas like south America where emissions for agriculture plays an important role. So for example electric vehicles like TESLA cars in U.S.A. are also a great step to the right direction.

The suffering planet. Earth is suffering from the way we treat to the planet. Climate changes, environmental disasters are only the beginning of the results we face today. The final step of this map analysis comes with maps like the change of temperature (Fig. 10), total deaths (Fig. 11) which are only two examples of our suffering planet.

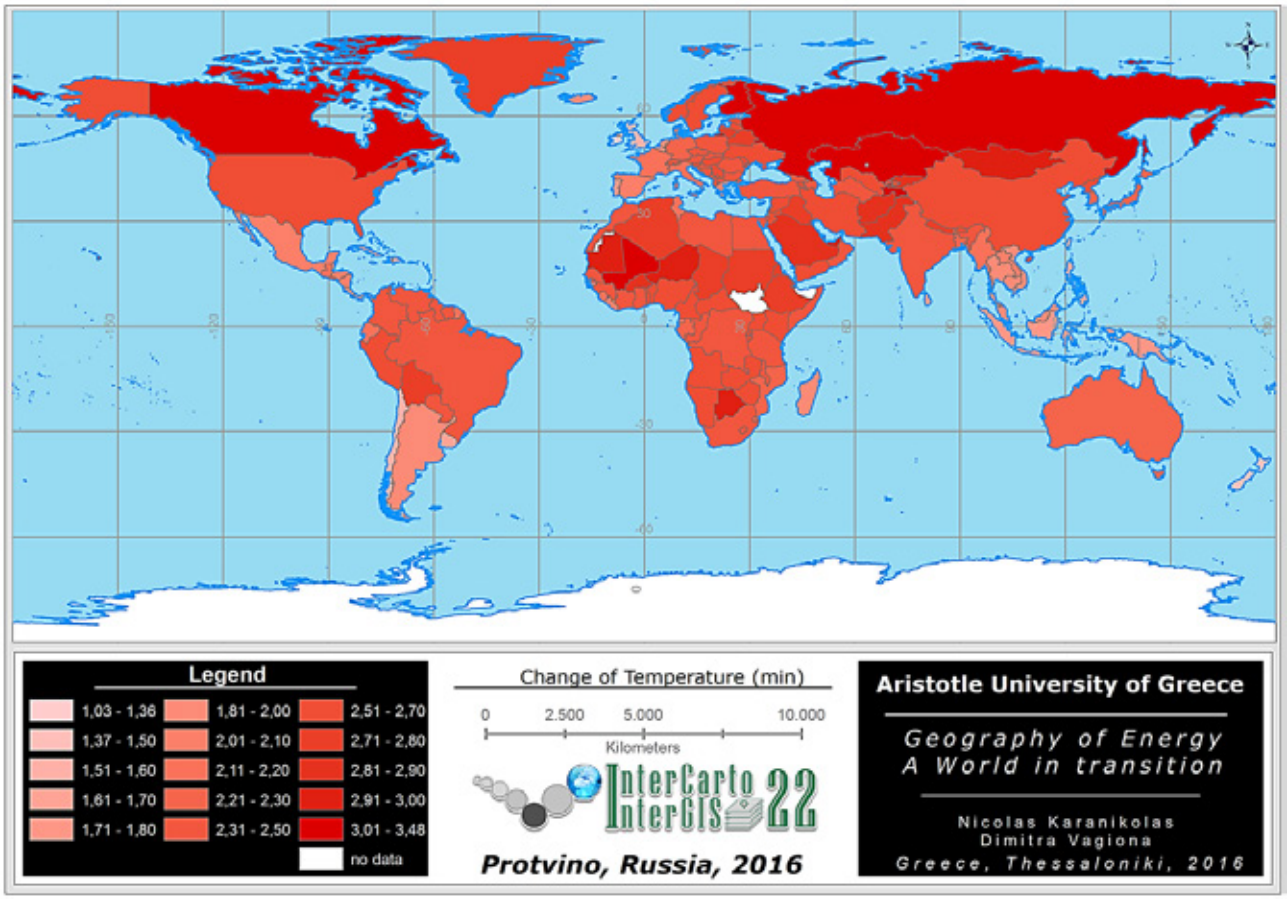

Fig. 10. Map showing the change of min temperature during last years

Conclusions. There are reasonable reasons to rethink about the way we produce energy. Geography teach us that there are no limits or borders in the results of the way we treat to the planet. Emissions, temperatures, climatological catastrophes are only the first results of what we have cause to our future. The relation between environment and society is one of the basic fields of geography of energy.

So Geography has to be the framework of explanation of many aspects of energy characteristics. Some of these characteristics can be marked as the following:

- The spatio-temporal characteristics of energy production, chains and use. This has to be done using many and different scales from international to regional scale.
- The geographical imaginaries of spatial identities of energy.
- Geographies of the past to future behaviors and patterns of energy.
- The interactions between energy producers and energy users.
- Political Geography of today's energy world.

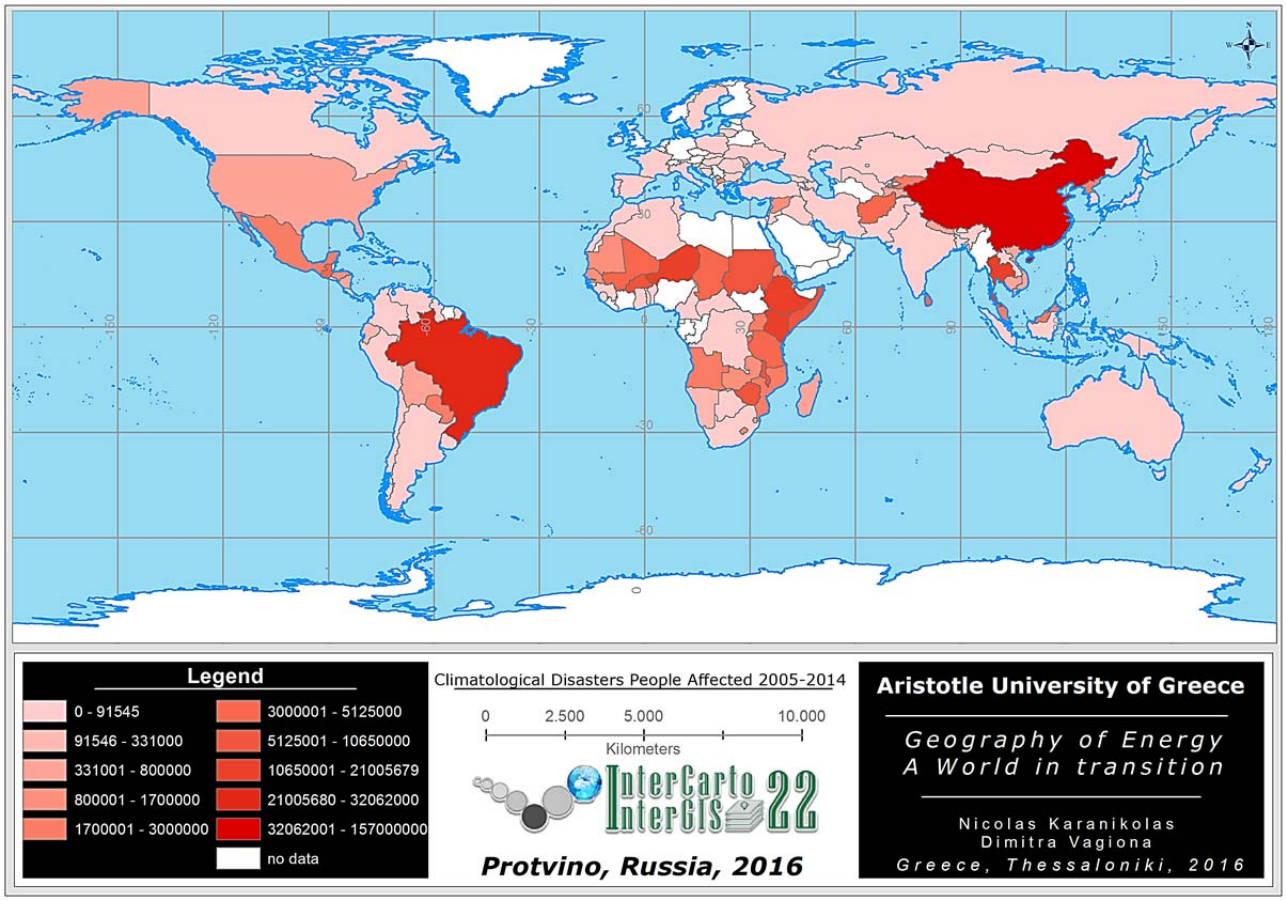

Fig. 11. Climatological map of people affected during last dacade

REFERENCES

1. *Andrews E., McCarthy J.* Scale, shale, and the state: political ecologies and legal geographies of shale gas development in Pennsylvania. Journal of Environmental Studies and Sciences, 2013, pp. 1–10.

2. *Bickerstaff K.* «Because we've got history here»: nuclear waste, cooperative siting, and the relational geography of a complex issue. Environment and Planning A 44: 2012, pp. 2611–2628.

3. *Bithas K., Kalimeris P.* Re-estimating the decoupling effect: is there an actual transition towards a less energy-intensive economy? Energy 51: 2013, pp. 78–84.

4. *Bridge G.* Heading 'downstream': Towards a cultural political economy of energy consumption. 'Intervention remarks' prepared for Energy Subjects: cultural economies of energy consumption Seminar 3 in the ESRC-funded 'Geographies of Energy Transition' series, Manchester October 15 2010, University of Manchester, 2010.

5. *Bridge G.* Teaching energy issues in Geography. Briefing report prepared for the School of Environment and Development, University of Manchester. July 2012.

6. *Calvert K., Pearce J and Mabee W.E.* Toward renewable energy geo-information infrastructures: applications of GIS and remote sensing that build institutional capacity. Renewable and Sustainable Energy Reviews 18: 2013, pp. 416–429.

7. *Calvert K., Mabee W.E.* Energy transition management as a 'spatial strategy'? Geographical implications of the transition toward renewable energy. Pennsylvania State University working papers, site: http://www.geog.psu.edu, access 2016.

8. *Calzonetti F.J., and Solomon B. (eds.).* Geographical dimensions of energy. Boston, MA: D. Reidel Publishing Company, 1985.

9. *Chapman J.D.* A geography of energy: an emerging field of study. The Canadian Geographer 1: 1961, pp. 10–15.

10. *Cook E.F.* Man, energy, society. San Francisco, USA: Freeman and Co. 1976.

11. *Court C.D., Jackson R.W., White N.* The role of regional science in shale energy development. The review of Regional Studies 42: 2013, pp. 99–105.

12. *Devine-Wright P.* Place attachment and public acceptance of renewable energy: a tidal energy case study. Journal of Environmental Psychology 31: 2007, pp. 336–343.

13. *Dorian J. P., Franssen H. T., Simbeck D. R.* Global challenges in energy. Energy Policy, Vol. 34, No. 15, 2006, pp. 1984–1991.

14. *Dorow S., O'Shaughnessy S. Fort McMurray,* Wood Buffalo, and the oil/tar sands: revisiting the sociology of «community»: Introduction to the special issue. Canadian Journal of Sociology 38(2): 2013, pp. 121–140.

15. *Farrell A.E., Brandt A.R.* Risks of the oil transition. Environmental Research Letters 1: 014004, 2006.

16. *Feder D.A.* Regionally based energy end-use strategy: case studies from Centre County, Pennsylvania. The Professional Geographer 56: 2004, pp. 185–200.

17. *Florini A., Sovacool B.K.* Who governs energy? The challenges facing global energy governance. Energy Policy, Vol. 37, No. 12, 2009, pp. 5239–5248.

18. *Frantal B., Pasqualetti M.J., Van den horst D.* New trends and challenges for energy geographies: Introduction to the special issue. Moravian Geographical Reports, 2/2014, vol. 22, 2014, pp. 2–6.

19. *Furlong K.* Small technologies, big change: Rethinking infrastructure through STS and geography. Progress in Human Geography 35: 2011, pp. 460–482

20. *Greene D.L., Hopson J.L., Li J.* Have we run out of oil yet? Oil peaking analysis from an optimist's perspective. Energy Policy 34: 2006, pp. 515–531.

21. *Harrison C.* The historical-geographical construction of power: electricity in eastern North Carolina. Local Environment 18: 2013, pp. 469–486.

22. *Hauser D.P.* System costs and the location of new generating plants in England and Wales. Transaction of the Institute of British Geographers 54: 1971, pp. 101–121.

23. *Horner M.W., Zhao T. and Chapin T.S.* Toward an integrated GIScience and energy research agenda. Annals of the Association of American Geographers 101: 2011, pp. 764–774.

24. *Huber M.* Energizing historical materialism: fossil fuels, space and the capitalist mode of production. Geoforum 40: 2008, pp. 105–115.

25. IEA: World energy outlook, 2012, 2013.

26. *Kedron P. and Bagchi-Sen S.* A study of the emerging renewable energy sector within Iowa. Annals of the Association of American Geographers 101: 2011, pp. 882–896.

27. *Kittel C., Kroemer H.* Thermal Physics. Macmillan. ISBN 9780716710882, 1980.

28. *Leach G.* The energy transition. Energy Policy 20: 1992, pp. 116–123.

29. *Li W., Stadler W. and Ramakumar R.* Modelling and assessment of wind and insolation resources with a focus on their complementary nature: a case study of Oklahoma. Annual Association of American Geographers 101: 2011, pp. 717–729.

30. *Luten D.R.* The economic geography of energy. The scientific American 224: 1971, pp. 164–175.

31. *Mabee W., Mirck J.* A regional evaluation of potential bioenergy production pathways in Eastern Ontario, Canada. Annals of the Association of American Geographers 101: 2011, pp. 897–906.

32. *Manners G.* The Geography of energy. London, UK: Hutchinson & Company, 1971.

33. *Nadaï A., Labussière O.* Playing with the line, channeling multiplicity: wind power planning in the Narbonnaise (Aude, France). Environment and Planning D 31: 2013, pp. 116–139.

34. *Neville K.J., Dauvergne P.* Biofuels and the politics of mapmaking. Political Geography 31: 2012, pp. 279–289.

35. *Nguyen H.T., Pearce J.M.* Estimating potential photovoltaic yield with r.sun and the open source Geographical Analysis Support System. Solar Energy 84: 2010, pp. 831–843.

36. *Owens S.* Energy, planning and urban form. London, UK: Pion, 1986.

37. *Pasqualetti M.J.* Social barriers to renewable energy landscapes. Geographical Review 101: 2011, pp. 201–223.

38. *Pasqualetti M.J.* The geography of energy and the wealth of the world. Annals of the Association of American Geographers 101: 2011, pp. 971–980.

39. *Pryde P.R.* Energy courses in American geography departments. Journal of Geography 84: 1985, pp. 154–157.

40. Renewable Energy Network 21 (REN21). Renewables 2012: Global status report, 2012.

41. *Sabins F.F.* Remote sensing for energy resources. In Encyclopedia of energy: Volume 2, ed. C.J. Cleveland, San Diego, CA: Elsevier, 2004, pp. 291–300.

42. *Simon C.A.* Alternative Energy: political, economic and social feasibility Lanham, MD: Rowman and Littlefield Publishers, 2005.

43. *Solomon B.D., Pasqualetti M.J., Luchsinger D.A.* Energy geography. In Geography in America at the Dawn of the 21st Century, ed. G. Gaile and C. Willmott, Oxford, UK: Oxford University Press, 2004.

44. *Solomon B.D., Pasqualette M.J.* History of energy in geographic thought, In Encyclopedia of energy: Volume 2, ed. C.J. Cleveland, San Diego, CA: Elsevier, 2004, pp. 831–842.

45. *Spinney J., Green N., Burningham K., Cooper G., Uzzell D.* Are we sitting comfortably? Domestic imaginaries, laptop practices, and energy use Environment and Planning A 44: 2012, pp. 2629–2645.

46. *Spooner D.J.* The geography of coal's second coming. Geography 66: 1981, pp. 29–41.

47. *Spooner D.J.* New geographies of energy. In: Kent A., (Ed), Reflective Practice in Geography Teaching. Kent, London, UK: Paul Chapman Publishing Ltd. 2000, pp. 68–83.

48. *Van der Kroon B., Brouwer R., can Beukering P.J.H.* The energy ladder: theoretical myth or empirical truth? Results from a meta-analysis. Renewable and Sustainable Energy Reviews 20: 2013, pp. 504–513.

49. *Van Zyl F.D.W.* Power supply and industry in South Australia. The Australian Geographer 6: 1968, pp. 507–514.

50. *Wang S., Leduc S., Obersteiner M., Schill C., Koch B.* A new thinking for renewable energy model: Remote sensing-based renewable energy model. International Journal of Energy Research 33: 2009, pp. 778–786.

51. *Warr B., Ayres R., Eisenmenger N., Krausmann F., Schandl H.* Energy use and economic development: a comparative analysis of useful work supply in Austria, Japan, the United Kingdom and the US during 100 years of economic growth. Ecological Economics 69: 2010, pp. 1904–1917.

52. *Zimmerer K.* New Geographies of Energy: Introduction to the Special Issue. Annals of the Association of American Geographers. Vol. 101, No. 4, 2011, pp. 705–711.

53. *Zvoleff A., Kocaman A.S., Huh W.T., Modi V.* The impact of geography on energy infrastructure costs. Energy Policy 37: 2009, pp. 4066–4078.

УДК 528.942

А.М. Карпачевский[1], **О.Г. Филиппова**[2]

КАРТОГРАФИЧЕСКАЯ ОЦЕНКА ВЕРОЯТНОСТИ КАСКАДНЫХ АВАРИЙ В ИЗОЛИРОВАННЫХ ЭНЕРГОСИСТЕМАХ ВОСТОКА РОССИИ

Резюме. *Описан способ представления электросетей с помощью графа. Рассмотрено понятие структурной уязвимости сети как ключевого свойства надежности энергоснабжения, позволяющего оценить вероятность каскадных аварий в энергосистемах. Разрабо-*

[1] Московский государственный университет имени М.В. Ломоносова, географический факультет; e-mail: karpach-am@yandex.ru.

[2] Московский государственный университет имени М.В. Ломоносова, географический факультет; e-mail: missnothing96@yandex.ru.