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Climate Change as a Driving Force on Urban Energy Consumption Patterns

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INTRODUCTION

Climate change has impacted on Iranian natural ecosystems and urban area in various ways (Jafari, 2010). Climatic factors, including temperature, precipitation and humidity have changed in pattern in recent decades (Jafari, 2011). Changes in temperature and precipitation patterns could have impacts on urban areas as well as forests, rangelands and desert ecosystems (Jafari, 2008a). Changing climate patterns and increasing pollution may lead to changed production patterns (Jafari, 2012a) or may increase pressure on the environment (Jafari, 2012b). Environmental sustainability among two others, Energy security and Energy equity are the world energy trilemma (Wyman, 2013). Attempts to mitigate climate change need to be done without compromising food security or environmental goals (Smith *et al*., 2013).

In this paper, we present a case study, from Rasht City in Iran, to show how changing climate is expected to have influenced energy consumption patterns. We use climatic data to determine the number of days when heating and cooling demands occurs, using Heating Degree Days (HDDs) and Cooling Degree Days (CDDs). These are based on daily temperature observations, with each month having at least 25 records and no less than 15 years of data (Anonymous, 2008a). HDD and CDD, which indicate the level of comfort, are based on the average daily temperature which is taken as the mean of maximum and minimum daily temperature (the National Oceanic and Atmospheric Administration – US NOAA).

If the average daily temperature falls below comfort levels, heating is required and if it is above comfort levels, cooling is required. HDD is an index of the energy demand to heat buildings, and an analogous index for the energy demand for cooling is represented by cooling degree days (Sivak, 2013). The HDDs or CDDs are determined by the difference between the average daily temperature and the BASE (comfort level) temperature. The BASE values used are 12 and 18 degrees Celsius for heating and 18 and 24 degrees Celsius for cooling (Anonymous, 2008a). In this case, base degrees for heating are 18°C and for cooling is 21°C. For example, if heating is being considered to a temperature BASE of 18 degrees, and the average daily temperature for a particular location was 14 degrees, then heating equivalent to 4 degrees or 4 HDDs would be required to maintain a temperature of 18 degrees for that day. However if the average daily temperature was 20 degrees then no heating would be required, so the number of HDDs for that day would be zero. If cooling is being considered to a temperature BASE of 21 degrees, and if the average temperature for a day was 27 degrees, then cooling equivalent to 6 degrees or 6 CDDs would be required to maintain a temperature of 21 degrees for that day. However if the average temperature was 20

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degrees, then no cooling would be required, so the number of CDDs for that day would be zero. Similar estimates have been made in the USA, mainly using the Fahrenheit temperature scale (Anonymous, 2008c; Anonymous, 2008d). Costs are calculated by multiplying the HDD or CDD by the average daily cost of heating or cooling (Anonymous, 2008e).

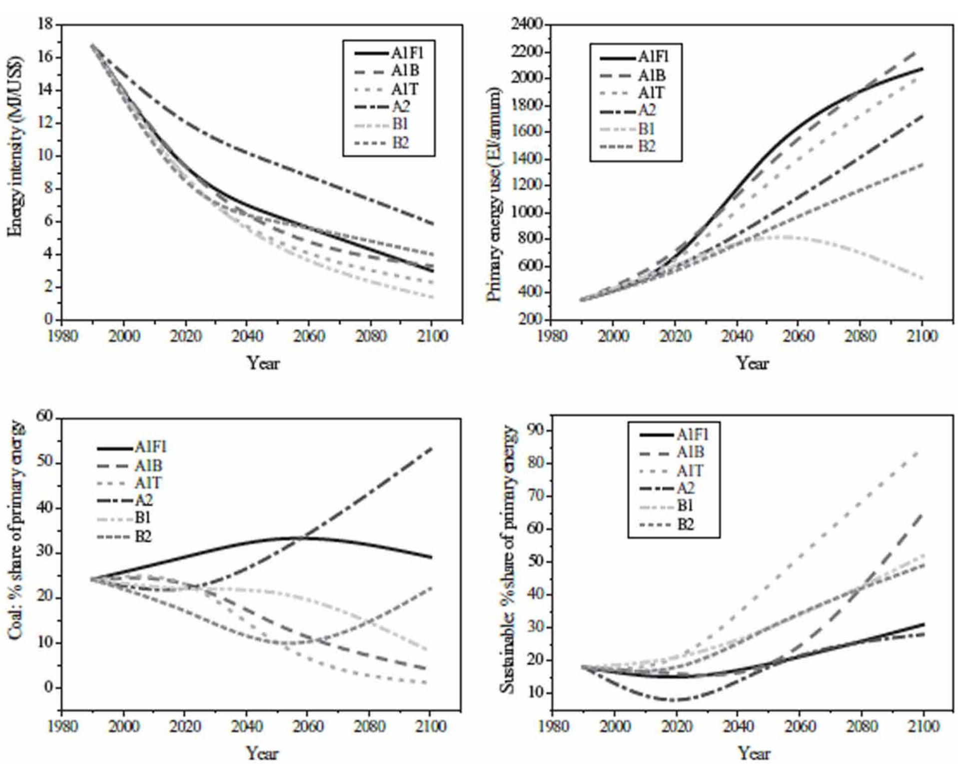
HDD can be added over periods of time to provide a rough estimate of seasonal heating requirements. In the course of a heating season, for example, the number of HDD for New York City is 5,050 whereas that for Barrow, Alaska is 19,990. Thus, one can say that, for a given home of similar structure and insulation, around four times the energy would be required to heat the home in Barrow than in New York. Likewise, a similar home in Los Angeles, California, where heating degree days for the heating season are 2,020, it would require around two fifths the energy required to heat the house in New York City (Anonymous, 2012).

The following figures (Figure 1) show some of the energy-based driving forces within the scenarios that are particularly important to us. The world faces a range of futures, with the possibility that energy intensity (efficiency) might improve by a factor of eight by 2100: primary energy use rise initially under all scenarios, then decrease slightly or increase by a factor of 3.3: coal use may increase slightly, or almost disappear completely: and alternative, non-carbon, energy sources (including non-commercial) may halve in importance or become the norm. The question is which future will we choose? (Coley, 2008).

Our civilization and our standard of living depend on an adequate supply of energy. We need energy to light and heat our homes, to cook

Figure 1. Energy-based driving forces of SRES illustrative scenarios, A1F1, A1B, A1T, A2, B1, B2:1980-2100 [data from IPCC 00]; energy intensity (MJ/US$): top left; primary energy use (EJ/ annum): top right; coal: % share of primary energy: down left; sustainable: % share of primary energy: down right

Source: adapted from data in Emission scenarios: summary for policy makers, IPCC, 2000, www.ipcc.ch/pub/synergy.htm



our food, to drive our transport and power our communications and to provide the motive force that drives the factories. Without energy all this would be impossible on the scale needed, and our civilization would soon collapse. Our dependence on energy is strikingly illustrated by the connection between average life expectancy and energy consumption (Hodgson, 2010). Climate is one of the determining features of civilization, so any change in the climate can have momentous consequences (Hodgson, 2010). The importance of climate for civilization is further discussed by Hodgson (2010).

BACKGROUND

An attempt has made to evaluate climate change impact on different sectors including natural ecosystem and urban areas. Outcomes obtain from research project in urban zone which is near to forest area may help to recognized its impact on natural ecosystem in one way or another (Jafari, 2013). According to the research outcome, consideration and analysis on Energy Consumption Pattern and GDP in global level in different developed and developing countries it has been proved that, GDP and Energy Consumption of developing countries are increasing exponentially, while GDP and Energy Consumption of developed countries are increasing linearly (Akhter Hossain, 2012).

ENERGY CONSUMPTION PATTERN

Energy consumption patterns have changed in urban environments during the last few decades. Climate and environmental changes can be considered as one of the main driving forces for the changing pattern. Climate change has impacted on Iranian natural ecosystems and urban area in various ways. Climatic factors, including temperature, precipitation and humidity have changed in pattern in recent decades. Changes in temperature and precipitation patterns could have impacts on urban areas as well as forests, rangelands and desert ecosystems. Changing climate patterns and increasing pollution may lead to changed production patterns or may increase pressure on the environment. Environmental sustainability among two others, Energy security and Energy equity are the world energy trilemma. Attempts to mitigate climate change need to be done without compromising food security or environmental goals. This research investigated the phenomenon in Rasht city, Iran. HDD, in cases where temperatures are below 18°C, and CDD, in cases where temperatures are above 21°C, were used as energy consumption indices. During the last half century, mean annual temperatures have increased and as a consequence, CDD in the warm season have increased sharply. In the same time slice, HDD, even in the cool and cold season have declined steadily. This present work shows that energy consumption patterns have increased sharply, and with available projection scenarios, is projected to increase more rapidly, leading to higher energy costs.

STUDY METHOD

Electricity Energy and Heating Oil

Site-specific total electricity energy and heating oil consumption for individual residences show very high correlation with national weather temperature data when transformed to heating degree days (Quayle & Diaz, 1979). In this investigation, past climate conditions for temperature in Rasht City were considered. Energy demand for climate control was analyzed for Rasht city. The relevant parameters, climatological deviations from the desired indoor, were analyzed (Sivak, 2013). HDD, in cases where temperatures are below 18°C, and CDD, in cases where temperatures are above 21˚C, were used as energy consumption indices. Heating degree days and cooling degree days were analyzed (Jafari, 2013).

Location

Rasht is situated on the western part of the Albourz Mountain Range in the North West of Iran. The location of the study area is shown in Figure 2.

Temperature

Changing trends of temperature and precipitation in the last fifty years of the Caspian region have been investigated (Jafari, 2008a). In Rasht City, in the last 49 years (ended by 2005) precipitation increased by 56.4 mm and mean temperature increased by 1.28˚C. Minimum temperature increased by 2.45˚C and maximum temperature by 0.08˚C.

Past Climate Changes in Rasht

Past climate conditions for temperature in the region were analyzed in synoptic (49 years, 1956-2005) and climatology (Pasikhan climatology station which is nearest station to Rasht, 22 years, 1983-2005) stations. Two important factors, HDD and CDD, in Rasht, were considered. Mean annual daily temperature (15+0.02˚C) (1.28˚C increase) and mean annual minimum (10+0.05˚C) (2.45˚C increase) and maximum (20+0.001˚C) (0.08˚C increase) temperatures have increased (Jafari 2008a). The HDD trend decreased in the last 49 years (1652 → 1470.7) (Figures 3a and 3b), while at the same time, CDD has increased sharply (298

Figure 2. Study area location

Source: Maps from different sources: IPCC 2007 Asia WGII Chapter 10, Google, http://en.wikipedia.org/wiki/File:Locator_map_Iran_Gilan_Province.png

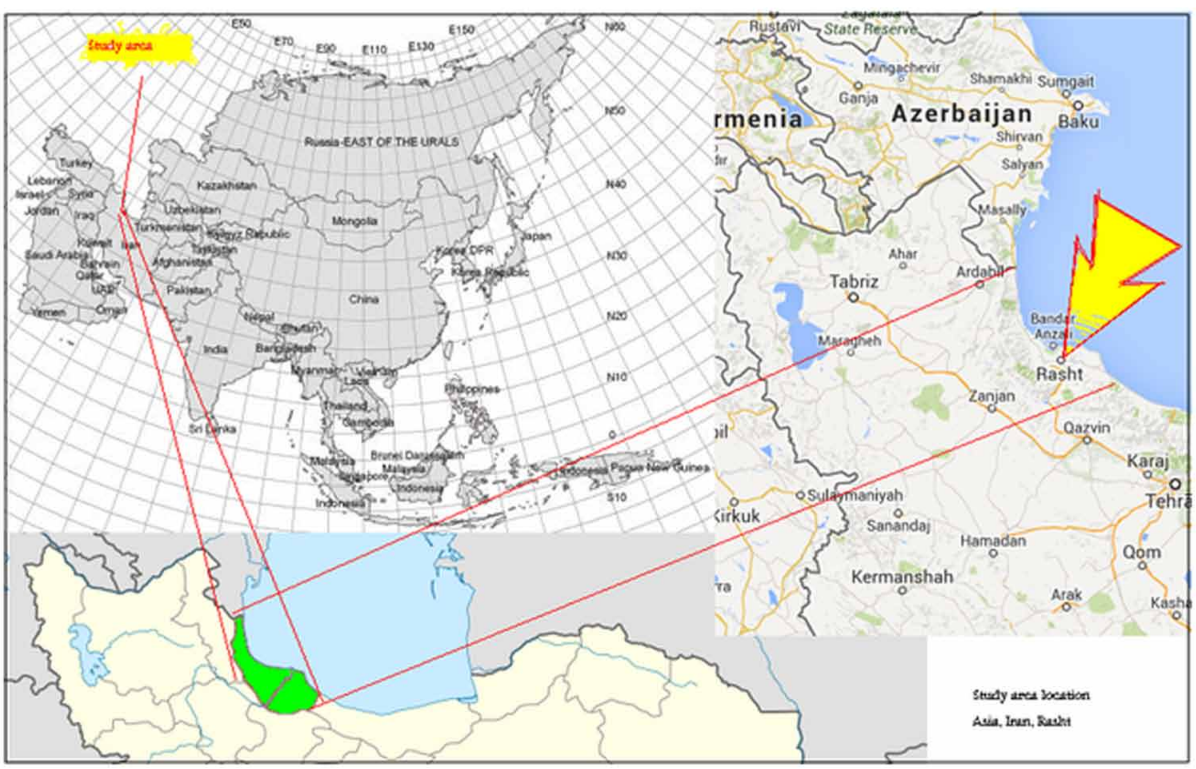


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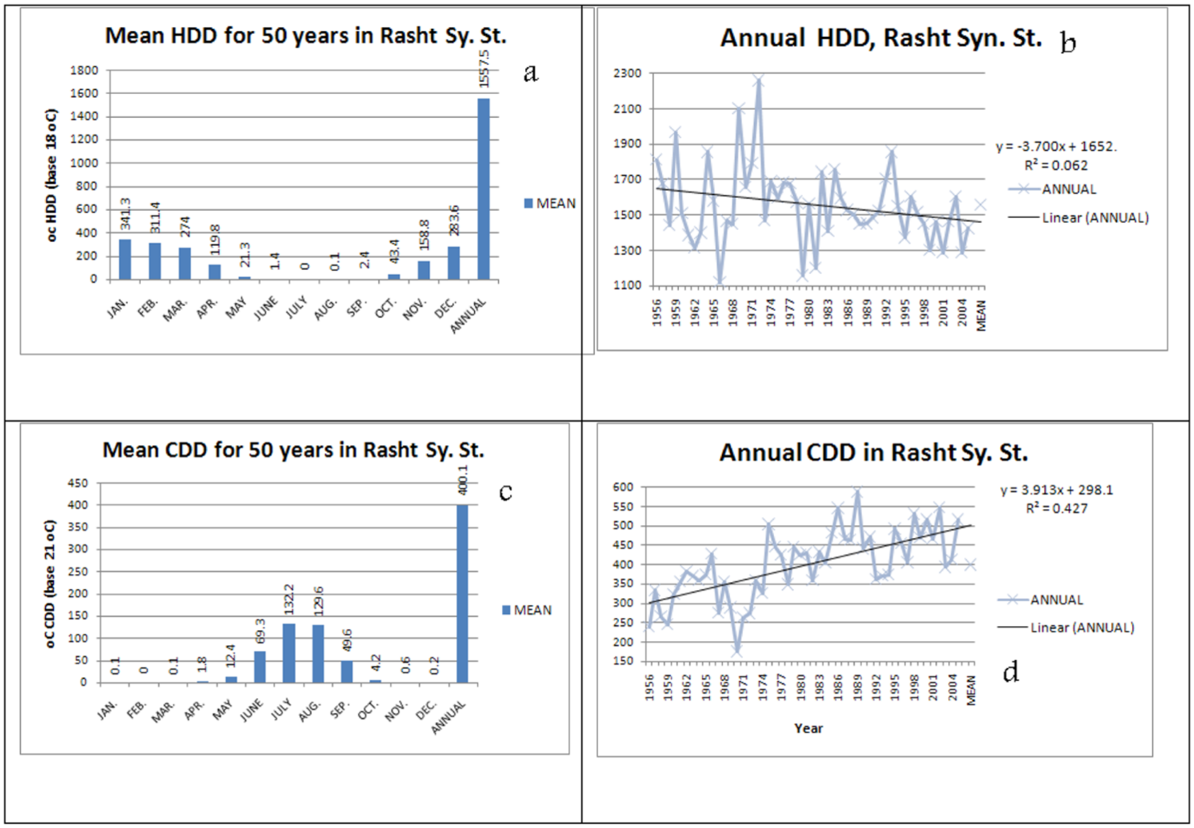
Figure 3. Rasht synoptic station, 1956 – 2005, total monthly mean: a) mean heating degrees days °C (based upon 18°C); b) linear trend of mean heating degrees days, °C; c) mean cooling degrees days, °C (based upon 21°C); d) linear trend of mean cooling degrees days, °C



→ 490) (Figures 3d and 3c),) indicating a warming trend in the Rasht region.

Investigation on Climate Change Projections in Rasht

Based on IPCC data and models in global scale and national data and information, downscaling maps at national and regional scales (Figure 4) have been produced (Anonymous, 2008b). Temperature in study area of Rasht is projected to increase between 1.2 to 1.4°C. Mean temperature of Gilan province for the time slice of 1976-2005 was about 16.2°C, and is projected to increase by 1.3°C, to reach to 17.5°C for the period of 2010-2039. Based on the same results, projections for the future, the number of hot days in Rasht region will increase by between 11-20 days, and the number of freezing days will decrease by between -11 and -8 days.

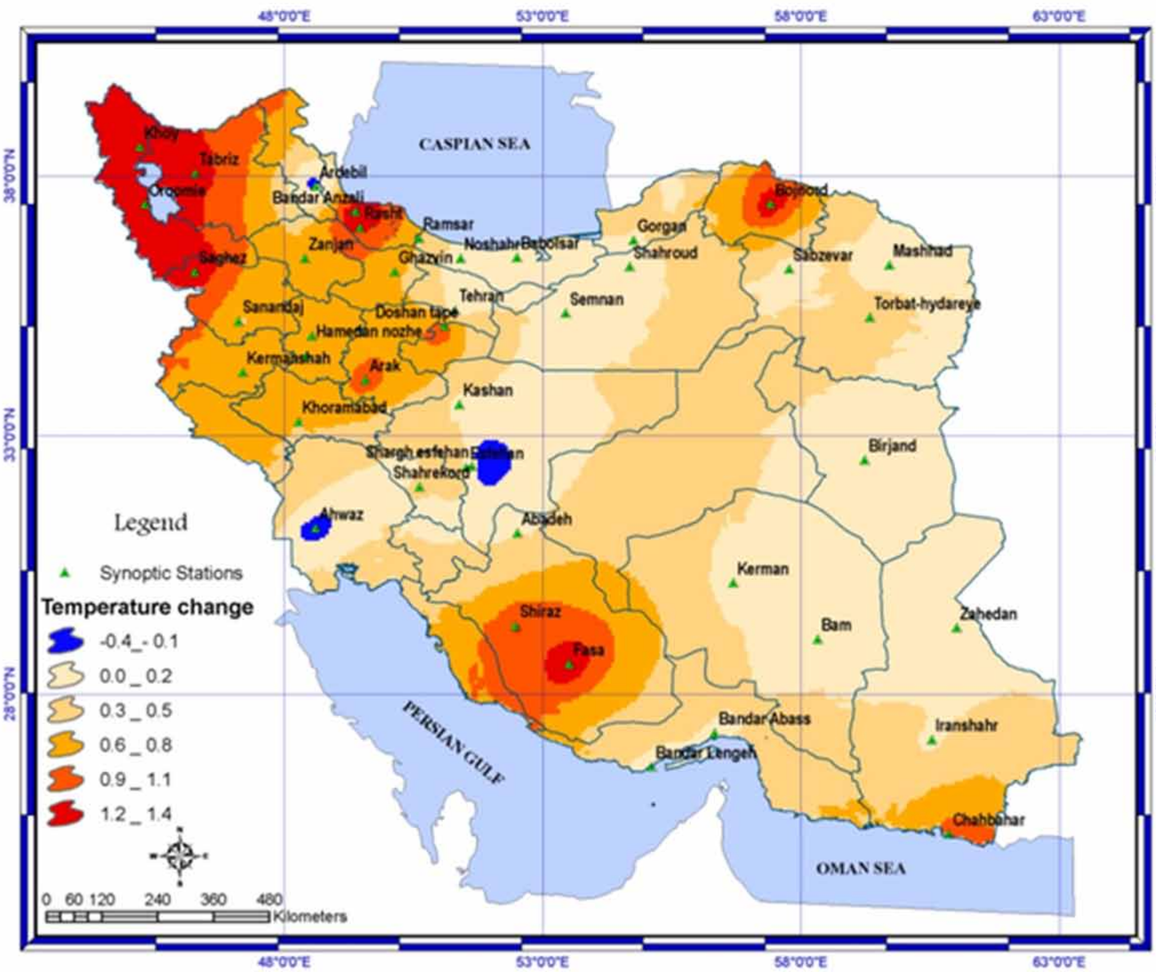
RESULTS

Heating Degree Days (HDD) and Cooling Degree Days (CDD)

In the Rasht case study, total monthly heating degrees recorded in the winter season reached 341.3 degrees of centigrade (January) which is about 11.37 degrees per day (Figure 3a). In the same period, cooling degrees was 0.1 (Figure 3c).

Total monthly cooling degrees recorded in the summer season reached 132.2 degrees of centigrade (July) which is about 4.40 degrees per day

Figure 4. Distribution of mean temperature differences comparing 2010-2039 with 1976-2005 according to the downscaling of ECHO-G model outputs
Source: Anonymous, 2008b



(Figure 3c). In the same period heating degree is about zero (Figure 3a).

The trend in HDD has decreased in last 49 years (1652 → 1470.7) (Figures 3a and 3b), while in the same period CCD has increased at a sharper rate (298 → 489.7) (Figures 3c and 3d). These factors certify the warming trend in the Rasht region.

Total annual heating degrees in years 1956 in Rasht station was 1652 degrees of centigrade (Figure 3b) and total annual cooling degrees was recorded as 298 degrees of centigrade (Figure 3d). During the 49 years between 1956 and 2005, the trend of mean annual temperature increased from 15°C by about 0.02°C to 15.02°C

This warming caused a decrease of total annual heating degrees by about 181.3 degrees of centigrade per year down to total annual of 1470.7°C (Figure 3b). Total annual cooling degrees increased by about 191.7°C per year up to total annual of 489.7°C (Figure 3d).

Decrease of 181.3°C per year of heating degrees and increase of 191.7°C of cooling degrees gives a difference of total of 10.4°C (191.7 – 181.3 = 10.4°C) of extra energy consumption over the 49 year period.

Differences of HDD and CDD in year 1956 (1652-298= 1354) and year 2005 (1470.7- 489.7=

981) shows about 373 degrees (1354-981= 373), which is large.

The price of weather derivatives traded in the summer is based on an index made up of monthly CDD and HDD values. The settlement price for a weather futures contract is calculated by summing a month's CDD and HDD values and multiplying by $20.

HDD monthly cost = HDD × 30 (days of month) × 20 US$

In the Rasht case study a difference of annual total of 10.4°C calculated for an energy saving over 49 years' time. If we want to calculate cost as a rate of $20 similar to USA conditions, after converting Celsius to Fahrenheit, it would be about $374.4 as follow:

$10.4 \times 9/5 = 18.72$

$18.72 \times \$20 = \$ \quad 374.4$

Temperature Changes

Based on recorded data in synoptic station, in Rasht during last forty-nine years, daily maximum (0.08°C), minimum (2.45°C) and mean (1.18°C) of temperature have increased.

Annual HDD with a base temperature of 18°C have reduced in the last 49 years (Figure 5e). HDD in January, which is a cold month, also slightly reduced. During the same period, annual CDD increased sharply (Figure 5f). CDD in July, August and September, which are warm months, also sharply increased (Figure 5d).

In Rasht City, total monthly heating degrees recorded in the winter season reached 341.3°C (January) which is about 11.4°C per day (Figure 3a). During the same period, cooling degrees were 0.1 (Figure 3c).

Total monthly cooling degrees recorded in the summer season reached 132.2oC (July) which is about 4.4°C per day (Figure 3c). During the same period, heating degrees were close to zero (Figure 3a).

SOLUTIONS AND RECOMMENDATIONS

Research work outcome on climate change impact on energy consumption pattern could help to plan better an adaptation action program.

It is a need to enhance much more research projects to consider climate change impact on natural resources including forest and firewood consumption.

FUTURE RESEARCH DIRECTIONS

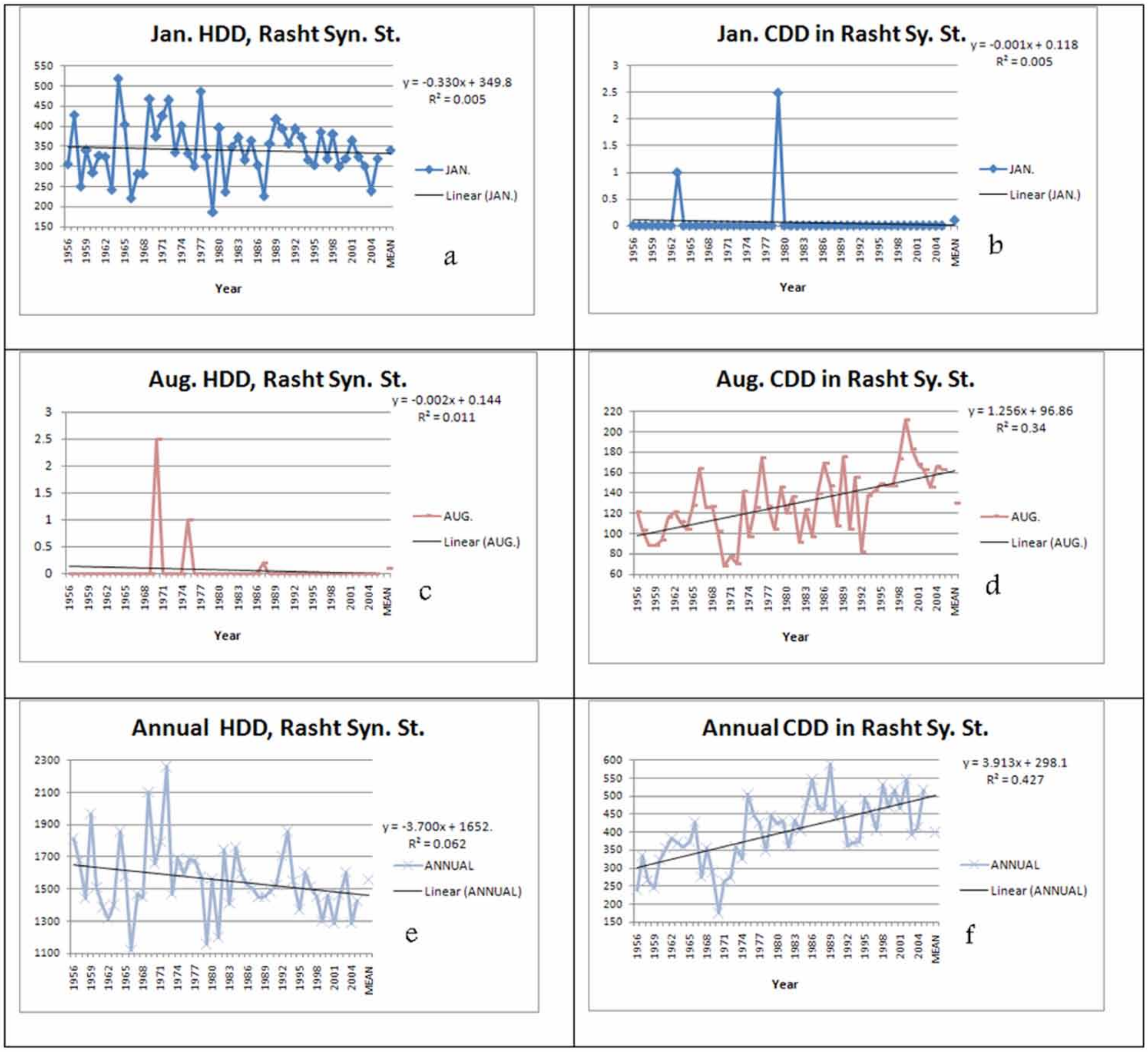
As it has been mentioned earlier, main field of research project should be identified for consideration of climate change impact on different sector in related to the energy consumption.

One direction is cooling and heating energy consumptions and other direction is using biomass as energy resources and it comparing with fossil fuel consumptions.

CONCLUSION

Climate change is driven by the cumulative amount of GHGs emitted to the atmosphere (Meinshausen, *et al.,* 2009; Solomon *et al.,* 2010), in particular of long-lived species such as carbon dioxide (CO_2) (Huber & Knutti, 2012). Therefore, to halt anthropogenic climate change, global GHG emissions need to be reduced to virtually zero in the long term (Matthews & Caldeira, 2008). Achieving this will require massive transformations of all GHG-emitting sectors. Given that the global energy system (which supplies fuels and electricity to the residential/commercial, industrial and transportation end-use sectors) is currently responsible for about 80% of global CO_2 emissions (RCP Database, 2009; Boden *et al*., 2012), transformations in this sector will be essential for realizing a low-carbon future. Moreover, the need for transformational change in the energy system has also been advocated for other important reasons, for instance to spur sustain-

Figure 5. Rasht synoptic station, 1956 – 2005, monthly and annual total HDD (˚C, base 18˚C) and CDD (˚C base 21˚C): a) HDD in January, b) CDD in January, c) HDD in August, d) CDD in August, ˚C, e) HDD for total annual, and f) CDD for total annual

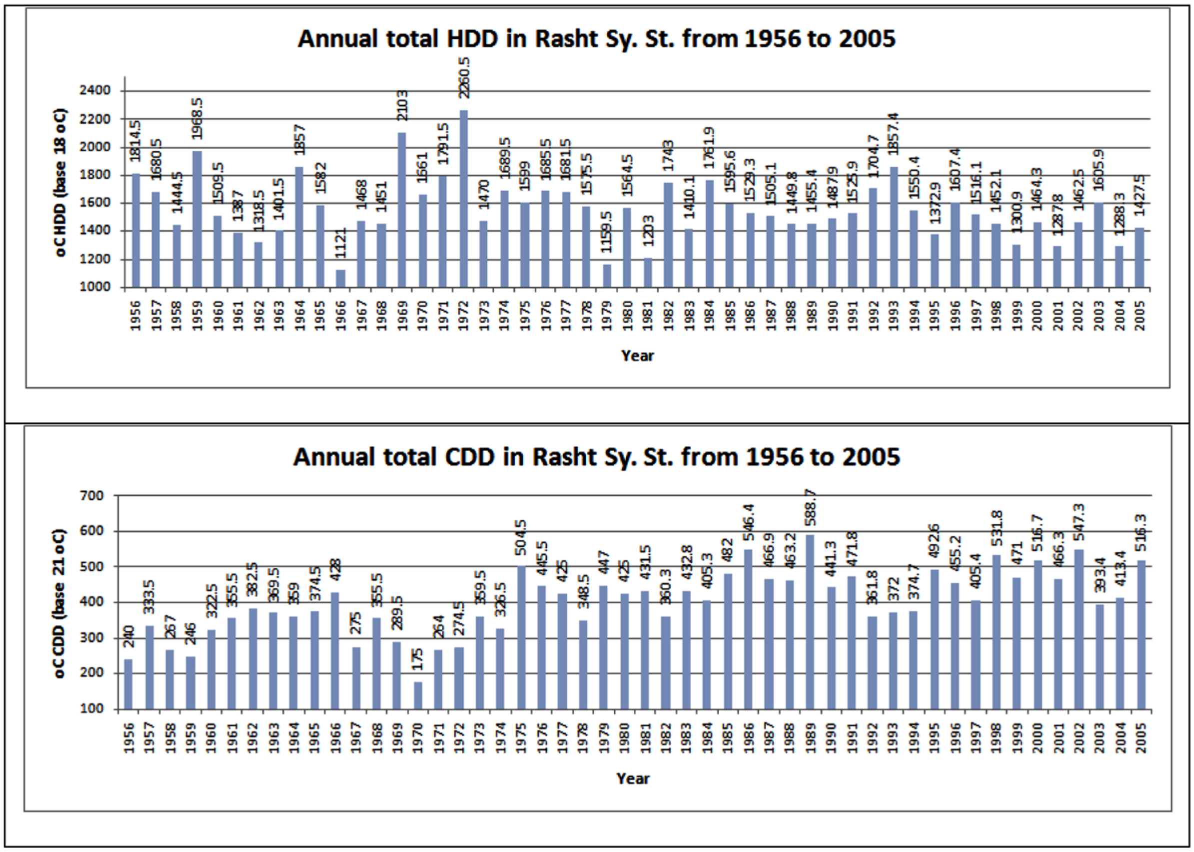


able development or to improve the well-being of the impoverished billions in our society who lack regular access to modern forms of energy to meet their basic needs. From this perspective, we look at how energy-related targets fostering the abovementioned objectives would, or would not, be consistent with global climate protection (Rogelj *et. al*., 2013).

Mean annual temperature and even minimum temperature in last half century in Rash city has increased (Jafari, 2008a), Table 1). Projections for future temperature changes in Rasht are mainly documented for increasing temperature and the extent of temperature increase varies by scenario (Jafari, 2012c).

The data provided by Energy in Focus, BP Statistical Review of World Energy, BP Plc, 2004, bpdistributionservices@bp.com, and adapted by Coley, (2008) shows how energy is spilt across the world. Obvious inequalities can be observed in

Figure 6. Rasht synoptic station, 1956 – 2005, annual total HDD (°C, base 18°C) (top), CDD (°C base 21°C) (bottom)



how the world's primary energy is shared out, with North America (mainly the USA) using almost ten times more primary energy than the whole of Africa. This point is re-emphasized if we divide national primary energy use by national population, to give the energy use per capita (Figure 7). Much of the world is seen to use less than 63 GJ (1.5 Toe) (see end note) per capita per annum, whereas others use many times this (Coley, 2008). The annual primary energy consumption per capita (toe) (ENE, 2004) for Iran is in the range of 1.5-3, which in the development process, may increase.

As reported by National Iranian Oil Co. (NIOC 2007), in comparison of years 2006 and 2007, consumption of white oil (petroleum) has decreased by – 5.7%. This decrease may be described of effect of warming as well as subsidy payment policy (Table 1, data obtained from NIOC (2007) and modified by authors).

Rasht city, according to the IPCC assessments report, is located in both Central Asia and West Asia sub-regions (Cruz *et al.*, 2007). Based on the projection for Central Asia sub-region, the region will face with higher degrees of temperature change. Downscaled projections in local level project that Gilan province as a whole will have a higher degree of temperature change than the western part of the province. Westwards into the mountainous area, a reduction in temperature is projected. Downscaling and projection of seasonal extreme daily precipitation has been studied elsewhere (Wang & Zhang, 2008).

Based upon mean monthly temperature changes in Rasht city, Jan. & Feb. were recorded

Figure 7. Annual primary energy consumption per capita (toe)
Source: ENE (2004). Reprinted from Energy in Focus, BP Statistical Review of World Energy, BP Plc, 2004, bpdistribution-services@bp.com

Table 1. Comparison of energy consumption changes in Rasht city for years 2006 and 2007

Rasht City	Consumption (1000 Lit.)		Consumption Changing Rate (%)	Subsidy 2007	
	2006	2007		1000 US$	Million Rials
Petroleum (White Oil)	126136	118906	- 5.7	66485	618311
Gas Oil	442099	594478	34.5	326004	3031838
Heating Oil	7128	8884	24.6	2961	27540

Source: Data obtained from NIOC (2007) and modified by authors

as coldest months and July & Aug. were recorded as warmest months (Figure 8 – top).

Monthly mean HDD and CDD changes are in high correlation with temperature changes pattern (Figure 8 – middle).

Marginal plot of annual total CDD vs HDD presents distributed dots as normal form for HDD, but for CDD is presented a little abnormality, which may refer to changing and increasing pattern of temperature (Figure 8 – bottom).

The amount of monthly and annual total of HDD (mean= 1556 Figure 9 bottom) are much higher than CDD (mean=400 Figure 9 top) in the investigated area. Even though, annual total HDD and CDD have a negative correlation (Pearson correlation = - 0.493; $p< 0.001$).

HDD declines only a little and steadily (R2= 0.062 Figure 3b, p =0.099 Figure 9 bottom), but CDD increases sharply during the same time slice (R2=0.427 Figure 3d, p =0.813 Figure 9 top). This means that the energy consumption pattern is expected to have increased sharply, and is expected to increase more rapidly in the future, which will result in increased costs.

Energy consumption for heating and cooling are driven by climate factors such as temperature, and is expected to change with a changing climate elements. Energy optimization solutions should

Figure 8. Recorded mean monthly temperature changes in Rasht city (top), Rasht synoptic station, 1956 – 2005, CDD (base 21°C) and HDD (base 18°C) for mean months for 50 years (middle), and marginal plot of annual total of CDD and HDD for 50 years (bottom)

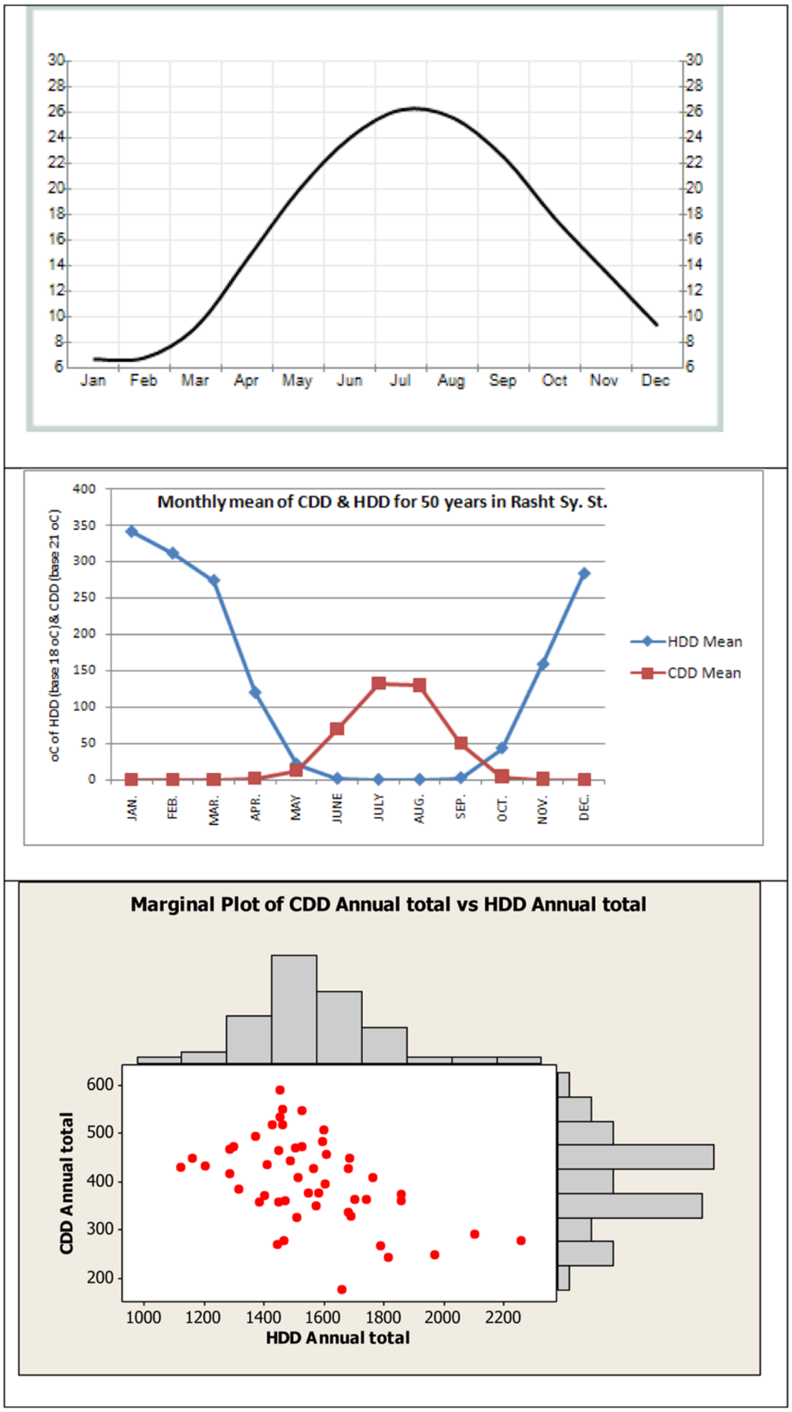
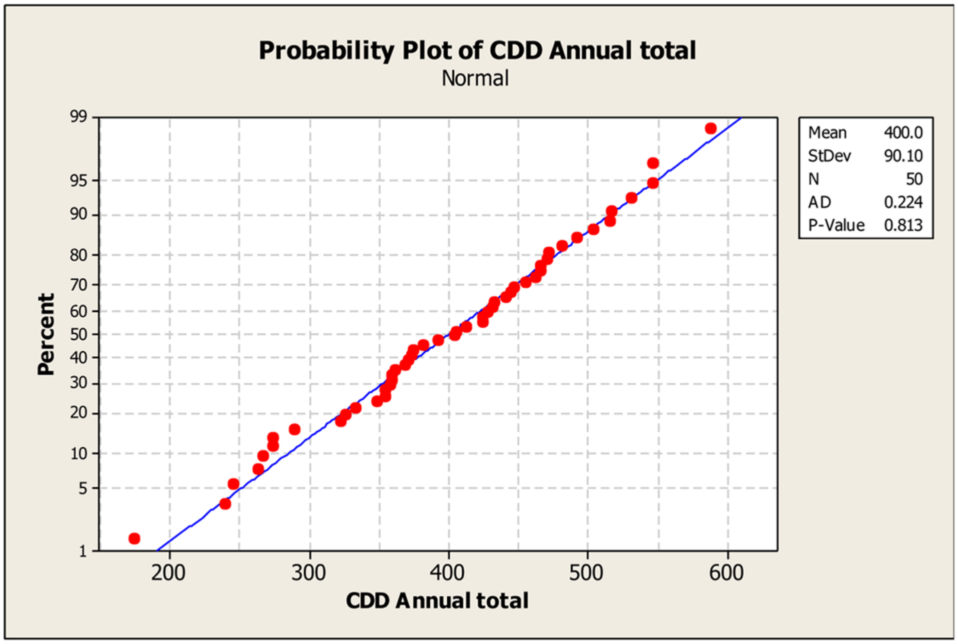
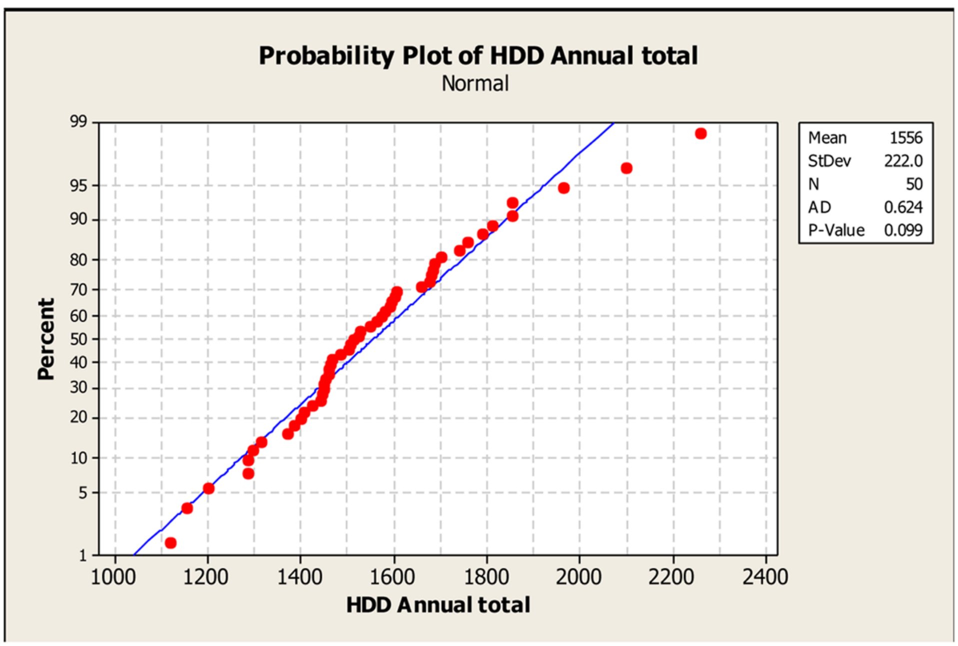


Figure 9. Rasht synoptic station, 1956 – 2005, probability plot of annual total of CDD (base 21°C) (top), and HDD (base 18°C) (bottom)





be considered, as an important energy related issue. It has been investigated in Nigeria at country level (Anayochukwu & Ndubueze, 2012). Results obtained by the Sivak (2013), in USA indicate that climate control in Minneapolis (the coldest large metropolitan area in the US) is about 3.5 times as energy demanding as in Miami (the warmest large metropolitan area in the US). This finding suggests that, in the US, living in cold climates is more energy demanding than living in hot climates (Sivak, 2013).

Heating degrees, cooling degrees are factors which impact on energy consumptions and these have changed, and are projected to change further in the future in Rasht City, unless mitigated by improved building energy performance, as suggested for Greece (Maleviti 2012). Heating and cooling energy demands have changed in Rasht by 10.4°C between 1956 and 2005, representing an annual extra cost of ~$374, calculated based upon US daily costs for heating and cooling.

REFERENCES

Anayochukwu, A. V., & Ndubueze, N. A. (2012). Energy Optimization at GSM Base Station Sites Located in Rural Areas. *International Journal of Energy Optimization and Engineering*, *1*(3), 1–31. doi:10.4018/ijeoe.2012070101

Anonymous. (2008a). *Australian government, Bureau of meteorology.* Retrieved from http://www.bom.gov.au/index.shtml

Anonymous (2008b). *CC IRIMO, National Centre of Climatology*. Islamic Republic of Iran Meteorological Organization, Downscaling Report.

Anonymous. (2008c). *Nebraska Public Power District.* Retrieved from http://www.nppd.com/

Anonymous. (2008d). *NOAA, The National Oceanic and Atmospheric Administration*. Retrieved from http://www.noaa.gov

Anonymous. (2008e). *The Free Dictionary*. Retrieved from http://financial-dictionary.thefreedictionary.com/Heating+Degree+Day+-+HDD

Anonymous. (2012). *Wikipedia, The Free Encyclopedia*. Retrieved from http://en.wikipedia.org/wiki/Heating_degree_day

Boden, T. A., Marland, G. & Andres, R. J. (2012). *Regional, and National Fossil-Fuel CO2 Emissions.* 10.3334/CDIAC/00001_V2012

Coley, D. A. (2008). Energy and climate change: creating a sustainable future. John Wiley & Sons Ltd.

Cruz, R. V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B.,... Huu Ninh, N. (2007). Asia. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

ENE. (2004). *Energy in Focus, BP Statistical Review of World Energy*. BP Plc.

Hodgson, P. E. (2010). Energy, the Environment and Climate Change. Imperial College Press.

Hossain, A. K. (2012). Global Energy Consumption Pattern and GDP. *International Journal of Renewable Energy Technology Research, 1*(1), 23 - 29. Available online www.ijretr.org

Huber, M., & Knutti, R. (2012). Anthropogenic and natural warming inferred from changes in Earths energy balance. *Nature Geoscience*, *5*(1), 31–36. doi:10.1038/ngeo1327

Jafari, M. (2008a). Investigation and analysis of climate change factors in Caspian Zone forests for last fifty years. Iranian Journal of Forest and Poplar Research, 16(2), 314-326.

Jafari, M. (2010). Climate Change Impact on Iranian Ecosystems, with review on Climate Change Study Methods. Research Institute of Forests and Rangelands Publication.

Jafari, M. (2011). *Forest trees as good indicators for precipitation and humidity changes: A dendrochronological study in Hyrcanian forest ecosystems*. Presentation in the Workshop on "The Caspian Sea Level Change: Human Impact and Impact of Sea Level" Iranian National Centre for Oceanography, Tehran, Iran.

Jafari, M. (2012a). Climate and environmental impacts on beech and oak wood production in the Hyrcanian forests. *Iranian Journal of Wood and Paper Science Research, 27*(3), 386-408.

Jafari, M. (2012b). Aviation Industry and Environment Crisis: A Perspective of Impacts on the Human, Urban and Natural Environments. In *Technology Engineering and Management in Aviation: Advancements and Discoveries*. IGI-Global. Retrieved from http://www.igi-global.com

Jafari, M. (2012c). Adaptation of global change projection for local level application: Case study, special forest ecosystem, Astara. *Iranian Journal of Natural Resources Research, 1*(1), 12-24. Retrieved from http://www.rifr-ac.org/FA/userfiles/file/news/ijnrr.pdf

Jafari, M. (2013). Energy consumption impacted by climate changes application: Case study Astara. Lecture Note in Electrical Engineering, 239, 29-50.

Maleviti, E. (2012). The Development of a Theoretical Model for Optimizing Energy Consumption in Buildings. *International Journal of Energy Optimization and Engineering*, *1*(4), 1–14. doi:10.4018/ijeoe.2012100101

Matthews, H. D., & Caldeira, K. (2008). Stabilizing climate requires near-zero emissions. *Geophysical Research Letters*, *35*(4), L04705. doi:10.1029/2007GL032388

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S. C. B., Frieler, K., Knutti, R., & Allen, M. R. et al. (2009). Greenhouse-gas emission targets for limiting global warming to 2 °C. *Nature*, *458*(7242), 1158–1162. doi:10.1038/nature08017 PMID:19407799

NIOC. (2007). *National Iranian Oil Co*. Retrieved from http://en.nioc.ir/Portal/Home/

Oliver, W. (2013). World Energy Trilemma, Time to get real – the agenda for change. World Energy Council.

Quayle, R. G., & Diaz, H. F. (1979). Heating Degree days Data Applied to Residential Heating Energy Consumption. *Journal of Applied Meteorology*, *19*(3), 241–246. doi:10.1175/1520-0450(1980)019<0241:HDDDAT>2.0.CO;2

RCP Database. (2009). *RCP Database (version 2.0)*. Retrieved from http://www.iiasa.ac.at/web-apps/tnt/RcpDb

Rogelj, J., McCollum, D. L., & Riahi, K. (2013). The UN's 'Sustainable Energy for All' initiative is compatible with a warming limit of 2 °C. *Nature Climate Change, 3*. Retrieved from www.nature.com/natureclimatechange

Sivak, M. (2013). Air conditioning versus heating: climate control is more energy demanding in Minneapolis than in Miami. *Environ. Res. Lett., 8*. Retrieved from stacks.iop.org/ERL/8/014050

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H. M., Elsiddig, E. A., & Tubiello, F. N. et al. (2013, August). How much land based greenhouse gas mitigation can be achieved without compromising food security and environmental goals? *Global Change Biology*, *19*(8), 2285–2302. doi:10.1111/gcb.12160 PMID:23505220

Solomon, S., Daniel, J. S., Sanford, T. J., Murphy, D. M., Plattner, G.-K., Knutti, R., & Friedlingstein, P. (2010). Persistence of climate changes due to a range of greenhouse gases. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(43), 18354–18359. doi:10.1073/pnas.1006282107 PMID:20937898

Wang, J. F., & Zhang, X. B. (2008). Downscaling and projection of winter extreme daily precipitation over North America. Journal of Climate, 21(5), 923-937.

KEY TERMS AND DEFINITIONS

Cooling Degree Days (CDD): If the average daily temperature is above comfort levels, cooling is required. An analogous index for the energy demand for cooling is represented by CDD (Sivak, 2013). CDDs are based on daily temperature observations, with each month having at least 25 records and no less than 15 years of data (Anonymous, 2008a). CDD, which indicate the level of comfort, are based on the average daily temperature which is taken as the mean of maximum and minimum daily temperature.

Energy Consumption Pattern: The way and total use of energy may be defined as its pattern. In general energy is classifies into two main groups: renewable and non-renewable. Renewable energy is the cleanest sources of energy and non-renewable sources are not environmental friendly source of energy. According to (Akhter Hossain, 2012) GDP and energy consumption of developing countries are increasing exponentially, whereas GDP and energy consumption of developed countries are increasing linearly.

Heating Degree Days (HDD): If the average daily temperature falls below comfort levels, heating is required. HDD is an index of the energy demand to heat buildings (Sivak, 2013). HDDs are based on daily temperature observations, with each month having at least 25 records and no less than 15 years of data (Anonymous, 2008a). HDD, which indicate the level of comfort, are based on the average daily temperature which is taken as the mean of maximum and minimum daily temperature.

APPENDIX

Although the joule will be our standard unit, the importance of oil is such that the energy industry more often uses tonnes-of-oil-equivalent (toe). This is the energy content of one tonne of oil, i.e. 42 billion joules (= 42 × 109 J = 42 GJ). (Coley, 2008).

Table 2. Common Energy Units

Unit	Pronunciation	Equivalence	Notes
kWh	kWh	1 kWh = 3.6 × 106 J	Energy used by a single-bar electric fire left on for one hour
ft.	lb foot-pound	1 ft.lb = 1.356 J	Energy required to raise one pound in weight (≈0.45 kg) by one foot (≈0.3 m)
cal	calorie	1 cal = 4.19 J	Energy required to heat 1 g of water 1 ∘C (at atmospheric pressure)
kcal or Cal	kilo-calorie	1 Cal = 4.19 kJ	Unit used by the food industry and easily confused with the cal
Therm	therm	1 therm = 100 000 BTU	
BTU	British thermal unit	1 BTU = 1055 J	
Toe	tonne of oil equivalent	1 toe = 42 GJ	