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