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Solar Cooking: Any place on our menu?

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1 Introduction and History

Cooking is considered as one of humanity's most integral and common activities. Being a process that usually requires a thermal treatment of food, securing the fuel to heat can be as important as providing for the food itself. Solar cooking devices can be classified into different types and subtypes, depending on their geometry and complexity. However, all solar cookers operate on a simple principle that consists of converting sunrays to thermal energy. This conversion is achieved by reflecting incident solar rays on a heat absorbing object that contains the desired food or liquid. In addition to cooking, these devices can also serve for pasteurization and sterilization [11,31].

The first documented attempt to cook using solar energy was that of a German physicist named Tschirnhausen (1651–1708); Tschirnhausen boiled water placed in a clay pot by focusing the sun's rays using a large lens [16].

Solar cookers can generally belong to one of three categories: solar panel cooker, solar parabolic cooker or solar box cooker (figure 1) [11].

The solar panel cooker type is the most popular due to its simple construction requirement in addition to its low-cost materials. It operates by reflecting sunrays on a transparent plastic bag containing the food via a reflective material [11]. However, this type of solar cookers relies on sunlight concentrated from above [17], thus limiting the cooking power and rendering it ineffective in cloudy conditions [18]. On the other hand, a solar box cooker consists of a transparent glass cover, mounted on an insulated box with a reflective surface inside. Sunrays are directed towards the heat absorbent interior containing the cooking vessel [19]. This type of solar cookers heats up slowly [20], however it is effective under unfavorable weather conditions [20,21].

Finally, parabolic solar cookers are considered as the most powerful among the three types. The

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parabolic solar reflector concentrates the sunlight on the cooking pot, allowing a fast cooking process at very high temperatures [11]. Recent research efforts are directed to increase the efficiency of solar cookers, to allow for heat storage and night cooking, in addition to rendering the devices less costly.

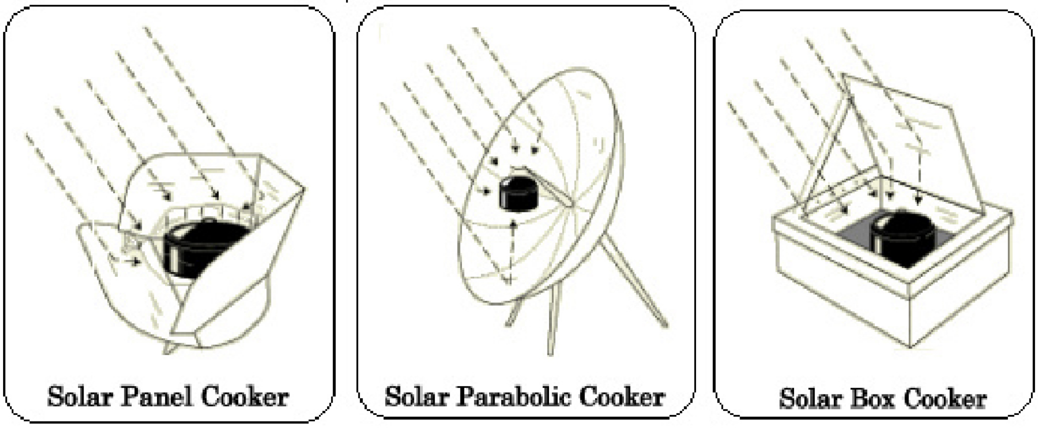

Figure 1: Types of solar cookers: (a) solar panel cooker; (b) solar box cooker; and (c) solar parabolic cooker.

2. Implementation in Lebanon: Potentials & Advantages

2.1- Solar Radiation, Expected Performance and Cost

Averaging at 4.8 kWh/m2 per day and 3,000 hours per year, Lebanon enjoys an abundance of solar radiation [15]. Like several other developing nations [11], these favorable conditions render the use of solar cooking in Lebanon an attractive substitute to biomass, electric and LPG-fueled cooking methods. In order to be a viable alternative for conventional cooking techniques, solar cookers have to be affordable, practical and yet capable of reaching the desired processing temperatures. However, the performance of solar cookers is determined by several parameters, such as location, weather conditions, wind speed, ambient temperature, solar intensity and the design of the device itself [24,25,26].

Abou Malouh et al. [24] designed and built a spherical solar cooker equipped with a two axes sun tracking system. Their device was tested in Shafa Bardan, Jordan, on three different days under different weather conditions. Figure 4 presents the solar cooker in use and Figure 5 shows the recorded ambient temperatures, solar intensities, temperatures inside and outside the pan during the three different days. The authors concluded that the maximum temperature reached of 93 °C was convenient for cooking food and pasteurizing water and milk. Additionally, they confirmed that the device can remain operational for a noteworthy period of the day and that higher temperatures can be reached on hotter days. It is worth mentioning that the solar radiation and air temperature values present in Shafa Badran (Figure 4) [27], are very similar to those recorded in many Lebanese areas (Figure 2, Figure 3).

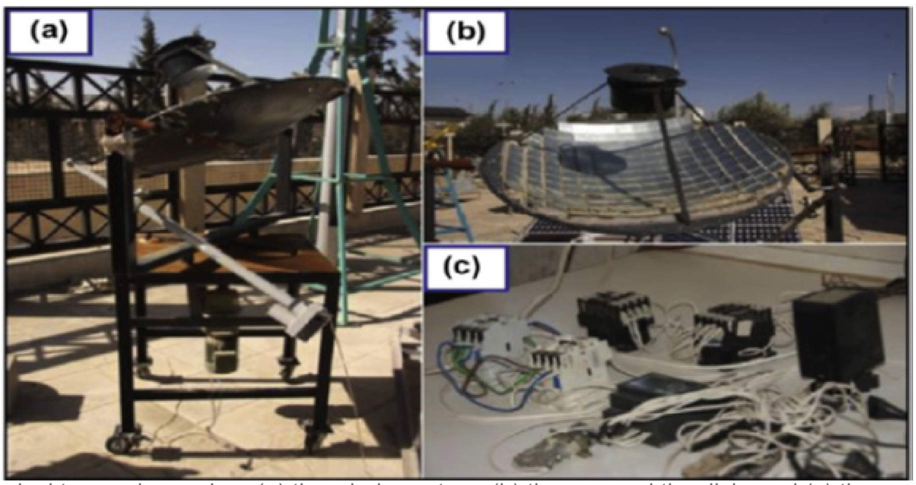

Figure 2: Spherical type solar cooker: (a) the whole system; (b) the pan and the dish; and (c) the control devices.

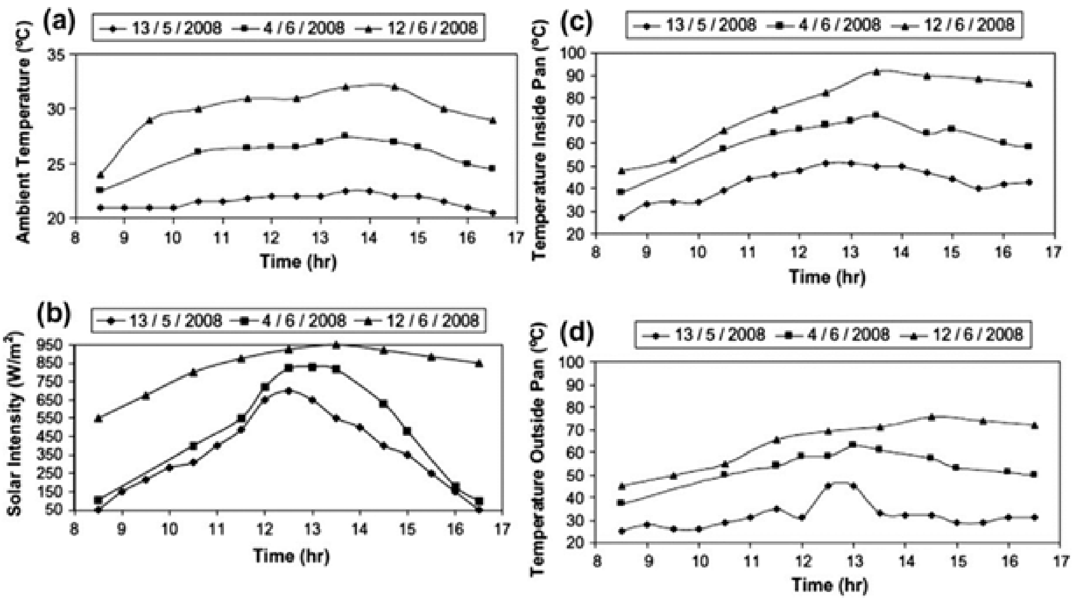

Figure 3: Variation of (a) ambient temperature; (b) illumination intensity level; (c) temperature inside pan; and (d) temperature outside pan with time.

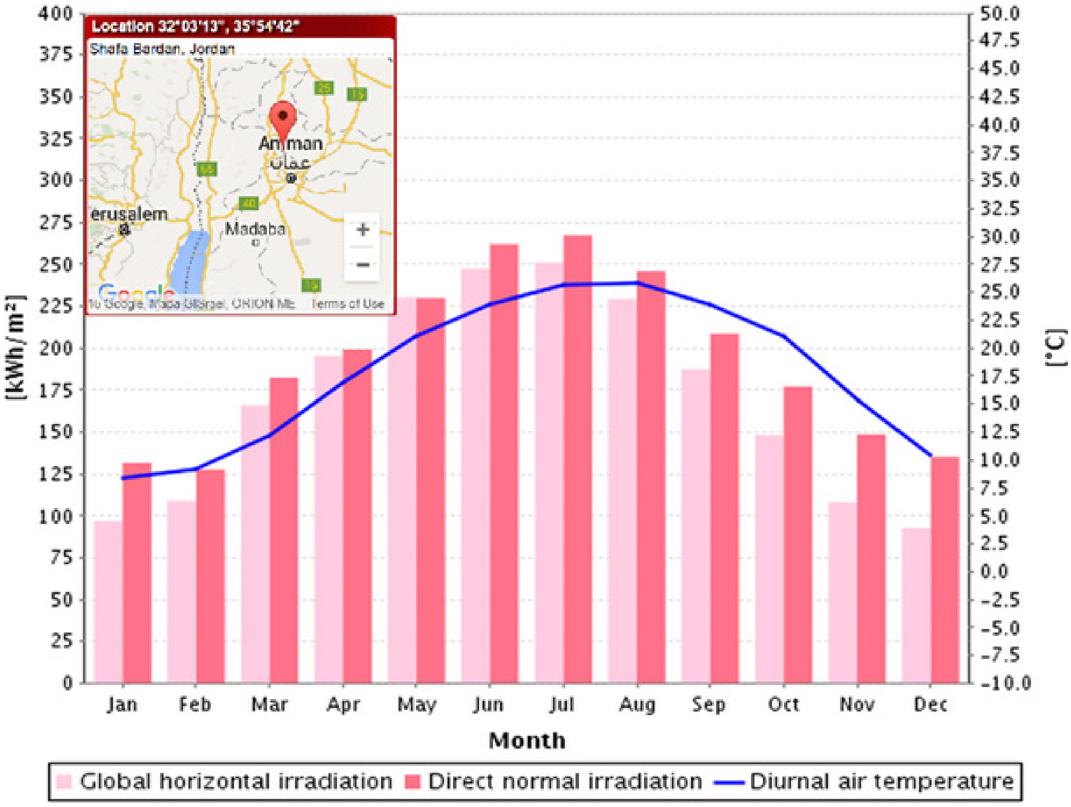

Figure 4: Monthly global horizontal irradiation, direct normal irradiation and diurnal air temperature in Shafa Bardan, Jordan.

In another study [28], Barker showed that solar cookers made from easily available materials, can reach temperatures up to 100 °C. Moreover, Terres et al. [29] were able to numerically show that a solar box cooker, coupled with internal reflectors, was able to heat bee honey, olive oil, milk and water to 91.8, 91.6, 86.2 and 85.3 °C, respectively. This device was tested in Mexico City on 26 February 2006. Another widely used solar panel cooker [30], invented by Dr. Roger Bernard and commercially known as CooKit (Figure 5) [33], can reach cooking temperatures ranging from 82 to 135 °C [31]. This cooker can be purchased online for 39 USD [32] and can be made using low cost materials, for an estimated price of 5-7 USD [31,33,63]. In its manual dedicated to promote the use of solar cookers [31], the U.S. based NGO Solar Cookers International, has indicated that CooKit can reach the required temperatures for cooking and pasteurizing (Figure 6). Additionally, the manual presented the required period of time needed to cook 2 kilograms of food on a sunny day (Figure 7). This time varied from a 1-2 hours interval, up to 5-8 hours depending on the desired food. Moreover, the manual mentioned that typically a solar cooker can be used to cook a noontime meal and an evening meal. Finally, it presented the average solar radiation throughout the world, which indicates the areas where solar cookers can operate optimally (Figure 8). Although costly and complex parabolic solar cookers can easily reach temperatures in excess of 300 °C [11,19,34], the results presented above show that inexpensive and easily-made solar devices can be used to satisfy cooking and pasteurizing needs.

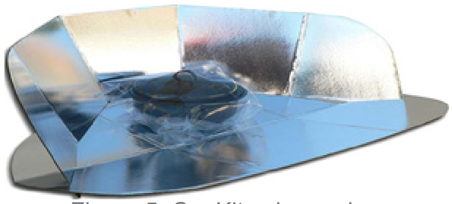

Figure 5: CooKit solar cooker.

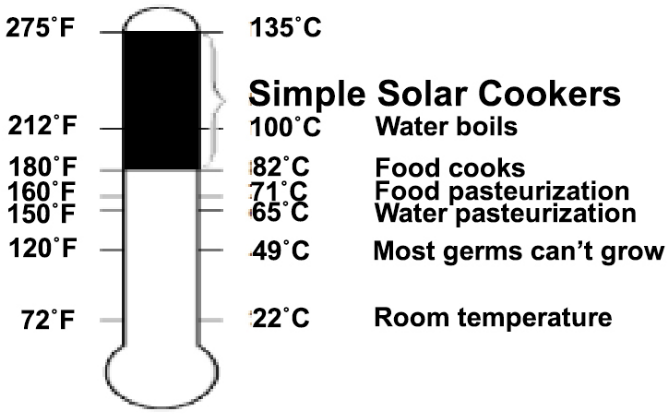

Figure 6: Temperature range reached by CooKit and other similar solar cookers.

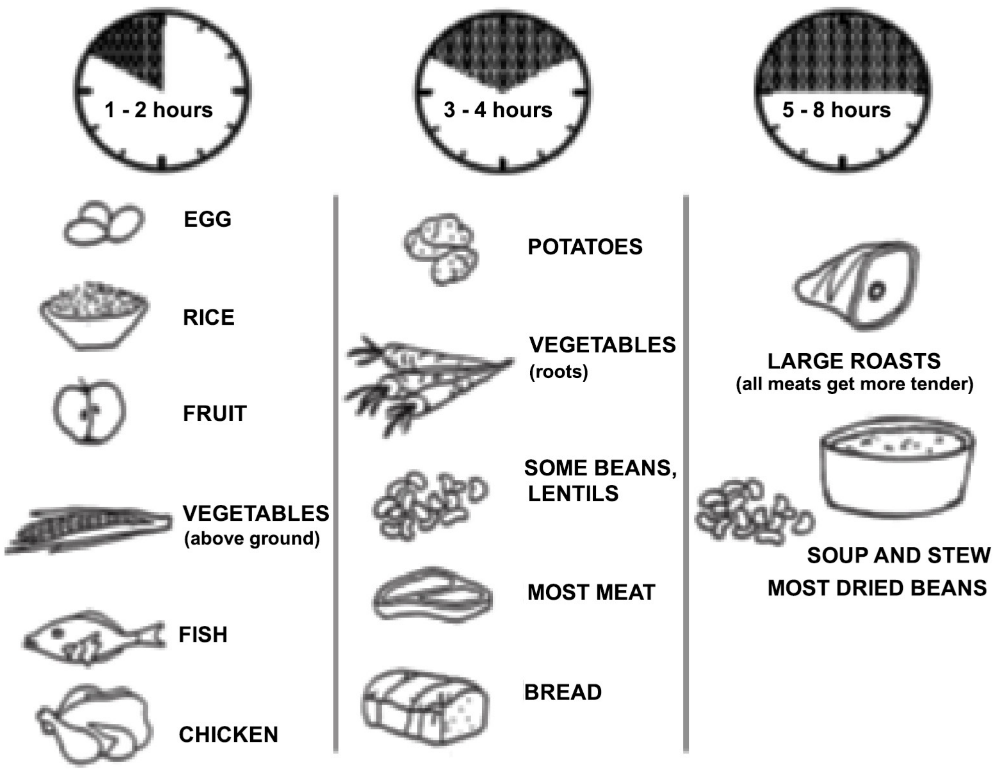

Figure 7: Required time needed to cook 2 kilograms of food on a sunny day using a typical solar cooker.

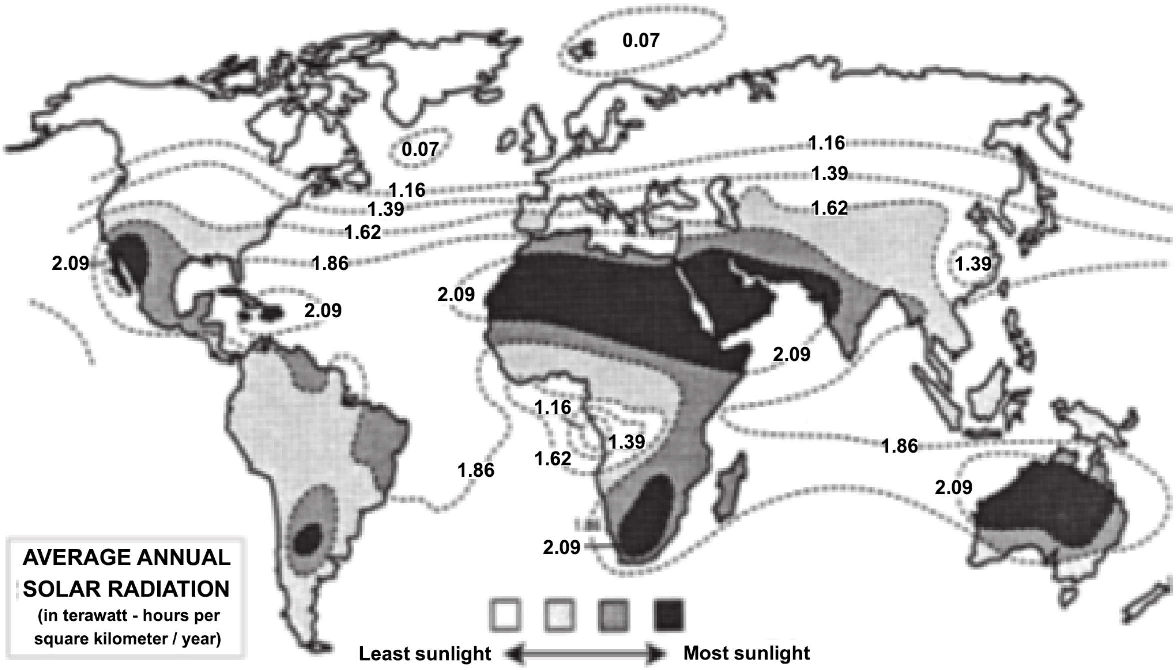

Figure 8: Global average annual solar radiation.

2.2- GHG Emissions, Expected Savings & Safety

Whether in Afghanistan [10], India [12], Senegal [5] or South Africa [14], the use of solar cookers was able to provide free cooking fuel for the local communities. Moreover, it has alleviated the negative environmental and health impacts of using biomass energy sources to cook. On a quantitative level, Solar Cookers International has estimated that, if only 5% of the population living in the developing world relies on solar power instead of biomass for cooking, 16.8 million tons of firewood can be saved per year, corresponding to 56 million trees. Consequently, the conservation of this large amount of trees in our forests can avoid the direct emission of 21.6 million tons of CO2 per year, and another 16.8 million tons of indirect emissions [38].

In 2008, imported LPG occupied a 2% share of Lebanon's country's total energy mix [40,41]. Although Lebanon's consumption of LPG has been minimal compared to other oil products (Figure 9) [43], this liquid fuel has been central in providing Lebanese with the required energy to cook [39,40,41,45]. It is estimated that from the 243 Kilotons of LPG imported in 2012 [44], 85% was used by the residential sector for cooking purposes, while the other 15% was used by the industrial sector [45]. Thus, it is estimated that approximately 206.55 Kilotons of LPG is burned annually for cooking purposes in Lebanon. Moreover, it is interesting to observe that, even among Syrian refugees currently present in the country, an overwhelming 93% of households use LPG for cooking, while a mere 4% rely on wood or charcoal [42].

Being a mixture of hydrocarbon gases, burning LPG will mainly emit carbon dioxide molecules into the atmosphere. As presented in (Table 1) [45], it can be seen that in the year 2000, the "other sectors" category was responsible for 1,280 Gg CO2 equivalent of GHG emissions, corresponding to a 7% share of the nation's total GHG emissions. The "other sectors" category includes all the space-heating and cooking operations performed by the Lebanese commercial, residential, institutional and agricultural sub-categories. Moreover, it is estimated that all the LPG quantities used by this sector were burned to provide energy for cooking [45]. Figure 10 shows the GHG emissions by fuel type under "other sectors". It can be noticed that LPG, which is primarily used for cooking, is responsible for 32.56% of the sector's GHG emissions. Thus, it can be estimated that in year 2000, burning LPG for cooking in Lebanon has emitted approximately 416.77 Gg CO2 equivalent, corresponding to 2.28% of the nation's total GHG emissions [45].

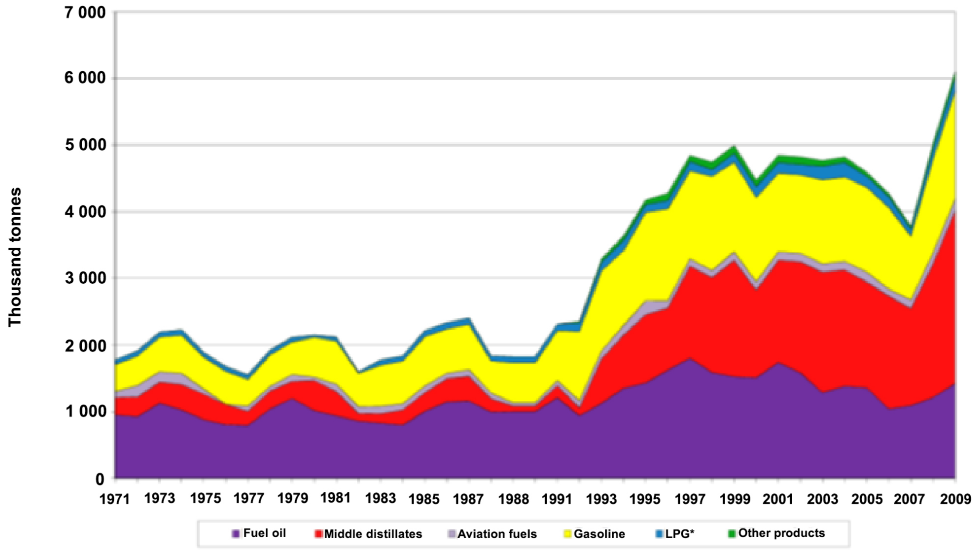

Figure 9: Annual consumption of oil products in Lebanon.

Energy Sub - Sectors	GHG Emissions ($Gg\ CO_2$ eq.)	Share of Total Energy Emissions	Share of Total National Emissions
Energy Industries	5,773	42%	31%
Manufacturing Industries and Construction	2,830	20%	15%
Transport	3,963	29%	21%
Other Sections	1,280	9%	7%
Total	13,846	100%	75%

Table 1: Greenhouse gas emissions from the energy sector per sub-category.

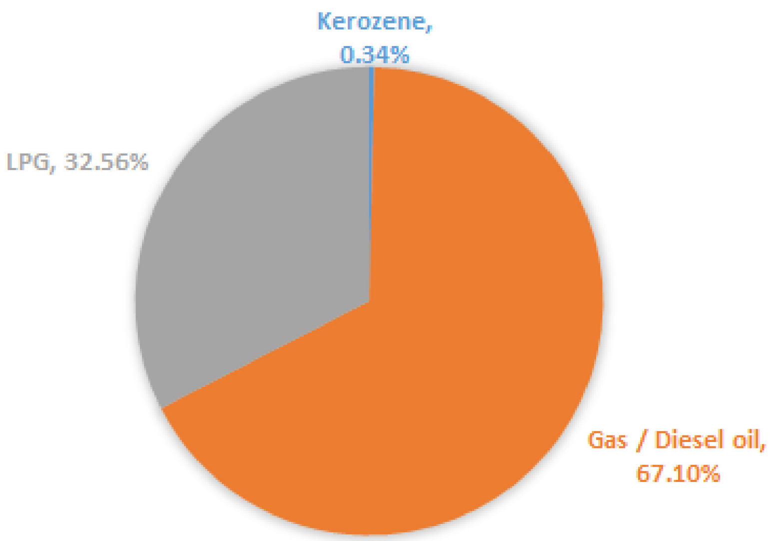

Figure 10: Share of GHG emissions by fuel type under other sectors.

2.3- Smoke Elimination, Fire Prevention and Deforestation

Unlike biomass or LPG-fueled cooking devices, solar cookers are fireless systems that do not require the existence of an open flame to cook [12,31,48]. This distinction is a significant factor in eliminating indoor air pollution and dangerous smoke, in addition to preventing indoor/outdoor accidental fires [31,38,48].

According to the World Health Organization [3], indoor air pollution, resulting from burning solid biomass fuels inside households, is responsible for the annual death of 1.5 million individuals in the developing world. Due to the ability of solar cookers to eliminate all smoke emissions, it is estimated that these devices can reduce childhood pneumonia by half and decrease the toll of other diseases by 5% [38]. However, in Lebanon, this advantage will be of limited scope, given that less than 5% of the population burn solid fuels domestically [3], with the majority relying on the much cleaner LPG for cooking [39,40,41] (Figure 11) [3].

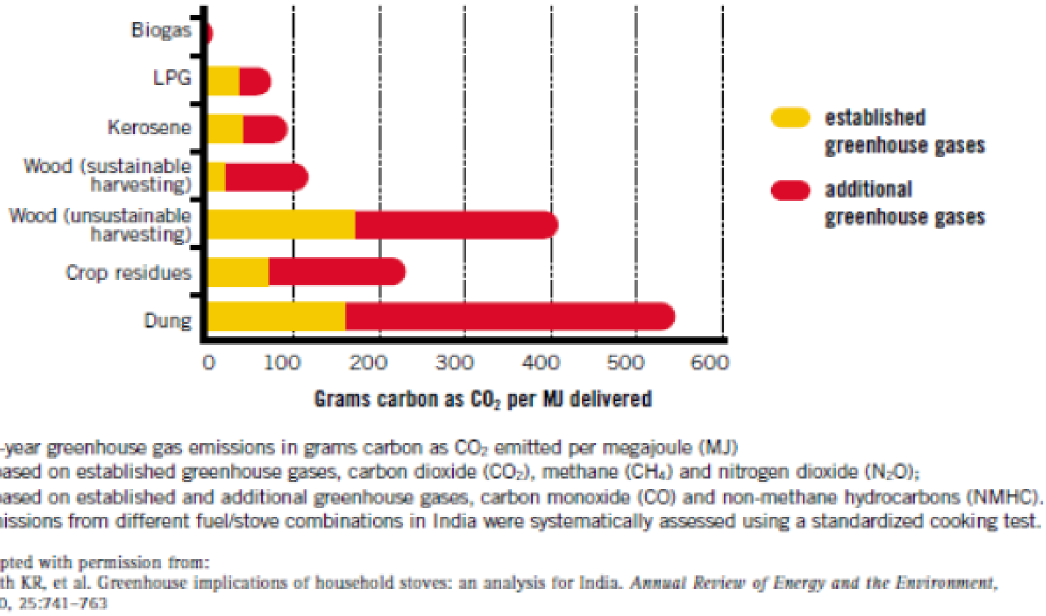

Figure 11: Household energy and global warming.

Furthermore, the ability of solar cookers to prevent indoor and outdoor fires can prove extremely important for Lebanon. This conclusion arises from several facts, particularly present in Lebanon:

High risk of fire, cooking fire hazards & ease of fire propagation:

Due to several natural factors and human practices, a large percentage of Lebanese areas are classified as having “high” to “very high” risk of fire. For instance, in 2007, 28% of the country’s total area was severely threatened by fires (Figure 12) [49]. On the other hand, despite the lack of accurate data, outdoor cooking fires are considered as one of the most common causes of forest fires in Lebanon [49]. Another worrying report presented by the Lebanese Ministry of Environment states that, in 2007, 95% of all fires recorded in Lebanon have burned an area ranging from 7 to 29 hectares [51]. Moreover, the risk of fires is expected to increase in the future, due to the noticeable change of climatic conditions experienced in the country [45,49]. Finally, the high population density in Lebanon, estimated at 400 Inhabitants/km2 [47], can further aggravate the risk of fires and their toll on lives and properties.

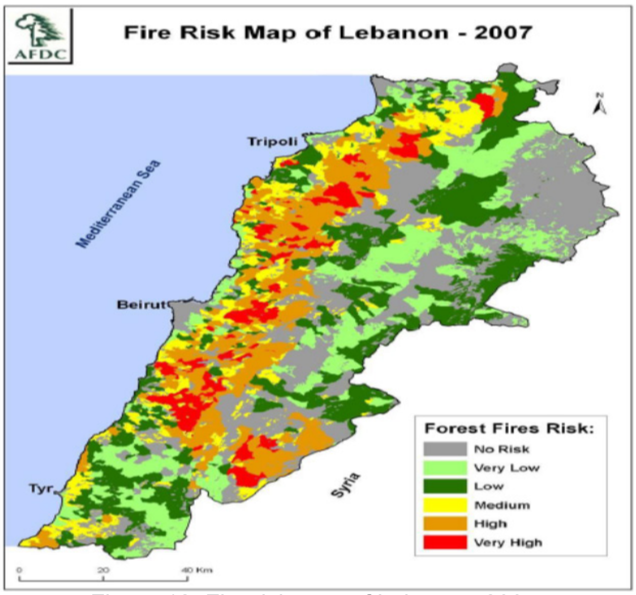

Figure 12: Fire risk map of Lebanon, 2007.

2.4- Energy Security, Refugees & Host Communities

Past experiences have shown that Lebanon's energy security is far from guaranteed. Fuel deliveries, especially to rural areas, can be hampered or even stopped, by a wide range of natural and man-made causes. Wars, damaged infrastructures and winter storms have frequently led to fuel shortages in several Lebanese regions [58,59,60]. Moreover, LPG, which is the country's main cooking fuel, is an imported fuel, delivered domestically via compressed gas cylinders. Therefore, its flow to Lebanese households is equally vulnerable to the aforementioned factors.

Given the capacity of solar cookers to cook meals, pasteurize and sterilize liquids, while only relying on the abundant and free energy of the sun, these devices can constitute a much-needed alternative for LPG and biomass cooking stoves during fuel crisis. Additionally, the ability of solar cookers to operate during sunny winter weather [12,61,62,63], coupled with Lebanon's average of 300 sunny days per year [64], render these devices a potent and reliable support for both urban and rural communities.

On the other hand, solar cookers can contribute in alleviating the burdens imposed on Lebanon by the presence of over 1 million Syrian refugees in the country [65]. A proliferation of solar cookers among Syrian refugees in Lebanon, similar to its spread among Afghani refugees [11], can contribute in improving the health and economic situation of these individuals, in addition to supporting the host communities and the central government. An analysis of the current statistics concerning the situation of Syrian refugees in the country [66], reveals the important rewards of implementing solar cooking projects on the current reality.

According to a report assessing the vulnerability of Syrian refugees in Lebanon [66], it was revealed that 20% of these households were unable to cook food at least one time per day. Figure 14 presents the reasons behind this inability to cook among refugees. It can be noticed that "lack of fuel", "lack of stove kitchen" and "lack of safe water" were reported by 41%, 23% and 2% of households, respectively. Thus, the ability of inexpensive solar cookers to provide free cooking fuel, a built-in stove and water pasteurization, can directly assist in tackling the causes of this problem and render solar cookers an indispensable piece of equipment for refugees. Moreover, given that "lack of time" was reported by only 2% of households, the relatively long cooking time of solar cookers (Figure 7) is not expected to constitute a major challenge for their diffusion. Additionally, solar cookers can compensate for the lack of gas stoves and water heaters in these households, both reported missing by approximately 57% of the respondents [66].

Finally, solar cookers can also prevent the spread of diseases, by pasteurizing the possibly contaminated drinking water consumed by 7% of the interviewed refugees [66]. On the other hand, 93% of Syrian refugee households used LPG as their main cooking fuel [66], which is also a common practice in Lebanese households. However, 31% of the interviewed families stated that their access to cooking fuels is not sufficient. Therefore, providing a clean and free alternative or backup cooking fuel through the use of solar cookers, can limit GHG emissions resulting from the cooking activities of 1 million refugees, in addition to alleviating the economic burden of procuring an energy source to cook.

2.5- Possible Areas of Implementation

Simple solar cookers can be easily constructed from basic materials for a total cost of 5-7 USD [31,33,63]. Conversely, complex and large-scale solar cookers can also be built to match specific performance requirements or to be used in community kitchens [11,12,34]. Therefore, the implementation and diffusion of solar cookers in different arenas, under different operational settings, can be enhanced by the versatile characteristics of these devices. Additionally, as previously shown, a possible diffusion of solar cooking in Lebanon can address the environmental, health, economic and safety challenges facing the country.

The spread of low-cost and simple solar cookers, in addition to large-scale communal ones, among Syrian refugees, can constitute an affordable and practical solution to the problems facing these individuals and their host communities. On the other hand, inexpensive state-sponsored programs can be implemented to encourage the use of solar cookers in the country, in particular in rural areas, which are prone to frequent fuel shortages. Solar cookers can be promoted as an outdoor kit, able to satisfy the users' needs, while preventing forest fires and protecting the environment.

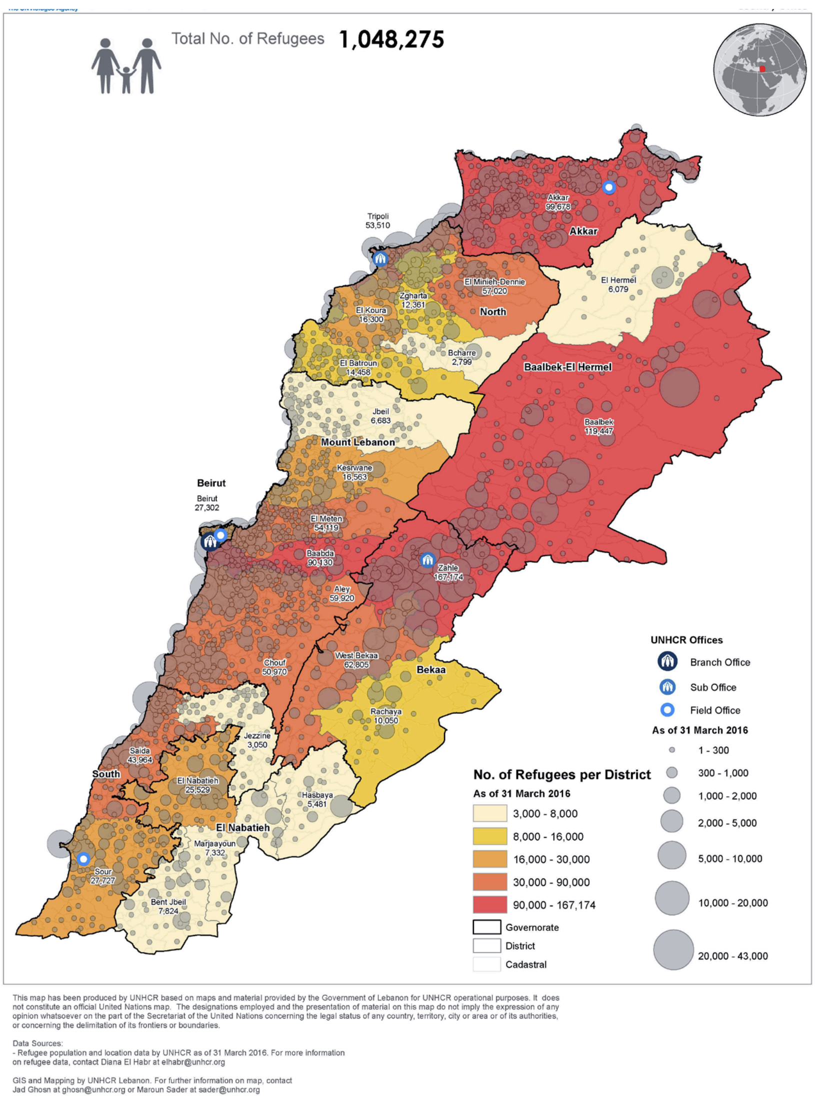

Figure 13: Distribution of Syrian refugees in Lebanon, September 2015.

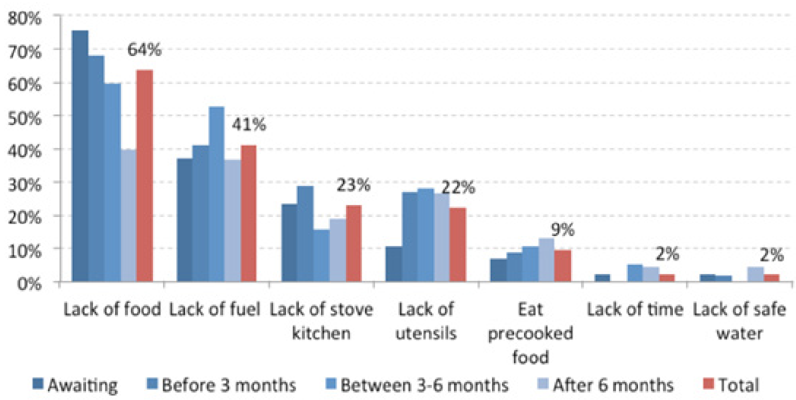

Figure 14: Reasons behind the inability of Syrian refugees households to cook. [66]

3. Implementation in Lebanon: Diffusion & Challenges

Although most studies on solar cooking addressed the technical aspects of this process, several researchers have focused on the challenges facing the spread of solar cookers in many areas of the world [10,12,13,14]. In their study [14], Wentzel and Pouris concluded that 'the diffusion of solar cookers greatly depends on satisfying the customers' needs and desires and not solely on the technical abilities of these devices'. Moreover, it was stated that the promoters of solar cookers should harness the versatility of solar cookers, in terms of types and models, in order to satisfy the specific needs of different market segments. Additionally, the authors concluded that, it is crucial to present solar cooking as an additional cooking option and not as a complete replacement for conventional cooking methods. Finally, providing an appropriate training and follow-up, in addition to securing the suitable financing means, were also considered as important factors in the effort to promote solar cookers. In another study [10], Michael Tucker argued that promoting solar cookers based on their environmental, economic or health benefits alone will not ensure a widespread use of this technology; he emphasized the need to address the contextual cultural and gender issues, in addition to encourage community involvement, in order to advance the diffusion of solar cookers.

In her study, "Solar cookers in developing countries - What is their key to success?" [13], Pia Piroschka Otte identified the major factors determining the adoption extent of solar cookers in the developing world. Figure 15 presents a flowchart of these variables, in addition to their effects on the acceptance or rejection of these devices. As can be seen, the adoption of solar cookers requires the positive contribution of all the environmental, cultural, technical, social and economic factors (the latter can be substituted by political factors). Moreover, it can be noticed that, any negative contribution of the first 4 factors can automatically lead to the rejection of solar cookers.

In the following section, the possible effects of these factors on the diffusion of solar cookers in Lebanon, based on the work presented by Pia Piroschka Otte, will be presented.

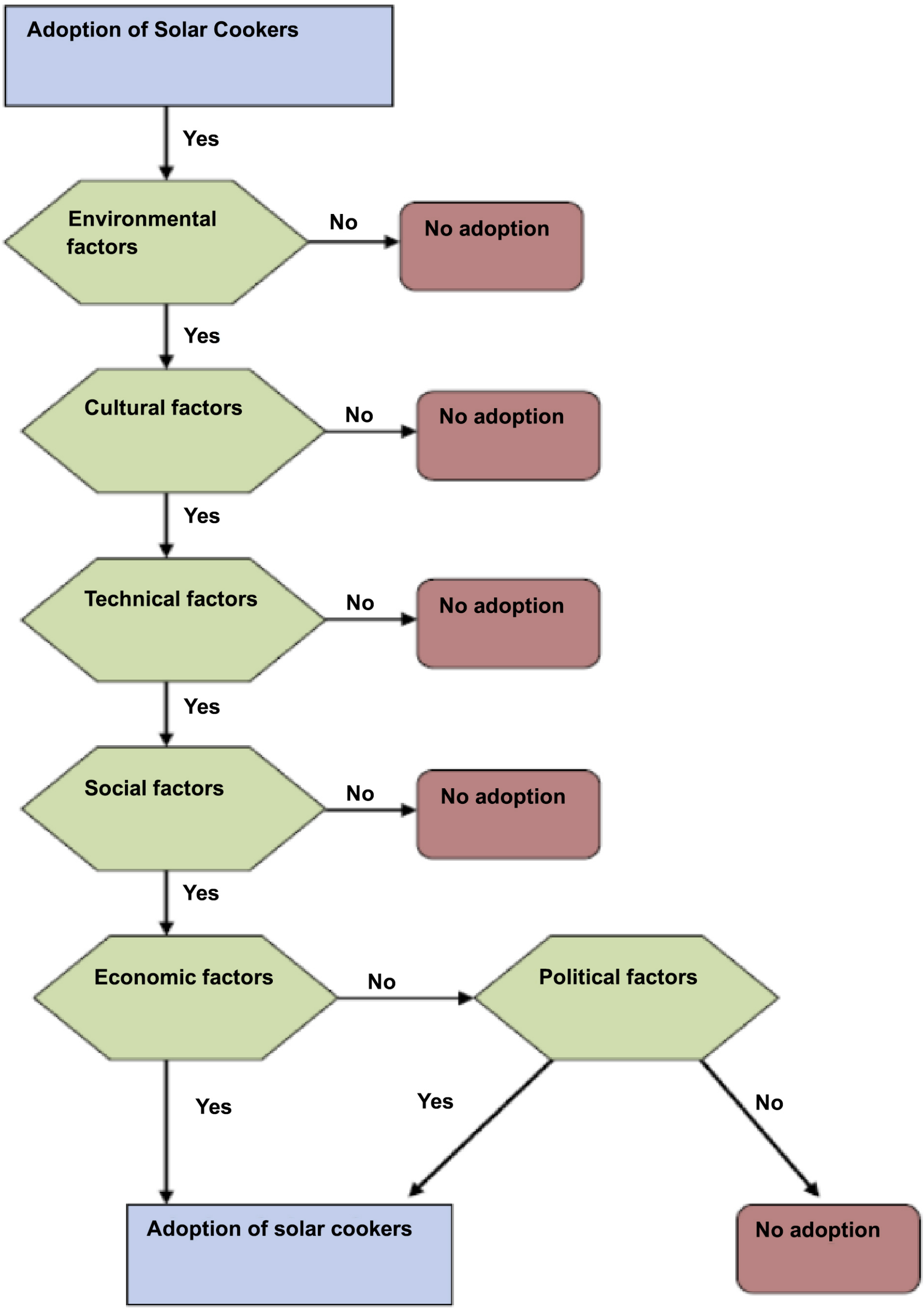

Figure 15: Flow chart relationship of relevant variables for solar cooking.

3.1 Environmental Factors

- Availability & price of alternative fuels: In Lebanon, fuel shortages are more common in rural areas than in urban ones. The threat to the country's energy security is most severe during major winter storms, internal strives and wars. Moreover, Lebanon imports the majority of its energy needs, including LPG, the country's main cooking fuel. Thus, the local cost of fuel is directly related to the international fuel prices. Therefore, it is expected that solar cookers are more likely to spread in Lebanon's rural areas than its cities, specifically during severe energy crisis or future fuel price hikes.

- Level of solar radiation: Lebanon enjoys an abundance of solar radiation, averaging at 4.8 kWh/m2 per day and a yearly average of 3,000 hours of sunlight; favorable conditions for solar cooking.
- Suitable place for solar cooking: It is expected that the space required to operate solar cookers is more available in rural areas than in cities, thus favoring the former.
- Level of infrastructure: Lebanon's relatively poor infrastructure would not lead to difficulties in spreading the idea of solar cooking.

3.2 Cultural Factors

- Food characteristics: No data is currently available concerning the effects of solar cooking on the taste, texture or color of Lebanese food. This is recommended to better assess the compatibility of the technology with Lebanese food.
- Traditional cooking habits: The diffusion of solar cookers in Lebanon may be hindered by their inability to fry food. For this reason, these devices must be presented as an additional cooking option, not as a replacement for LPG or biomass cooking stoves. On the other hand, added features, such as heat storage and practicality, are expected to encourage the use of solar cookers.
- Schedules of daily routine: Solar cookers necessitate sunlight to operate. This requirement can obstruct the spread of solar cookers especially during the Muslim Holy Month of Ramadan, when most meals are prepared or heated at night.

3.3 Technical Factors

- Level of performance: Given the country's favorable location, climate and solar radiation intensity, it is expected that solar cookers in Lebanon will have a relatively high performance ratio. However, the performance of a specific solar cooker will largely depend on its added features and cost. Consequently, it is important to ensure that, for a given level of complexity and price, the highest possible performance level is attained. Finally, the performance of these devices should guarantee the ability to achieve the required tasks.
- Ease of use: This feature is crucial in order to facilitate the training procedures, thus allowing a greater number of people to use solar cookers.
- Safety: Solar cookers reflect sunlight to one focal point. This can be especially dangerous for children. Thus, it is crucial to ensure the safety of these devices.
- Sensitivity to reparation: Solar cookers must be durable and should require a low maintenance level.
- Able to be built with local resources: A local construction of solar cookers can lead to job creation, lower prices and better maintenance. Thus, it is important to encourage the Lebanese industrial sector to get involved in the solar cooking market.

3.4 Social Factors

- Motivation: Although solar cooking offers economic, environmental and health benefits, a particular user may not be equally interested in all three advantages. For instance, some refugees may be more interested in the economic and safety benefits of solar cooking, rather than the environmental ones. Conversely, a number of wealthy families may not be interested in the economic benefits of solar cooking, as much as the environmental ones. Understanding this distinction of motives, coupled with the wide price range of solar cookers, should render these devices an interesting equipment for people from different socio-economic backgrounds.
- Use of solar cookers by its disseminators: A successful diffusion of solar cookers cannot be achieved if these devices are solely promoted in the economically disadvantaged communities. It is critical that the promoters of solar cooking use the technology themselves, and include other more advantaged people in their efforts towards diffusion.
- Existing power and gender relations: Similar to other Middle Eastern countries, many households in Lebanon dedicate food preparation to women and financial decisions to men. For this reason, a successful promotion of solar cookers must understand the needs of both genders and address their different motives.
- Supplier characteristics: Future solar cookers providers in Lebanon must build a trust relationship with their customers. This can be achieved by

providing an adequate training, good product performance and after sale support.

3.5 Economic Factors

Lebanon is classified among the upper middle income countries. However, the prices of solar cookers should be carefully considered in order to ensure the accessibility of this technology to all Lebanese and non-Lebanese residents, irrespective of their socio-economic backgrounds.

3.6 Political Factors

- The role of renewable energy policies: An appropriate governmental support for solar cooking can significantly enhance its propagation among Lebanese and non-Lebanese residents. Adequate financing schemes can assist underprivileged families in purchasing their own devices. Tax exemptions on the manufacturers of solar cookers can lead to job creation, lower prices, better maintenance, in addition to avoiding business monopoly. Moreover, organizing the convenient demonstration and information campaigns can encourage the use of this technology.

It can be expected that, no particular factor of the six mentioned above can lead to an immediate rejection of solar cookers in Lebanon.

4. Conclusion

Given the country's relative abundance of solar radiation, it is expected that these devices can prove to be a potent, safe, inexpensive and environmentally friendly backup to LPG stoves. Moreover, it was calculated that if only 5% of the Lebanese population switches to solar cooking, LPG imports can be decreased by approximately 9 million USD and direct GHG emissions can be curbed by 0.114%.

Given that solar cookers are fireless devices, it was shown that an effective implementation of this technology can substantially reduce the risk of indoor and outdoor cooking fires, thus alleviating their devastating effects on our environment, forests and safety. Additionally, it is expected that solar cooking can enhance the energy security of rural communities and Syrian refugees, especially when LPG deliveries to distant areas are not possible. Finally, these devices can tackle various other problems, such as water contamination, competition on biomass and fossil fuels, deforestation and indoor/outdoor air pollution.

On a final note, although this study presented the expected effects of environmental, cultural, technical, social, economic and political factors on the diffusion of solar cookers in Lebanon, it was concluded that a more thorough understanding of these determining factors, coupled with an effective use of the versatility of solar cookers, in terms of complexity and price, can lead to a successful and wide diffusion of this technology in the country.

References:

[1] IEA, 2006. Energy for cooking in Developing Countries. World Energy Outlook (WEA), Paris, France, (accessed 14.09.12).
[2] Toonen HM. Adapting to an innovation: solar cooking in the urban households of Ouagadougou (Burkina Faso). Phys Chem Earth 2009; 34:65-71.
[3] World Health Organization (WHO). Fuel for life. WHO, Geneva; 2006.
[4] Miller, K., Tangley, L., 1991. Trees of Life: Saving Tropical Forests and Their Biological Wealth. Beacon Press, Boston.
[5] GEF, SGP, UNDP, Empowering Women One Community at a Time, The Mekhe Solar Cooker Project, October 2004 – September 2006.
[6] Lampinen, A., 1994. Reduction of deforestation by massive use of solar cookers. Technology for Life, Finland, October 18, <http://www.kaapeli.fi:tep:keitin4e.html>.
[7] Shyam S. Nandwani, Solar cookers cheap technology with high ecological benefits, Ecological Economics 17 (1996) 73-81.
[8] Muthusivagami RM, Velraj R, Sethumadhavan R. Solar cookers with and without thermal storage: a review. Renew Sust Energy Rev 2010;14:691–701.
[9] Pandey, M.R., Neupane, R.P., Gautam, A., Shrestha, I.B., 1989. Domestic smoke pollution and acute respiratory infections in a rural community of the Hill Region of Nepal. Environment International 15, 337–340.
[10] Michael Tucker, Can solar cooking save the forests?, Ecological Economics 31 (1999) 77 89.
[11] Erdem Cuce, Pinar Mert Cuce, A comprehensive review on solar cookers, Applied Energy 102 (2013) 1399–1421.
[12] Pia Piroschka Otte, A (new) cultural turn toward solar cooking—Evidence from six casestudies across India and Burkina Faso, Energy Research & Social Science 2 (2014) 49–58.
[13] Pia Piroschka Otte, Solar cookers in developing countries, what is their key to success?, Energy Policy63(2013)375–381.
[14] Marlett Wentzela, Anastassios Pouris, The development impact of solar cookers: A review of solar cooking impact research in South Africa, Energy Policy 35 (2007) 1909–1919.
[15] World Bank, Energy Efficiency Study in Lebanon, December 2009.
[16] Halacy, B., Halacy, C., 1992. Cooking With the Sun. Jack Howel, Lafayete, CA.
[17] Ashok K. A review of solar cooker designs. TIDE; 1998.
[18] Kimambo CZM. Development and performance testing of solar cookers. J Energy S Afr 2007;18(3).
[19] Abhishek Saxena, Varunb, S.P. Pandeyc, G. Srivastavd, A thermodynamic review on solar box type cookers, Renewable and Sustainable Energy Reviews 15 (2011) 3301– 3318.
[20] Telkes M. Solar cooking ovens. Solar Energy 1959;3(1):1-10.
[21] Funk PA, Larson DL. Parametric model of solar cooker performance. Solar Energy 1998;62(1):63–8.
[22] Solar-Med-Atlas, Tarchich, Lebanon. http://www.solar-med-atlas.org/.
[23] Solar-Med-Atlas, DNI map, Lebanon. http://www.solar-med-atlas.org/.
[24] Abu-Malouh R, Abdallah S, Muslih IM. Design, construction and operation of spherical solar cooker with automatic sun tracking system. Energy Convers Manage 2011;52:615–20.
[25] N.L. Panwara, S.C. Kaushika, Surendra Kotharib, State of the art of solar cooking: An overview, Renewable and Sustainable Energy Reviews 16 (2012) 3776– 3785.
[26] Buddhi D, Sharma SD, Sharma A. Thermal performance evaluation of latent heat storage for late evening with three reflectors. Energy Convers Manage 2003;44:809–17.
[27] Solar-Med-Atlas, Shafa Bardan, Jordan. http://www.solar-med-atlas.org/.
[28] Barker JED. The "solar nest" – a very low cost solar cooker. Solar world congress of the international-solar-energy-society, Beijing, China; 18–21 September 2007.
[29] Terres H, Ortega JA, Gordon M, Morales JR, Lizard A. Heating of bee honey, olive oil, milk and water in a solar box type with internal reflectors. In: Energy sustainability conference, Long Beach, California, USA; 27–30 June 2007.
[30] Muthusivagami RM, Velraj R, Sethumadhavan R. Solar cookers with and without thermal storage: a review. Renew Sust Energy Rev 2010;14:691–701.
[31] Solar Cookers How to make, use and enjoy 10th edition, Solar Cookers International spreading solar cooking to benefit people and environments.
[32] http://shop.solarcookers.org/?pn=CooKit&cn=Cookers&p=621&c=27.
[33] http://solarcooking.wikia.com/wiki/CooKit.
[34] http://www.climatetechwiki.org/technology/solar-cookers.
[35] http://data.worldbank.org/country/lebanon.
[36] Sudha Mahalingam, Dr.Aparna Basu, sustainable energy policies for promotion of solar cookers in India.
[37] http://solarcooking.wikia.com/wiki/Lady_Fatemah_Trust.
[38] Shyam S. Nandwani, Solar cookers cheap technology with high ecological benefits, Ecological Economics 17 (1996) 73-81.

[39] Sami Karaki, Farid Chaaban, Riad Chedid, and Toufic Mezher, Ali Hamzeh, Ahmad Harb, and Fayez Abdulla, Electric Energy Access in Jordan, Lebanon and Syria, Draft Paper Prepared for "Energy Access II" Working Group Global Network on Energy for Sustainable Development.
[40] CAS 2009 Energy consumption for year 2008, unpublished, Central Administration of Statistics, 2009.
[41] MOEW 2011 Information provided by the Petroleum Directorate, Ministry of Energy and Water, March 2011.
[42] UNHCR, UNICEF, WFP, Vulnerability assessment of Syrian refugees in Lebanon, 2013 report.
[43] Consumption of oil products, Lebanon, http://www.iea.org/stats/index.asp.
[44] http://www.iea.org/statistics/statisticssearch/report/?country=LEBANON&product=oil&year=2012.
[45] GEF, MOE, UNDP, Lebanon's second national communication to the UNFCCC, 2011.
[46] http://www.iptgroup.com.lb/ipt/en/our-stations/fuel-prices.
[47] MOE/UNDP/ECODIT, 2011.
[48] Vandana K. Designing fireless cooker of indigenous insulation material for better heat retention. J Human Ecol 2010;30(2):99–104.
[49] Lebanon's National Forest Fire Management Strategy Second Draft December 2008
[50] http://www.usfa.fema.gov/data/statistics/.
[51] Ministry of Environment, Service of Planning and Programmes, November 2007, Statistical Analysis for Fires in Lebanon for the Year 2007.
[52] Food and Agriculture Organization of the United Nations (FAO) (2010) Global Forest Resources Assessment 2010.
[53] Association for Forests, Development and Conservation. 2007. State of Lebanon's Forests. Italian Cooperation through ROSS Program, Hanns Seidel Foundation, UNDP, IUCN. Beirut. 128p.
[54] UNDP-CEDRO, The National Bioenergy Strategy for Lebanon, 2012.
[55] MoE/GEF/UNDP, Fourth National Report of LEBANON to the Convention on Biological Diversity, July 2009.
[56] MOE-UNDP, Lebanon's first National Communication, Summary Report, 2002
[57] Ministry of Agriculture-Lebanon. 1996. Biological Diversity of Lebanon – Country Study Report. UNEP, Project GF/6105-92-72. Publication No. 9. 255p.
[58] http://www.unfpa.org.lb/Documents/Elderly-Study-Web.aspx.
[59] http://www.nytimes.com/2006/08/09/world/middleeast/09lebanon.html?_r=0.
[60] http://www.dailystar.com.lb/ArticlePrint.aspx?id=288119&mode=print.
[61] ThulasiDas TC, Karmakar S, Rao DP. Solar box cooker: part I. Modeling. Solar Energy 1994;52(3):265–72.
[62] ThulasiDas TC, Karmakar S, Rao DP. Solar box cooker: part II. Analysis and simulation. Solar Energy 1994;52(3):273–82.
[63] http://video.nationalgeographic.com/video/solar-cooking.
[64] http://www.lb.undp.org/content/lebanon/en/home/library/environment_energy/solar photovoltaic.html.
[65] http://data.unhcr.org/syrianrefugees/country.php?id=122.
[66] UNHCR, UNICEF, WFP, Vulnerability assessment of Syrian refugees in Lebanon, 2013 report.
[67] http://www.dailystar.com.lb/News/Lebanon-News/2015/Jun-02/300198-fire-ravages-bekaa-refugee-camp-kills-syrian-child.ashx.
[68] http://www.dailystar.com.lb/News/Lebanon-News/2015/Feb-19/288020-3-syrian-refugee-children-killed-in-north-lebanon-camp-fire.ashx
[69] Continuing War in Afghanistan Intensifies Demand for Solar Cookers, 1996. Solar Cooker Review, January < http://www.accessone.com/~sbcn:sbrown1.htm>.
[70] Solar box cookers in Ladakh, 1996. Solar Cooker Review, January, http://www.accessone.com/~sbcn:ladakh1.htm
[71] Rodgers, P.M., 1994. Solar box cookers in Zimbabwe: the introduction of a radical innovation. Thesis, University of California at Davis.
[72] World Resources Institute, 1994. World Resources 1994–1995. Oxford University Press, London.

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