



## Hybrid Solar Air Conditioning Co-driven by Heat and Electric power

To seamlessly cool and heat with the power of the sun

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### 1 Overview

Linum Systems Ltd. was founded in 2009, by Yuval Berson and Amir Hirshfeld. Linum Systems is developing a hybrid solar air conditioning technology which provides heat-driven cooling and heating, and seamlessly switches to electricity-driven mode during off-sun conditions.

This energy-saving technology offers better efficiency and significant cost reductions in comparison to other solar air conditioning systems available today in the market. The air conditioner is based on a novel, patent-pending cycle developed and owned by Linum, using mainly standard industry components with no use of strong chemicals or vacuums found in current solar air-conditioning market solutions.

Linum Systems received Seed funding from Terra Venture Partners ([www.terravp.com](http://www.terravp.com))

#### 1.1 The Global Need for Solar Cooling and Heating

**Energy Concerns:** Residential heating and cooling account for about **56%** of the energy use in a typical U.S. home, making it the largest energy expense for most homes<sup>1</sup>.

The average residential house in the United States spends a third (**33%**) of electricity consumption on cooling, heating and water heating<sup>2</sup>. In 2006, this amounted to 440,000 MWh in the USA. (For comparison, the **total** annual consumption of Israel of was ~52MWh) **6.4%** of electricity demand in the OECD countries is spent on residential cooling alone. Many **blackouts** are directly linked to peak demand in hot weather days<sup>3</sup>.

**Environmental Concerns:** Global warming is expected to raise summer temperatures in Europe and parts of the USA by **2-4°C** by the end of the century. Already, **Spain, Italy, Greece** and **parts of France** have turned from having a winter electricity peak to a summer peak, due to increase in A/C systems installed and used.

**Solar cooling and heating can reduce peak energy demand and increase the use of renewable energy, while providing energy savings to the end user.**

<sup>1</sup> Source: DOE, US Dep. of Energy

<sup>2</sup> Source: Energy Information Administration (EIA)

<sup>3</sup> France 2003, Australia 2008 etc.

## 1.2 The Need for a Practical, Efficient and Affordable Solar Air Conditioning

A multitude of government and industrial bodies have been formed globally to promote the use of solar cooling<sup>4</sup>. Governments have started to offer **incentives** (EU, USA and other) for solar heating and cooling, in order to combat the high costs of the technology.

Although the need is clear and several solutions are available, the market for solar cooling is still relatively small.

The main barriers holding back the market are:

- **Cost of Systems** – A 10 kW Absorption Cooler costs € 30,000–50,000<sup>5</sup> in the residential and small commercial market. This is 7 times higher than commercial A/C systems and has an ROI of at least **8-10 years** (incentives included).
- **Low Efficiency of Chillers** – Requires many solar collectors to collect enough energy which adds cost and roof area required.
- **Off-sun Backup Systems** – Implemented by expensive Gas heaters or none at all.
- **Water Cooling Towers** – Use of water for cooling which requires careful maintenance.
- **Use of Chemicals** - The use of chemicals such as ammonia or strong salts such as Lithium Bromide are perceived as hazardous.
- **Complex Maintenance** – Required by Absorption coolers and water cooling towers.
- **Complexity of Design and Implementation** – Systems require customized design and installation per site. This increases costs as well as requiring highly experienced personnel.

## 2 The *Linum Systems* Air conditioner

The Linum Air conditioning system is designed for cooling and heating of residential and light commercial spaces. It incorporates a **breakthrough thermodynamic cycle** which enables utilization of solar energy for cooling and heating at an affordable price.

The air conditioning system provides cooling and heating with or without sun available, for seamless, uninterrupted operation required by the residential user.

The A/C can be driven from standard off-the-shelf solar collectors, or from any other waste heat source, at medium temperatures (100 - 120°C).

The A/C has a familiar look and feel of a standard electrical A/C system and is easy to install and operate.

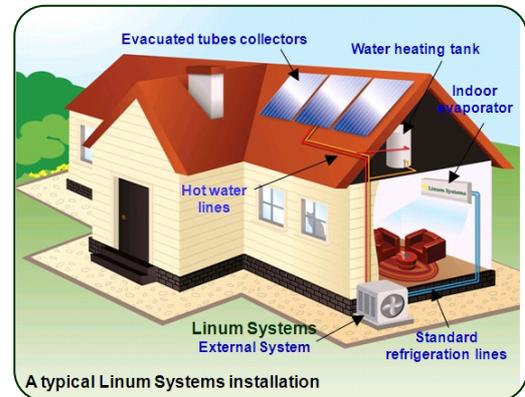
The system is planned for 3 sizes:

- **10.5 kW (36,000 BTU/h)** of cooling and heating, ideal match point for a medium residential villa, or a small office.
- **17.5 kW (60000 BTU/h)**, ideal for restaurants, small offices and large US residences.
- **7 kW (24,000 BTU/h)**, ideal for residences in cooler climates, such as Europe.

### The Linum Air conditioner is;

#### A Practical system -

- ✓ Extremely efficient, saving as much as **50%** of annual energy use on cooling and heating
- ✓ Provides cooling, space heating and water heating.
- ✓ Will run **seamlessly** regardless of sun availability.
- ✓ Normal, familiar looking indoor elements.



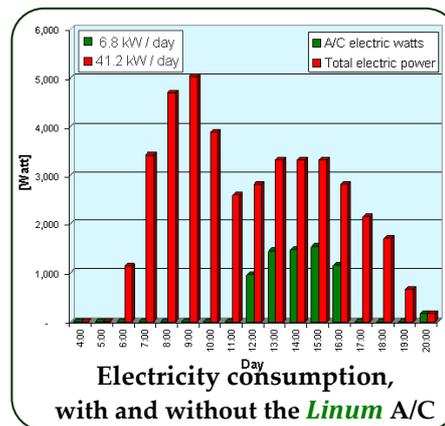
<sup>4</sup> Organizations such as ESTIF, SHC, SOLCO, NREL, EREC, ROCOCO, Solar COMBI+ and many more

<sup>5</sup> Source – FP6 EU Reduction of costs of Solar cooling systems (ROCOCO) program , 2007

- ✓ No corrosive chemicals or vacuums.
- ✓ Simple to install by current A/C installers.
- ✓ Air-cooled, no water cooling towers.

#### An Affordable system -

- ✓ Calculated ROI of 2-3 years (CA, Spain).
- ✓ Built mostly with standard air conditioning components.
- ✓ Use of industry standard (and low cost) refrigerant.
- ✓ No need for additional costly backup systems.



## 2.1 Market Opportunity

The global residential and light commercial market for A/C was **\$39 billion** in 2007<sup>6</sup>. By units, this accounts to the order of **48 million residential split A/C units** sold annually.

The prime markets are the US Sunbelt (California, Arizona, Nevada, Texas, Colorado), Spain and Portugal, Italy, Southern France and Australia.

The United States has **65 million** detached single family houses and **2.5 million** small detached stores and offices<sup>7</sup> Spain has approximately **8 million** single family houses, Portugal **3 million**<sup>8</sup>. More than 3 million 10kW systems are sold annually in the USA.

**An A/C system with a good ROI model and a practical, simple, seamless operation should see a very significant market share in these market segments.**

Linum Systems A/C can save as much as **\$1,500 - \$2,000** annually on cooling, heating and water heating electricity bill.

This calculates to **Return of Investment (ROI) of 2-3 years in California!**

## 2.2 Competitive Analysis

The main competition in the market is the electrically driven A/C. These systems, typically run at 450€/kW in the EU, setting a 10kW system to 4,500 € (initial investment, excluding additional annual electricity costs for operation).

Competition in the residential solar air conditioning market is divided into several technologies. Most mature are Small Scale Absorption Chillers and Evaporative Coolers. These machines are installed in small numbers due to the reasons discussed above.

## 2.3 Business Model

Linum Systems will design, qualify and initially market the Linum A/C system, which will be sold and installed by local A/C contractors and later via private labeling (OEMs). Manufacturing will be done by subcontractors, with final assembly by Linum. The initial target market will include single homes in the residential and small commercial buildings (retail, small restaurants, small offices etc.) The prime customers are chains of small stores and owners of single family dwellings, who seek to reduce energy costs by use of renewable energy.

Clearly, as market penetration and awareness grows, private labeling and eventually licensing of the technology is the preferred venue, as the big players in the market, such as Carrier, Trane, Mitsubishi, Daikin etc. have better distribution and manufacturing capabilities, enabling the support of volume growth.

<sup>6</sup>Source: Building Services Research and Information Association (BSRIA)

<sup>7</sup>Source: US housing Census, 2007

<sup>8</sup>Source: SolarCombi+ marketing data and other

## 2.4 The Team

### **Yuval Berson, Co-Founder and CEO:**

An experienced marketing and business development professional, with **14 years** of multidisciplinary experience in the Renewables, Power Distribution and Telecom markets. Till recently, Yuval has served as Head of Marketing at Di.S.P, a distributed solar power company, as Director of Marketing at Dekolink Wireless and as Director of Product Management at PowerDsine, a digital power management company. PowerDsine was later acquired by Microsemi corp. Yuval holds a B.Sc. in Electrical Engineering from the Technion and is the author of several patents.

### **Amir Hirshfeld, Co-Founder and VP of Engineering:**

An experienced R&D and Engineering professional with 13 years of various engineering experience in different sectors, Amir was Head of Engineering at Di.S.P, a distributed solar power company. Previously he served as Mechanical Engineering Group Head at Rada, an Avionics company. Before that Amir worked as a Design engineer at Limco Airepair Inc. (Tulsa, USA), an advanced heat exchanger and thermal solution company, and in El-Op and IAI as a Thermal Task Leader, responsible for the design of a turbine driven refrigerant cooling system, and Aircraft Air-Conditioning engineering (ECS) respectively. Amir holds a B.Sc. in Mechanical Engineering from the Technion.

**Technology Advisor, Eng. Amos Halfon:** AES technologies, senior advisor on renewable energies and cooling technologies. A 31 year industry veteran, working closely with governmental and large scale projects as well as extensive experience with use of renewable sources for heating and cooling and green building design. (<http://www.aes.co.il/amos.html> )

**Business Advisor for the US A/C Market , Steve Hutchcraft:** An experienced C-level executive with an extensive career in the heating and air-conditioning industry, culminating with his role as President and Chief Executive Office of Amana Heating and Air-conditioning, Vice President of Sales for International Comfort Products, Executive Assistant to the President of Carrier's North American Operations, and held several other leadership positions within Carrier. Steve holds a M.B.A. from Harvard University and a B.S. in Mechanical Engineering from Stanford University.

## 2.5 Current Status of Linum Systems

The Linum Proof of Concept system (PoC) has been developed to demonstrate the validity of the thermodynamic cycle and prove the ability of the system to operate at the three main modes of operation (Solar only, hybrid operation of combined heat and electricity and electrical only)

The PoC is operational and provides 24,000 BTU/h (7kW) of cooling at Linum systems lab. It affirms the validity of the cycle, providing active cooling in all three modes of operation.

Development of the commercial system has commenced.

The company is in the process of a new round of investment (round A) in order to raise funds to develop a commercial prototype of the system and pilot the prototypes in a fully solar installation.