OPEN INNOVATION AND ITS ROLE IN A NANO-ENABLED SOLAR INDUSTRY

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Project Overview

While nano-enabled solar technology promises to deliver a new generation of lighter, more efficient, more versatile photovoltaics, the companies developing these technologies are failing. A different approach to innovation may be of use here.

Open Innovation is a process of collaborative development wherein intellectual property is distributed freely, accelerating the innovation process. Open innovation has made substantial contributions to information technology and has made inroads into other fields such as manufacturing and medical technology. We explore the possibility that open innovation may help solve problems faced by the solar industry, particularly nano-solar startups. This requires that we consider the following:

- How has open innovation happened in software and hardware?
- Can we apply these ideas to nano-solar?
- What are the problems facing nano-solar development and implementation?
- Can open hardware communities deliver complex technological solutions?
- Are social conditions favorable to open sourcing of solar technologies?
- Is the required technology amenable to open innovation?

We investigated these questions by conducting interviews, collecting design information on various open source projects, and comparing the data to conditions established as favorable to open innovation by previous work.

Methods

We examine publications of open source hardware communities and consider whether they resemble better studied open source software communities. We determine what features of communities and technologies have led to successful innovation in software according to existing work, and review publications of open hardware communities to ensure that similar conditions exist. Based on these similarities, we extrapolate from existing models for successful open software development to the hardware domain in assessing the applicability of the method to solar. We contact developers and review specifications of a number of open hardware and software projects and determine which are built on the intellectual property generated by other projects. We generate a dependency tree in order to see the rate of development and kinds of technologies available in the open hardware landscape.

Because open innovation works best when the public has a positive normative or ethical valence toward a technology or holds a negative view of the technology being displaced[1], we consider relevant polling data.

Interviews are conducted with major companies in the nano-solar industry or closely related fields, such as innovative energy storage solutions. What is their approach to intellectual property protection? We determine where these firms fall on the range from closed, vertically integrated research and development to collaborative, distributed innovation. We determine what difficulties these firms are facing, and what kinds of changes they believe are needed for nano-solar to overcome these difficulties. We compare the suggested solutions to the capabilities of open hardware communities.

Closed Innovation

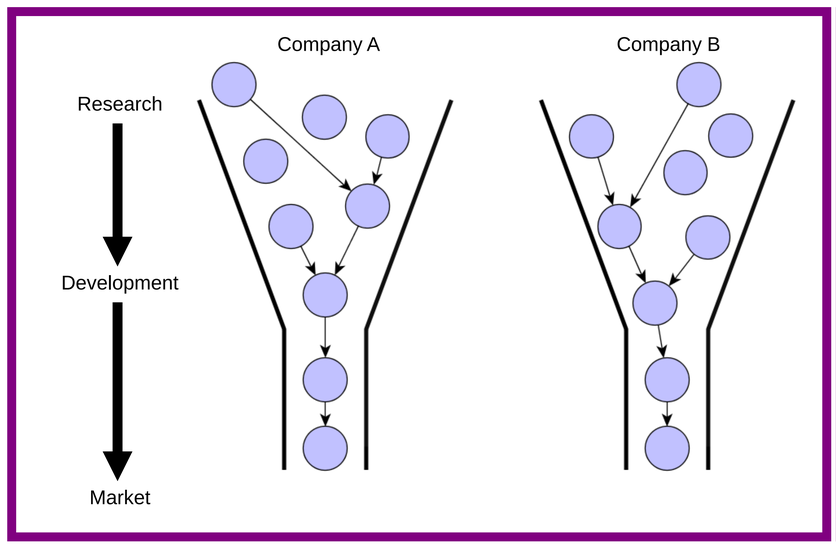

Figure 1. Generalization of the path for ideas from research to markets in closed firms[1]

Open Innovation

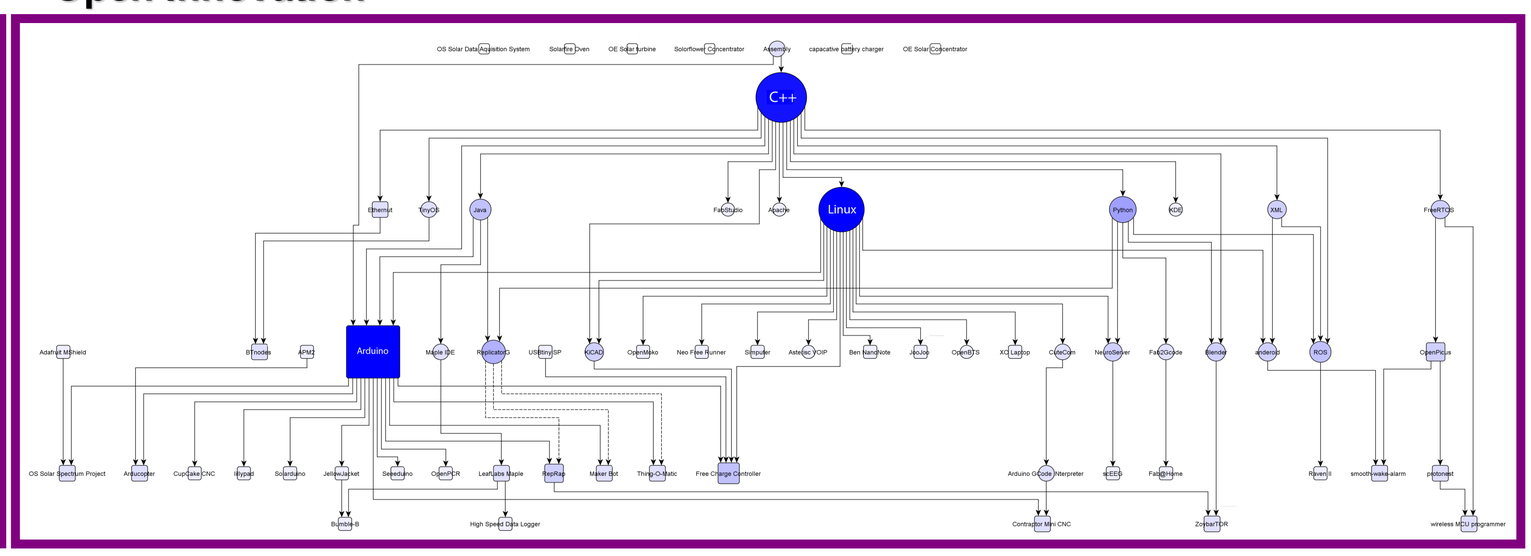

Figure 2. Actual dependencies between some open source projects

Known limitations of closed innovation

In the closed innovation process (fig. 1), many research projects yield outputs with no direct application to the existing markets targeted by the firm, or which can not be combined with other knowledge goods existing inside the boundaries of the firm. Trade secrets, which our interviews indicate are commonplace in the solar industry, leave technologies isolated. These technologies may appear to be dead ends, while in reality they could be combined with components in other firms to realize value that is otherwise lost. Two firms may each keep solutions to problems faced by the other secret, resulting in the failure of both firms. Innovative combinations of secret technologies will never be imagined, and these losses can not easily be estimated.[1]

"For solar,... there's no one size fits all."

- John Wood, CEO of Ecoult,

Developers of a breakthrough battery technology

"We strongly support a distributed energy model"

- Marc Thomas, CEO of DyeSol,

Producers of materials for dye-sensitized solar

"[the] Solar industry is not a very collaborative industry"

-Siva Siviram, CEO of Twin Creeks Technology,

Pioneering company in Proton Induced Exfoliation

Figure 3. 3 of the 6 nano-solar or related technology experts we interviewed

Mapping Dependencies

Figure 2. shows the dependency tree we have constructed from various sources. Circles represent software, squares represent hardware. An arrow from project A to Project B indicates that the technology produced by project A is a vital component in project B.

This tree has five layers, representing five generations of technology being developed in open innovation communities. These technologies are becoming progressively more complex. Unencumbered by boundaries defined by the firms developing these technologies, others recombine these technologies in ways their creators could not foresee, and new systems are rapidly developed. Items in each generation result from recombination of items from previous generations, along with modifications and additions. The mean release dates of the projects in each generation are separated by decreasing intervals of 14.5, 8.5, 3, and 2 years. This leads us to believe that these communities can produce new combinations of the technologies near the bottom of fig. 2 in under two years, provided that social requirements for contributor motivation are met. The projects in the most recent generations include CNC machines and surgical robots. This indicates that no current solar technology would be too complex for these communities to contribute to them in meaningful ways. Motion control software and hardware, charge controllers, wireless sensor networks, and more have been developed using open innovation. These components can provide direct support to emerging solar technologies through infrastructure if properly coordinated.

Extending known characteristics from open innovation in software to open innovation in hardware

Review of a variety of publications by and about open hardware communities reveal that their motives are quite like those of the open software communities studied in previous work. We believe that the characteristics known to be conducive to open innovation from studies of software should apply to hardware.

The following conditions are favorable for open innovation in software: [4]
- Opinions of incumbent technologies are negative
- People hold a positive normative or ethical valence toward the technology
- The technology is modular
- Many variations are required for specialized applications
- No central node requires hierarchical control (solution is distributed)

Contributor Motives and Nano-Solar

- Open Innovation communities are motivated by a common enemy and/or shared goals.[1]
- The public has a "negative attitude toward oil companies in general", and "increasing concern for the environment". [2]
- In 2011, 88% of Americans thought the US should rely more heavily on solar power.[3]

Interview Results

According to our interviews, Nano-enabled solar industry growth is limited in part by underdeveloped supporting technologies.
Our long term solar solution should be modular and distributed, with many variations to address local climates and varying energy needs.
Our interviews reveal a closed, vertically integrated approach to R&D currently dominating the industry. Strong IP protection, trade secrecy, and reliance on private, short-term venture capital characterize the industry.

Conclusions & Continuing Work

- The open source community appears to have the motivation and the capability to develop and support a wide range of components required to build a new energy infrastructure around and including nano-enabled solar technologies.

- The solutions described by nano-solar industry leaders as desirable for our energy future closely match conditions favorable to open innovation.

- Open Innovation has the potential to greatly accelerate the development of nano-solar technology and a new energy infrastructure around renewables in the near future.

- Nano-solar companies might consider adopting open innovation practices in order to parallelize the continued development of their technologies, accelerating the growth of the industry. (in which their positions of leadership may remain based on tacit knowledge)

- Future work should look at the funding structures which support the innovators we have interviewed and others, and begin to explore new potential funding structures based on more open models of innovation. We have already conducted interviews with a number of venture capitalists investing in nanotechnology and hope that understanding their current modes of operation will inform our future research and lead to financially viable paths to success for nano-solar technology using an open innovation model.

Literature cited

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