Title: PNNL Technology Transfer

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Abstract

In this report, we evaluate the effectiveness of the transfer of the Grid Friendly Appliance (GFA) from a laboratory environment to a commercial one. GFA is one of many products developed by the Pacific Northwest National Laboratory (PNNL) that has also been transferred to another entity for commercialization. PNNL has multiple ways in which they commercialize or transfer their internally developed technology such as patenting, licensing, and commercialization. To gain an understanding of the steps taken by them regarding technology assessment and implementation of the technology transfer, interviews were interviewed PNNL managers. Comparisons are made between PNNL's technology transfer methodology and typical transfer techniques based on domain, patents, licenses, etc. We find that although the GFA may not be commercial in a large scale, it is however a good example of transfer of intellectual property to an outside agency or a private entity.

The primary objectives of this paper are to understand the many ways a successful technology transfer is defined, understand how it is applied at PNNL, and determine if the definitions should be expanded to include other perspectives not identified in our literature search.

Contents

DISCLAIMER: *By no means is it the intent of this paper to discredit the claims of successful technology transfer for the Grid Friendly Appliance (GFA) technology. Rather, it is to understand if the current definitions of a successful technology transfer are sufficient enough to cover other perspectives and/or definitions. The authors acknowledge the significant contributions made by PNNL.*

ABSTRACT

In this report, we evaluate the effectiveness of the transfer of the Grid Friendly Appliance (GFA) from a laboratory environment to a commercial one. GFA is one of many products developed by the Pacific Northwest National Laboratory (PNNL) that has also been transferred to another entity for commercialization. PNNL has multiple ways in which they commercialize or transfer their internally developed technology such as patenting, licensing, and commercialization. To gain an understanding of the steps taken by them regarding technology assessment and implementation of the technology transfer, interviews were interviewed PNNL managers. Comparisons are made between PNNL's technology transfer methodology and typical transfer techniques based on domain, patents, licenses, etc. We find that although the GFA may not be commercial in a large scale, it is however a good example of transfer of intellectual property to an outside agency or a private entity.

The primary objectives of this paper are to understand the many ways a successful technology transfer is defined, understand how it is applied at PNNL, and determine if the definitions should be expanded to include other perspectives not identified in our literature search.

INTRODUCTION

As technology continues to drive the global marketplace, innovation is increasingly vital to competitiveness in many industrial sectors. Thus, research by the industry is ever-increasing and so are the tie-ups of technologies between industry partners. PNNL is a

national lab that also undertakes such industrial research and hence it is closely tied to the marketplace.

PNNL is a regional national laboratory coming under the purview of the Department of Energy (DOE), and it is operated by Batelle, the largest independent scientific research and technology development organization, since 1965. It is dedicated to addressing the challenging problems in energy, environment, fundamental and computational sciences and national security. PNNL employs nearly 3000 technicians and support personnel, engineers and scientists with annual turnaround of more than $1B. Since 1965, they have been granted nearly 2000 patents in the US and abroad. In the field of energy alone, they have nearly 270 publications in various peer-reviewed journals.[1]

Technology transfer addresses the assessment, adoption and implementation of technology. It is the process by which existing knowledge, facilities or capabilities developed under federal R&D funding are utilized to fulfill public and private need. [2]

PNNL's world-class and cutting-edge lab research, has often led to creation of patented intellectual property (IP) and transfer of such IP into successful commercial products impacting public lives.

GRID-FRIENDLY APPLIANCE

One such technology transfer venture carried out by PNNL is the Grid-Friendly Appliance (GFA) Project from early 2006 to Mar 2007. GFA is a technology by which the load on the power grid can be optimized so that the peak load can be regulated. GFAs use a micro-controller chip that actively monitors fluctuations in the power that an appliance sees. Upon sensing fluctuations, the controller reduces or increases the load on the appliance so as to optimally utilize the power. The GFA can be retro-fitted onto existing appliances as well as newer generation ones. [3]

Based on the outcome of the project, PNNL commercialized the micro-controller chip by transferring the technology to a start-up firm recently. However, in this project, not all

the elements of technology transfer are evident and there are areas that differ from traditional literature. The findings based on interviews with PNNL staff and literature is elaborated in the sections below.

THE PNNL TECHNOLOGY TRANSFER PROCESS

PNNL defines technology transfer as a technology deployed in service[4]. The technology process begins with an invention report which describes the technology in detail and is reviewed for potential intellectual property (IP) or copyrights. When a patent is issued, or pending, the process translates to the fairness-of-opportunity phase. This is when the technology is available for licensing.

Now, once the technology is ready for licensing, it is marketed via many different avenues. These include the PNNL website (www.availabletechnologies.pnnl.gov/), conferences, trades shows, or in the case of the GFA, target companies are identified. For example, in case of GFA, the target companies include home appliance manufactures such as water heaters and dryers where the technology would most likely be applicable.

One Marketing Approach

PNNL uses their website to solicit interest in a new technology. A dashboard is provided where the user can view technologies and patents that are available for licensing (Fig. 1 and 2). There are a number of user-friendly search options which help to isolate applicable information. Searches can be done on an industry application, keyword search, or a portfolio (energy, IT, etc.). Because the available technologies change so frequently PNNL has added a “subscription” feature which allows the user to subscribe to emails which are sent by PNNL whenever an update is available for the chosen technology area.

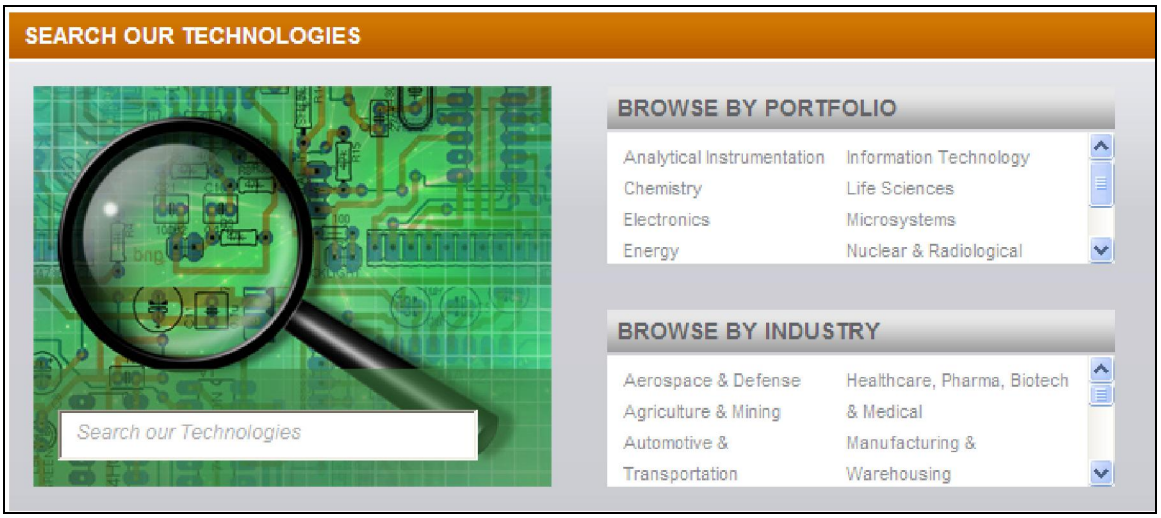

Figure 1: Technology search feature on PNNL's website

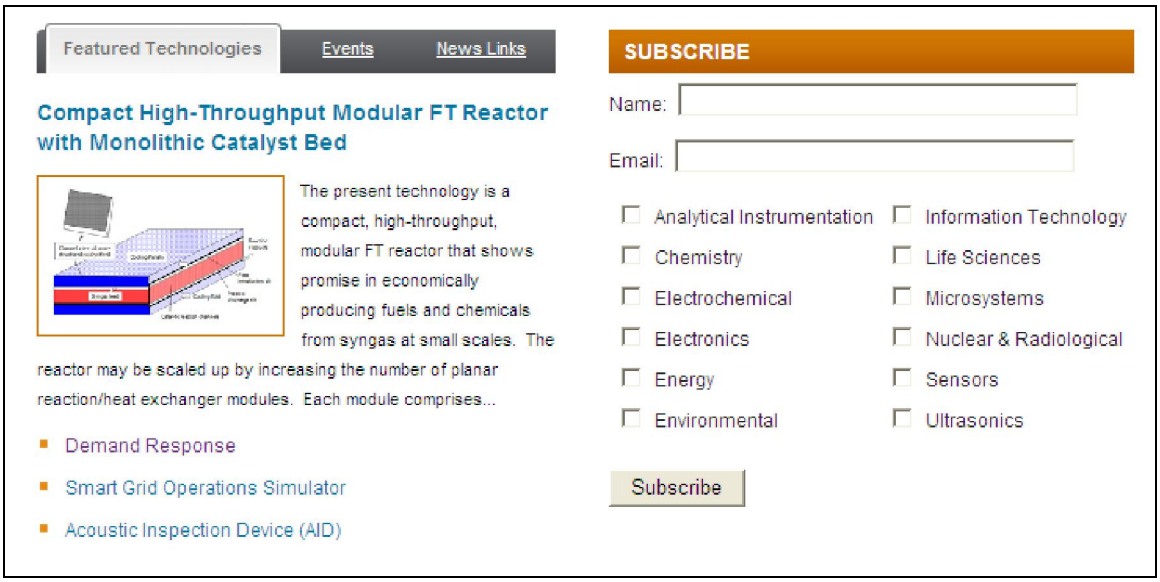

Figure 2: Subscription feature on PNNL's website

The Licensing Process

Once a potential customer is identified there are several considerations regarding the type of license to be issued. PNNL recognizes that "one size does not fit all" and is

flexible in terms of the licensing agreement so as to meet a company's unique requirements. For example, smaller organizations or start-ups generally need an exclusivity clause (vs. an established organization) to compete. In general, PNNL is adaptable and can create a contract that is tailored to an organization's specific needs. Steps outlining PNNL's licensing process once potential IP and copyrights have been determined are show below (Fig. 3).

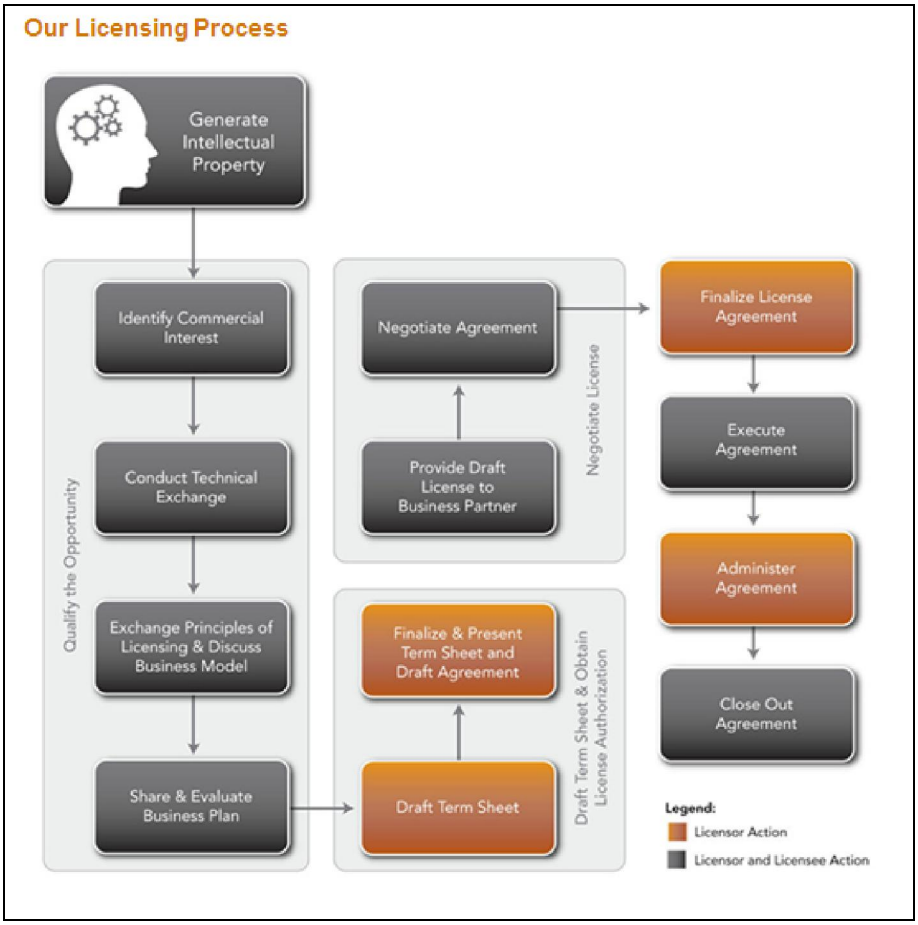

Figure 3: PNNL's licensing process

In case of the GFA project, PNNL granted Encryptor [5] a non-exclusive license in March 2011. Encryptor will further develop the GFA controller technology into a new electronic chip that will be built into appliances within the next two to three years and marketed to

target appliance manufacturers. Cheryl Cejka, PNNL's director of technology commercialization said: *"This technology has tremendous potential as a low-cost way of reducing stress on our nation's electricity system by making our everyday appliances better users of energy".*[6]

CHALLENGES TO TECHNOLOGY TRANSFER: R&D TO INDUSTRY

A concept frequently associated with the technology transfer process is known as the "valley of death". It is more typical for this phenomenon to occur when the technology is not developed in-house and is transferred to an external entity. If you refer to one of PNNL's definitions of technology transfer, "…it is a contact sport, requiring continuous interaction between technology sources, academia, the government, industry, and end users." [7], it is easy to understand some of the challenges with transferring technology, especially when it is being applied outside the organization. The contact element of the definition is minimized, therefore creating a challenge, albeit, one that can be overcome.

There are several methods available to overcome this challenge. Universities typically form technology transfer centers to help take discoveries from research labs to the hands of private companies for commercialization. [8] Another approach was presented by Francoise Bourdonnec (Intel).[9] Intel's approach to overcome the "valley of death" is to develop "Joint Path Finding Projects". Projects are selected based on their likelihood of success and early-on involve the business unit where the transfer will occur. Using this approach she quoted a 90% success rate of transferring the technology to application.

PNNL's approach is to assess the readiness of the technology and depending on the sophistication of both the technology and the company purchasing the license, PNNL funds 8 hours of a researcher's time to assist the company with integrating the technology or they might develop a Cooperative Research and Development Agreement (CRADA). A CRADA agreement provides a quick and unique access to

extensive government-funded R&D resources that can be pooled with your own to yield powerful research results, while providing intellectual property protection as you move swiftly toward commercialization. [7]

GRID FRIENDLY APPLIANCE CONTROLLER

GFA Project

From early 2006 through March 2007, Pacific Northwest National Laboratory (PNNL) managed the GFA Project, a field demonstration of an autonomous, grid-responsive controller called the Grid Friendly appliance (GFA) controller. This device is a small electronic controller board that autonomously detects under frequency events and requests that load be shed by the appliance that it serves. The GFA Project was one of two field-demonstration projects of the encompassing Pacific Northwest GridWise Testbed Demonstration. For the GFA demonstration, the GFA controller was configured to observe the nominally 60-Hz ac voltage signal, which is available at any residential wall plug receptacle, to recognize instances when the measured grid frequency fell below a 59.95-Hz threshold and to promptly alert the controlled appliance about the impending under frequency event. Grid frequency is a grid-wide indicator of any mismatch between generation and load on the grid. The sudden loss of a large generator on the grid will result in a sudden drop in grid frequency that cannot be immediately counteracted by the existing resource-side controllers and available spinning reserves. The resulting under frequency condition will continue until generation and load again become matched.

The study used 150 new residential clothes dryers that were manufactured for the project by Whirlpool Corporation and 50 retrofitted residential water heaters. The appliances were modified to shed major portions of their electrical loads when they received signals from their GFA controllers. These modified appliances were distributed among residences in several communities in the Pacific Northwest—Gresham, Oregon; and Yakima, Port Angeles and Sequim, Washington. The GFA controllers' output

signals and corresponding appliance responses were monitored at the participating residences for more than a year using commercial energy-management systems [10].

Technology

Throughout each of the three interconnected electricity systems that comprise the North American power grid, all power plants' generators rotate synchronously at 60 Hz as if they were one big machine. Using a simple computer chip to monitor fluctuations in the frequency of the electricity being delivered to an appliance, the controller can sense a disruption in the system's balance between electricity supply and demand. Slight imbalances occur daily, however occasionally these imbalances get out of control when large power plants or transmission lines go offline unexpectedly, potentially leading to widespread outages. When such a disturbance is detected, the controllers autonomously react within fractions of a second to reduce the electricity demand in an appliance and to help rebalance the system. In comparison, power plants that would typically shoulder the load during times like these could take minutes to come up to speed [11].

GFA controllers installed in appliances at the factory could be programmed to turn off only the high-consumption components of the appliances, such as a refrigerator's compressor, while leaving other functions such as the light and ice dispenser on for consumer use. Because the Grid Friendly controllers would only be installed in appliances that regularly cycle on and off, consumers would likely not even notice the interruptions thereby reducing impact on customer. However, the cumulative effect of delaying the defrost cycle in millions of freezers or turning off the heating element in millions of clothes dryers, even for a few moments, would be significant [11].

Grid Friendly appliance controllers, which are about the size of a playing card, can sense the frequency of electricity and measure deviations from its normal 60 Hz to determine the health of the energy grid and respond without the need for any communication system. The controllers also can be programmed to stagger the restart of appliances after a crisis rather than having them all come on at once, which could

shock the grid with a sudden jump in demand [11].

Potential Benefits and Impacts

GFAs can represent a more effective and less expensive emergency resource than the current approach to managing crises on the grid. Reducing demand within a fraction of a second during times of grid instability will allow the grid to recover, preventing blackouts and brownouts. Consumers would not be inconvenienced by GFA technology as they would not even notice if their appliances were shutting down for a few moments or if an energy-intensive function such as the defrost cycle on their freezer was delayed for a few minutes. By integrating the controllers with appliances at the factory, the cost to transform appliances from being part of the problem to being part of the solution in managing the grid could be as low as a few dollars per appliance. In the process, customers become an integral part of power grid operations and could even be rewarded for their participation in helping prevent a widespread outage [12].

Despite the benefits discussed above, it is necessary to remind that this is a pilot study on a limited number of households and that a larger scale demonstration of the effectiveness of the GFAs is yet to be verified.

DEFINITIONS OF TECHNOLOGY TRANSFER

Even though technology transfer is not a new business phenomenon, the considerable literature on technology transfer that has emerged over the years agrees that defining technology transfer is difficult due to the complexity of the technology transfer process. The definitions depend on how the user defines technology and in what context.

The term technology transfer can be defined as the process of movement of technology from one entity to another. The transfer may be said to be successful if the receiving entity, the transferee, can effectively utilize the technology transferred and eventually assimilate it . The movement may involve physical assets, know-how, and technical knowledge. Technology transfer in some situations may be confined to relocating and exchanging of personnel or the movement of a specific set of capabilities.

Technology transfer has also been used to refer to movements of technology from the laboratory to industry, developed to developing countries, or from one application to another domain [13].

However, there are many definitions of technology transfer. “Generally speaking, technology transfer is the sharing of knowledge and facilities among [14]:

- Federal laboratories
- Industry
- Universities
- Federal, state, and local governments
- Third party intermediaries

The following are some variety of definitions of technology transfer from different laboratories and institutions both within the U.S. and from abroad:

“The concept of technology transfer as a practical matter becomes clearer when one understands what technology transfer is designed to accomplish. For instance, the purpose of a federal technology transfer program is to make federally generated scientific and technological developments accessible to private industry and state and local governments. These users are then encouraged to develop the technology further into new products, processes, materials, or services that will enhance our nation's industrial competitiveness or otherwise improve our quality of life.”

National Technology Transfer Center (NTTC), USA
http://www.nttc.edu/products/guide/seca01.html

“The process by which existing knowledge, facilities or capabilities developed under federal R&D funding are utilized to fulfill public and private needs.”

Federal Laboratory Consortium for Technology Transfer, USA
http://www. federallabs.org/

"Technology transfer is the exchange of technical knowledge, data, designs, inventions or trade secrets from one organization to another organization or from one application to another application."

TRsG, Inc., USA
http://www.teamtrsg.com/tt%def.html

"The practice of making technological information and aid available at low or no cost to agencies in developing countries. Although it may conflict with patent considerations, technology transfer is an effective means of ensuring the spread of energy-efficient, greenhouse-gas-diminishing industrial capabilities. The term also refers to the co-development of new or advanced systems through partnerships between enterprises in different countries"

(Source: Mintzer, 1992)
http://www.globalchange.org/glossall/glosss-u.htm

"The transfer of intellectual property (patents, copyrights, trade secrets, know-how, et.) from the laboratory to the marketplace. It encompasses all the various life cycles of a product, from the initial thought through design to marketing and selling the product."

Office of Technology Transfer and Commercialization, USA
http://dor.ncat.edu/under/ottc/reference.htm

"The transfer of technology mandated as part of a countertrade or offset agreement, other than coproduction or license production. It may be in the form of research and development, technical assistance and training, or patent agreements between manufacturers. This is central to many Third World enterprises, public and private, and is the focus of a large number of countertrade and offset deals."

American Countertrade Association, USA
http://www.countertrade.org/acaoffset.htm

"The transfer of knowledge or equipment to enable the manufacture of a product, the application of a process, or the rendering of a service."

Belgian National Focal Point to the Convention on Biological Diversity, Belgium
http://bch-cbd.naturalsciences.be/belgium/glossary/glos_t.htm

"The transfer of ideas, information, methods, procedures, techniques, tools, or technology from the developers to potential users."

Northeastern Research Station, USA

http://www.fs.fed.us/ne/newtown_square/research/themes/glossary.shtml

"The set of activities that support moving research results into the market place."

University of Arizona, USA

http://w3fp.arizona.edu/dataadmn/Infoarc/iara.htm

"The broad set of processes covering the exchange of knowledge, money and goods amongst different stakeholders that lead lo the spreading of technology for adapting to or mitigating climate change. In an attempt to use the broadest and most inclusive concept possible, the Report uses the word 'transfer' to encompass both diffusion of technologies and cooperation across and within countries."

Methodological and Technological issues in Technology Transfer

http://www.grida.no/climate/ipcc/tectran/362.htm

"Transfer of technology that occurs as a result of an offset agreement and that may take the form of: research and development conducted abroad; technical assistance provided to the subsidiary or joint venture of overseas investment; or other activities under direct commercial arrangement between the U.S. manufacturer and a foreign entity."

Conventional Arms Transfer Project, USA

http://www.clw.org/pub/clw/cat/offsetdefinitions.html

"Technology transfer addresses the assessment, adoption and implementation of technology [15]."

"Technology transfer is the process by which existing knowledge, facilities or capabilities developed under federal research and development funding are utilized to fulfill public and private needs [15]."

"Technology Transfer is the process by which research and other new technologies are

transferred into useful process, products, and programs. Another way of saying the same thing is: technology transfer is the process by which a better way of doing something is put into use as quickly as possible. [16]"

COMPARING THE DEFINITIONS OF A SUCCESSFUL TECHNOLOGY TRANSFER: Is there a one size fits all answer?

From the previous section it is apparent that there are many ways one can define a successful technology transfer. PNNL's definition of a successful transfer is when the technology is deployed into service [4], or quoting Cheryl Cejka "…our mission is to develop game changing technology and transfer it to a useful purpose…" [17]. However, after further research it is further understood that the GFA technology has not actually been deployed into consumer products, yet. On the surface this appeared to contradict the traditional understanding of a successful technology transfer. Provided is a side by side comparison of the definitions identified in literature versus the GFA technology. The question is to determine if it satisfies the criteria of a "successful technology transfer".

LITERATUE DEFINITIONS	PNNL PERSPECTIVE	OUTCOME
Purpose of a federal technology transfer program is to make federally generated scientific and technological developments ***accessible*** to private industry and state and local governments.	PNNL has a federal technology transfer program and the developments are made available to private industry and state/local governments via traditional modes of outreach and communication.	
The transfer of IP from laboratory to marketplace … encompasses all the various life cycles of a product – from	It is possible that selling the license to Encryptor could form the basis of PNNL's definition of a successful technology	

design to ***selling*** the product	transfer.	
The transfer of ideas, information, methods, procedures, techniques …. from the developers to potential users	The GFA technology was transferred from the developers (PNNL) to potential users (Encryptor).It might be common to assume that the potential users would be customers who purchase appliances with GFA technology. In which case the GFA technology would not meet the criteria because it is not commercially available in appliances yet – there could be many perspectives of a potential user!	
The transfer of knowledge or equipment to ***enable the manufacture*** of a product	License sold to Encryptor who plans to further develop the GFA controller into a chip that will be available in appliances within the next two to three years	

Table 1: Literature vs PNNL's perspective of Technology transfer w.r.t GFA

CONCLUSIONS

PNNL is a highly successful National Laboratory with a demonstrated and substantial research portfolio. Notwithstanding these impressive credentials there appeared to be a fundamental difference between how a successful technology transfer was defined as compared to the literature results. After an extensive literature review, the conclusion is

that it is appropriate to define success differently depending on the technology developer, the objectives, and the application. In the case of the GFA technology, PNNL may only need to get the technology into the hands of a company to claim a success, in this case Encryptor. At which point Encryptor may define their success as installing the technology into appliances on a wide scale. It is also important to note that the terms “user” or “customer” have many different interpretations and depending on how this is defined would have an impact on the definition of success. In the case of the GFA, *if* it is assumed that the customer is the person who purchases an appliance with a GFA controller, then this might not be defined as a successful transfer – these appliances are not commercially available. Lesson learned: there is no “one size fits all” understanding of a successful technology transfer!

REFERENCES

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[3] http://www.pnl.gov/main/publications/external/technical_reports/pnnl-17079.pdf

[4] Interviews with Peter Christensen, Commercialization Manager, PNNL, 07/21/2011 and 08/01/2011 – notes from interview are included in the appendix.

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