IPRO 350

Small Town Sustainable Economic Development
Feasibility of a Biochar System in Orange, Massachusetts

Project Plan

Illinois Institute of Technology
Spring 2011

Project Sponsor: Town of Orange, Massachusetts
Faculty Advisor: Dr. Nasrin Khalili, Jim Braband

Team Members

Remi Adejinle
Gokul Butail
Samantha Cosenza
Tillman de Graaff
Takahiro Futagami
Ben Hinshaw
Asfandyar Khan
Catherine Latour
Brandon Lee
Dashiell Stewart
Yani Wang

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I. TEAM CHARTER

A. Team Information

Name	Major, year	Email	Phone
Remi Adejinle Team Leader	Chemical Engineering, 5th	radejinl@iit.edu	[redacted]
Gokul Butail Design Sub-Team Leader	Mechanical Engineering,4th Aerospace Engineering, 3rd	gbutail@iit.edu	[redacted]
Samantha Cosenza	Mechanical Engineering, 3rd	scosenza@iit.edu	[redacted]
Tillmann De Graaff	Architecture, 4th	tdegraaf@iit.edu	[redacted]
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Ben Hinshaw	Computer Engineer, 4th	bhinshaw@iit.edu	[redacted]
Asfandyar Khan	Architectural Engineering, 3rd	akhan9@iit.edu	[redacted]
Catherine Latour	Chemistry	clatour@iit.edu	[redacted]
Brandon Lee Business Development Sub-Team leader	Business Administration-Finance, 3rd	blee21@iit.edu	[redacted]
Dashiell Stewart	Psychology, 3rd	dstewar9@gmail.com	[redacted]
Yani Wang	Business Administration-Corporate Finance, 3rd	ywang203@iit.edu	[redacted]

B. Team member strengths and expectations

Remi Adejinle, Chemical Engineering

Remi is a fifth year chemical engineering student and brings her engineering knowledge, the ability to lead and follow, excellent communication skills and good writing skills to the group. She hopes to learn all about the biochar technology and how to work effectively with others as well as learn organizational ethics. She expects the IPRO team to successfully deliver the team's set goals by IPRO day.

Gokul Butail, Mechanical and Aerospace Engineering
Gokul is a third year Mechanical and Aerospace engineering student. He comes from a rural environment, a perspective he believes will be useful in the setting of this project. Gokul has knowledge from variety of disciplines and has a very practical approach. In this project, he hopes to learn about biochar, a sustainable and efficient technology, in hopes of setting-up a similar model in his hometown back in India. He wants the project to be a learning experience for each individual member of the team and expects that the project would bring a visible and positive change in the town of Orange.

Samantha Cosenza, Mechanical Engineering
Samantha is a third year mechanical engineering student. She will contribute her knowledge of mechanics and add her communication and writing skills to the team. She also hopes to learn about biochar and the technology involved in producing it, to learn how to work as a team on a difficult task, and to increase her knowledge of the business world. She expects the team to meet the deadlines and achieve its goals by the end of the semester.

Tillmann de Graaff, Architecture
Tillmann is a fourth year Architecture student from Germany. He is an experienced team worker and a critical and creative thinker. He brings a variety of skills, including graphic design and layout, and architectural research. He is interested in applied sustainable design and the science of biochar. He wants to experience a successful teamwork that produces a convincing solution for the needs of Orange town.

Takahiro Futagami, International Business
Takahiro is a third year International Business student. He is an entrepreneurial spirit, and an innovative thinker. He expects to learn working with other members of different skill sets. He is interested to see pyrolyzer prototypes and what new improvements can be made to the biochar system. He expects the team to meet deadlines and their shared goals.

Ben Hinshaw, Computer Engineering
Ben is a fourth year computer engineering student. He possesses good communication skills, a team-oriented ethic and adaptability. He looks forward to learn about biochar technology, business modeling and dividing hard tasks into manageable pieces. He expects the team to develop a prototype and business model by the deadline.

Asfandyar Khan, Architectural Engineering
Asfandyar is a third year architectural engineering student. He is good at conducting research and understanding the mechanics of systems. He hopes to learn the advantages and disadvantages of biochar technology, and understanding the process of producing biochar and how to implement it to enhance the economy. He expects the team to be able to exceed the expectations of the town of Orange.

Catherine Latour, Chemistry Department

Brandon Lee, Business Administration-Finance
Brandon is a third year business administration-finance student. He has significant business knowledge, good communication skills, and works well on teams. He hopes to learn about the sustainable waste management, entrepreneurship and making a business plan. He expects the IPRO team to achieve the set goals by the scheduled deadlines.

Dashiell Stewart, Psychology
Dashiell is a third year psychology student. He has good communication skills, and working knowledge of group dynamics. His objectives are to learn about biochar, and business modeling and planning. He expects the IPRO team to develop a prototype and create a business model on time.

Yani Wang, Business Administration - Corporate Finance
Yani is a third year business student with strong research skills and statistical analysis, plus a broad knowledge about culture diversity. She works to contribute creative ideas to the team and clearly communicating with other team members. She wants to learn new knowledge about environmental management and how to approach feasibility challenges for implementing new technology. She expects the team to successfully accomplish the plan and meet the expectations of the town of Orange.

C. Team Identity

To be developed.

D. Team Purpose and Objectives

1. Team Purpose

The purpose of the team is to design a model of a sustainable waste management system for the town of Orange, Massachusetts. We seek to foster the economic attractiveness and vitality of the town by designing a better and more sustainable way to manage the town's waste.

2. Team Objectives

- Gather information and characterize the type, quality and quantity of organic solid waste generated in Orange, MA.
- Examine and compare biochar to other technologies to determine if it is a sustainable and economically feasible solution for managing and converting organic waste generated in rural areas into marketable byproducts while also encouraging economic development and job creation in those areas; specifically, the team will focus on the town of Orange, MA and its socio-economic characteristics.
- Develop a business case for the proposed technology, including costs, benefits, risks, potential market, and likelihood for economic growth in Orange.

- Examine and select the most promising technology identified based on our investigation mentioned above; develop a working prototype or acquire a pilot-scale technology for the following purposes:
    - Test and perform qualitative and quantitative analysis of the system.
    - Research the potential products and byproducts that can result from the process and their possible use.
    - Determine the commercial viability of the products and byproducts.

E. Background

1. Information about Sponsor

Orange, Massachusetts is a demographically diverse community with a significant number of artisans, recreational venues, environmental assets and strong sense of community. Orange has all of the social, technical and resource-based elements to foster a green economy: extensive waterways, productive woodlands, substantial organic farm works and a resilient work force whose machinist roots dates back two centuries. Using these assets as a foundation, the town has chosen to pursue a sustainable, environmentally informed development.

2. Information about the Problem

Small towns like Orange are severely affected by the increasing urbanization of the service sector and the outsourcing of manufacturing jobs to other countries. Forced to seek opportunity elsewhere, young people have moved out, leaving towns with aging populations, struggling economies, and crumbling infrastructures. Emerging entrepreneurs in the area hope to create jobs and stimulate the local economy by making use of the area's resources.

The current waste disposal method for the town of Orange, Massachusetts comes at a cost to the citizens of the town and requires shipping sewage waste a long distance. A waste management facility in or near Orange could reduce or eliminate this expense for residents and provide useful byproducts that could be sold commercially and subsequently stimulate the local economy.

3. Information about existing technologies

The aim of waste management is to prevent or reduce the impact of waste materials on human health or local amenity. Waste management can involve solid, liquid and/or gaseous wastes, and the methods involved for each are disparate. Waste management practices are often very different between urban and rural areas, and residential and industrial/commercial producers, even within the same local region.

There are several technologies available for converting waste into useful products. Mostly commonly used are discussed below:

- *Recycling*: This is the reuse a material that would otherwise be considered waste. The most common recycled material includes aluminum and steel cans, PET and glass bottles, paper boards, newspapers and magazines. The process of recycling requires significantly less energy, water and other resources to recycle materials than to produce new materials. Recycled or used materials have to compete in the marketplace with new

materials. The cost of collecting and sorting the materials sometimes make it equally or more expensive than virgin materials.

- *Incineration*: This method destroys waste material by burning it. The process is often used to produce electrical energy by burning the waste material and producing steam to drive an electric generator. Incinerations as a waste management process is very controversial as the gases and the ash residue produced are often toxic to human health and the environment.

- *Pyrolysis and Gasification*: These are related processes of thermal treatment where materials are incinerated with limited oxygen. The process typically occurs in a sealed vessel, under high temperature and pressure. Converting waste material to energy this way is more efficient than direct incineration, with more energy able to be recovered and used, making the process more environment friendly.

4. Biochar Technology

The main technology that the team will explore is biochar technology. Biochar is char derived from the thermal conversion of biomass that is used for non-energy purposes. Biochar is a fine-grained, porous charcoal substance that, when used as a soil amendment in combination with sustainable production of the biomass feedstock, effectively removes net carbon dioxide from the atmosphere. Thermal decomposition involves baking biomass in the absence of air to drive off volatile gases, leaving carbon behind. There are three main processes to achieve this: pyrolysis, gasification and hydrothermal carbonization. These methods can produce clean energy in the form of gas or oil along with the biochar. This energy may be recoverable for another use, or it may simply be burned and released as heat. It is one of the few technologies that are relatively inexpensive, widely applicable and quickly scalable.

Biochar technology is more than just the equipment needed to produce biochar. Biochar technology necessarily includes entire integrated systems that can contain various components that may or may not be part of any particular system.

In general, biochar systems include the following elements:

- Collection, transport and processing of biomass feedstock
- Production and testing of biochar
- Production and utilization of energy co-products: gas, oil or heat
- Biochar transport and handling for soil application
- Monitoring of biochar applications for carbon accounting or other purposes.

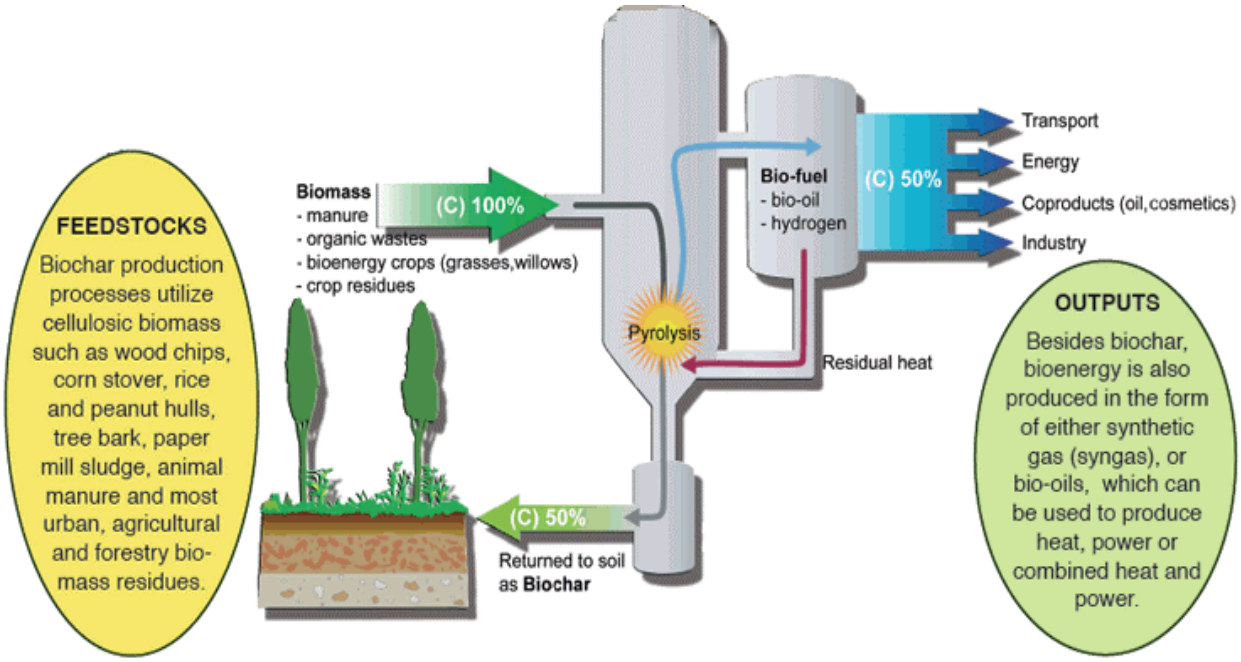


Figure 1. Biochar Process Map

5. Historical Success and Failure

The highly fertile dark earth soils of the Amazon River basin indicate that a form of biochar has been used in agriculture for many hundreds of years. These dark soils, also known as *terra preta*, contain a fine-grained, carbon rich material. Analysis show that this material comes from charred organic materials like manure, crop residue and bones that was added to the soil. Without sophisticated kilns and ovens to produce modern biochar, this ancient material was likely made by setting alight a pile of organic material before covering it with dirt to eliminate oxygen but hold in the heat from the fire which, in turn, baked the organic matter.

Companies around the globe are introducing biochar technology to agricultural areas to enhance the economy. Hans-Peter Schmidt, who directs the Delinate Institute for Ecology and Climate Farming, established a biochar trial at the experimental vineyard Domaine de Mythopia in Switzerland in 2007. His group also has provided biochar for about 10 agricultural field trials in Germany, Norway, France, Switzerland, and Austria.

Various research centers have been established in the UK, Canada, Chile, Hawaii and many other places. Most of these plants and research centers have shown great potential for development. They show potential for economic development in small towns, for sustainability and for reducing waste.

A company named Re:char is developing a low-cost mobile pyrolyzer in Brooklyn, New York to burn agricultural biomass waste and turn it into biochar. The current prototype can process up to a ton of biomass per day, running full time. Half of the output is bio-oil, thirty percent is biochar,

and the rest comes out as gases that are fed back through the system and react further to make more hydrocarbon vapor.

All projects, however, have not been a success. A commercial production plant was opened in Dunlap, Tennessee in August 2009 after testing and an initial run. However, it was subsequently shut down as part of a Ponzi scheme investigation.

6. Ethical Issues

While there are no obvious ethical issues in dealing with the development of a waste management system for the town of Orange, the team may communicate with a company in the area, in which case the matter discussed with the company, especially dealing with research involving technologies, must remain confidential.

7. Business Costs

To run a business in which waste sludge is converted to into biochar and other products that can be commercially sold, a great deal of time and money will need to go into the operation. The initial cost will be very high, but once the biochar system is implemented and the business gets running, it should begin to earn a profit after some time. The byproducts which result from pyrolysis can also generate a good market.

8. Practical Methodology

The team's approach to solving the waste management problem in Orange, Massachusetts is to construct a prototype that will be the most productive and efficient in converting waste into useful and marketable products. This prototype will be the model for an eventual waste management plant in the Orange region.

F. Team Values Statement

1. Team Desired Behavior

Team members will be expected to promptly attend all meetings with sufficient materials to accomplish the day's goals. Additional resources will be used and work will be facilitated through iGroups and Google Documents. Each member is expected to participate in general discussions as well as apply their efforts and expertise to more specialized portions of the project. Team members are expected to respect each other and make everyone feel comfortable as part of the group. Each member is also required to give his or her complete attention during meetings; no text messaging, calling or browsing the Internet outside of project work is allowed. The team succeeds or fails, not the individual.

2. How to address Problems

Discuss the problem openly as a team and come up with solutions which will be voted on; majority vote wins. If the problem persists, report to higher authority that is, the team's faculty advisor(s).

II. PROJECT METHODOLOGY

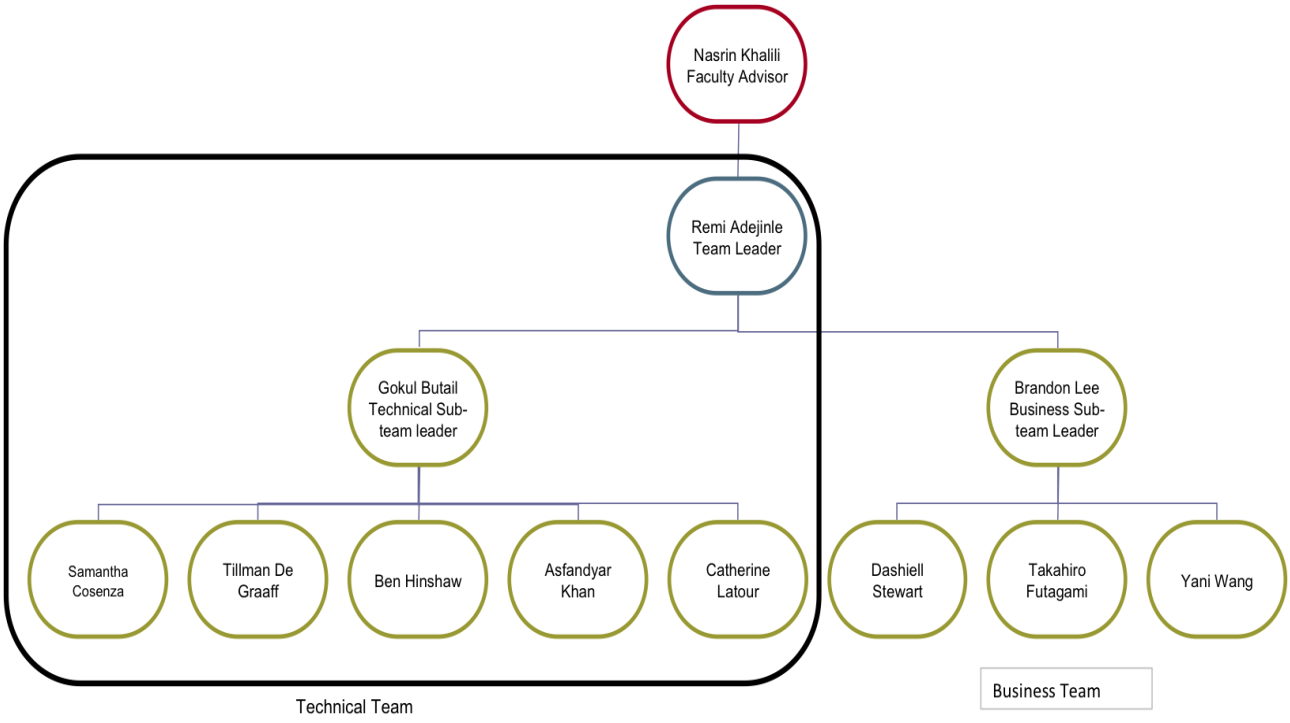
A. Work breakdown structure

1. Problem Solving Techniques

The team will conduct extensive research to gather existing information on the kinds and quantity of waste available for use as raw materials in the design of a model. We will also investigate the best existing technology that converts organic waste to usable and marketable products. The team will then decide what kind of system will best suit our customer's needs and conduct analysis on the costs and profitability of the model/design. A working prototype will then be developed based on our investigations. The system will be tested and a qualitative and quantitative analysis will be performed. Then research will be conducted on the potential products and byproducts that can result from the process and their possible use. Finally, the commercial viability of the products and byproducts will be determined.

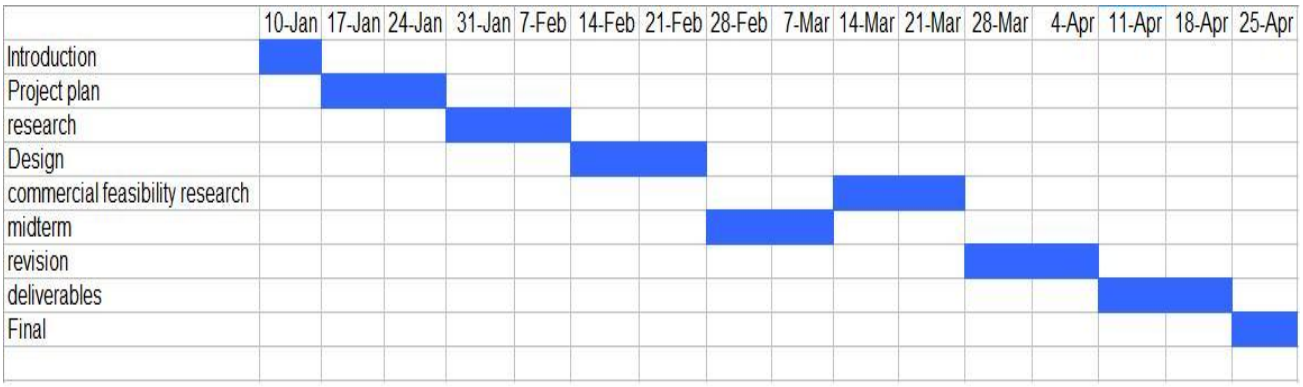
2. Team Structure

The team has been divided into two major parts: The design team and the business/marketing team. Design team members will be responsible for ultimately designing a sustainable waste management system for the town of Orange. The business/marketing team will perform a commercial viability analysis for the products and a marketing strategy.



3. Gantt Chart

Tasks	Start date	End date	Duration (days)	Members
Introduction	1/10/2011	1/16/2011	7	All
Project plan	1/17/2011	1/28/2011	12	All
Research	1/31/2011	2/13/2011	14	All
Design	2/14/2011	2/27/2011	14	All
Commercial viability research	3/14/2011	3/27/2011	14	All
Midterm	2/28/2011	3/13/2011	14	All
Revision	3/28/2011	4/10/2011	14	All
Deliverables	4/11/2011	4/24/2011	14	All
Final	4/25/2011	4/28/2011	3	All



B. Expected results

1. Details on Expected Activities: The team will engage in the following activities through the course of the project:

- Conduct research on existing technologies as well as the success and failure stories.
- Collaborate with the project representatives at Orange to get specific information about the town of Orange and its resources.
- Meet every class period to discuss the progress of the project.
- Make a visit to the town of Orange, if the need arises during the course of the project.

- All resources like Internet, Professors and the people from town of Orange will be extensively utilized.
- Market research on consumer demand and target market(s).
- Identify potentials for job creation and enhancement of economic viability if the town of Orange should use the technology.

2. Expected Data: We expect to obtain the following data from research:
   - Kinds and quantity of wastes available for use.
   - Technologies in use in different parts of the world for managing waste.
   - The types and quantity of products and byproducts from each technology and their uses.
   - Cost of production current market prices for the products.
   - Commercial viability of the products.
   - The system's economic impact on town.

3. Potential Products
   - A working prototype of a sustainable waste management system.
   - A commercial viability analysis.
   - Estimated costs towards the final commercial product and any other costs such as advertising, marketing, and manufacturing overhead.
   - Identify the benefits and impacts of the technology.

4. Summary of Challenges, Risks and Assumptions

The initial challenge involves developing a prototype of a sustainable biochar system that would eventually become a large-scale factory. To do this, research must be done on preexisting biochar technology to find the most efficient method of converting the waste sludge from Orange and the surrounding region into biochar. Once this is done and the cost of implementing a large-scale factory is determined, the challenge becomes creating a business plan for Orange so that they can sell the biochar commercially and make a profit.

The risks involve the building of the machinery and the operation of the system; as with any machinery one must be concerned about safety, especially since there will be a need for a large amount of heat in order to produce the biochar.

In developing this small-scale biochar system, it is assumed that the system can be made into a large-scale system using the same technology, and that the town of Orange will have enough funding to implement this large-scale system. If this is not the case, research will have to be conducted to try to find a less expensive method of converting waste into biochar.

5. How Expected Results will be incorporated in Proposed Solution

Results from data collected through intensive research will be used to design a working prototype of a sustainable biochar system for the town of Orange. Results from statistical and marketing research will be used to design a business model for the biochar facility and company.

C. Project Budget

Item	**Cost**
Technical Equipment	$3000
Materials	$2000
Communication	----
Transportation	$2500
Prototype/Test Unit	$1500
Printing Miscellaneous	$300
Total	**$9600**

- **Technical Equipment Fee** will be used for investigating those existing technologies and evaluating and selecting the most efficient and suitable one for Orange town (rural area);
- **Material Fee** will be used for collecting and measuring various possible materials and resources;
- **Report Fee** will be used for composing, proofreading, printing, faxing various reports (business plan, feasibility report, mid-term report, final report to IPRO Review Committee and local government of Orange Town, Massachusetts);
- **Transportation Fee** is a part of Communication fee, which will be used for necessary communication with local government of Orange Town, Massachusetts; at least, in this project, two trips from Illinois Institute of Technology, Chicago to Orange Town, Massachusetts, including three key team members are necessary; and
- **Prototype/Test Unit Fee** is used for sample experiment of organic and sustainable materials.

D. Designation of roles

Technical Team	**Business/ Marketing Team**
Remi Adejinle (Team leader)	Takahiro Futagami
Gokul Butail (Sub team leader)	Brandon Lee (Sub team leader)
Samantha Cosenza	Dashiell Stewart
Tillmann de Graaff	Yani Wang
Ben Hinshaw - Time keeper	

Asfandyar Khan	
Catherine Latour - Minute taker	

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