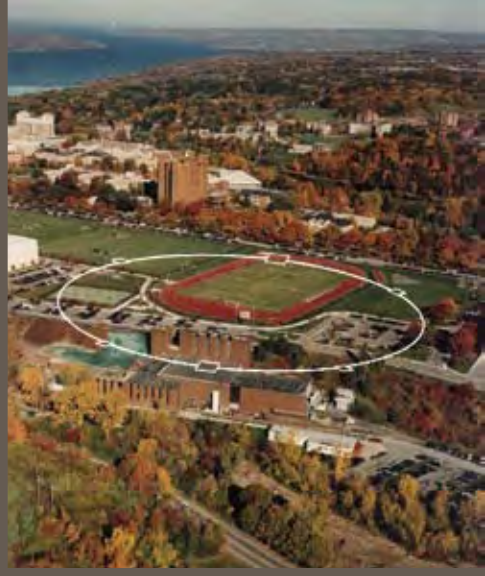
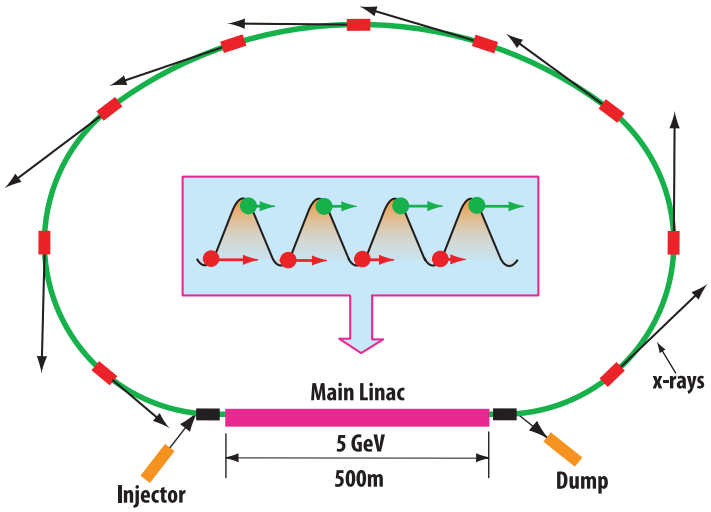
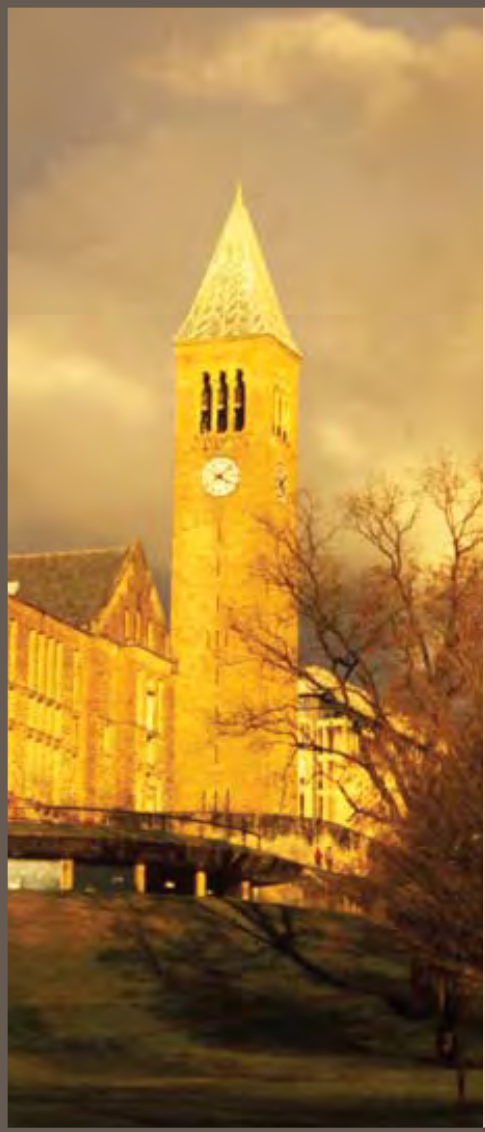
Cornell University



ECONOMIC IMPACT OF
CORNELL UNIVERSITY'S PROPOSED

ENERGY RECOVERY LINAC FACILITY





OCTOBER 2007
APPLESEED

Economic Impact of Cornell University's Proposed Energy Recovery Linac Facility

October 2007

Appleseed

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Executive Summary

Cornell University proposes to build the world's most advanced source of synchrotron radiation, the Energy Recovery Linac (ERL), to replace its existing synchrotron light source, the Cornell High Energy Synchrotron Source (CHESS).

Construction and operation of the Energy Recovery Linac will have a significant impact on New York State. The $500 million invested in development of the facility will create jobs in construction and related industries. Its operation will also create new jobs; and it will preserve hundreds of existing jobs that will otherwise be lost when CHESS closes – as it inevitably will if there is no ERL upgrade to CHESS. Moreover, the ERL would substantially surpass the capabilities of x-ray sources that could soon come on-line, assuring New York a premier role in synchrotron x-ray science for decades to come.

Taking into account direct spending and spending through the multiplier effect, we estimate the Energy Recovery Linac will generate more than $953 million in total economic output in New York State over its five years of construction and first ten years of operations. In the long run, the ERL will have an even greater impact on the State, by attracting and developing talented scientists and engineers, by helping New York State scientists compete for research funding, by spinning off new commercial products and businesses in the State, and by educating a new generation of students who will become future leaders in science and industry.

1) Past Impact on New York State

CHESS, a federally-funded national user facility since 1979, has expanded New York State's impact in research and education – particularly in the life sciences.

- CHESS – and the Cornell University Center that operates it, the Cornell Laboratory for Accelerator-based ScienceS and Education (CLASSE) – is a major source of revenue flowing into New York, with at least 85 percent of FY 2007 revenues coming from outside the state.

- Since 2003, almost 3000 scientists and engineers have used CHESS data. About half of these people were based in New York. These users were from all sectors: Industry, academe, and government.

- CHESS enables New York researchers to win federal research funding. For example, during 2006-‘07 scientists used CHESS to perform over $20M of biomedical grant research, half of which was awarded to New York-based scientists.

- CHESS is a major contributor to education. Since 1980 more than 550 students have used CHESS data to obtain their doctorate degree.

- CHESS-affiliated faculty and alumni have started at least three companies in Central New York.

2) Projected Impact of ERL Construction

Construction of the ERL will generate jobs and economic activity throughout New York State, especially in Central New York.

∞ In *Central New York*, the 5 year construction project will directly generate an estimated 897 person-years of employment in construction, 354 person-years in project-related services, and 338 person-years in firms equipping the facility – a total of 1,589 person-years of employment. Through the multiplier effect, the project will generate another 1,810 person-years of employment throughout Central New York and $196 million in economic output.

∞ In all of New York State, the project will directly generate an estimated 1,104 person-years of employment in construction, 415 person-years in project-related services, and 548 person-years in firms equipping the facility – a total of 2,067 person-years of employment in New York State. Through the multiplier effect, the project will generate another 2,169 person-years of employment throughout NY and $267 million in economic output.

∞ ERL construction will generate about $12.1 million in direct tax revenues to New York and $10.9 million in indirect tax revenues through the multiplier effect. This includes about $15.9 million in direct and indirect New York State income taxes.

∞ The ERL facility will require corporate expertise in many high technology areas, and will strengthen the ability of New York industry to compete for work on other large, technologically-sophisticated projects.

3) Projected Impact of ERL Operations

Once constructed, ERL operations will have a large impact on New York that will continue for decades. Annual Federal ERL operations support would be between $30 and $50 million.

∞ CLASSE employment will grow to an estimated 220 full-time employees (FTE). Estimated annual spending on goods and services will grow from $11 million to $15.5 million, with about 2/3 of this going to New York firms.

∞ CLASSE will directly create an estimated 234 FTE jobs in Central New York and, through the multiplier effect, another 129 FTE jobs and $6.5 million in annual economic output. In all of New York State, CLASSE will directly create 252 FTE jobs and, through the multiplier effect, 164 FTE jobs and $11.8 million in annual economic output.

∞ During the first 15 years of construction and operations the ERL will generate almost a billion dollars in economic activity in New York.

∞ User-visitors of the ERL would directly create 9 FTE jobs in New York. Through the multiplier effect, this spending would generate another 3 FTE jobs and $285,000 in annual economic activity in Central New York and $315,000 in annual economic output throughout New York State.

∞ When the ERL is operational, we estimate CLASSE will generate a total of $2.6 million in New York State taxes each year, directly and through the multiplier effect.

4) **Summary**

While the economic impact of the ERL is impressive, the larger impact will be on helping the economy of Upstate New York through the growth of science and technology education, and research and technology transfer. Although much of Upstate New York suffers from low population growth and a decline in the number of young adults, Cornell University, with facilities such as CHESS, has helped Tompkins County buck the trend. The ERL will help Central New York attract the most talented scientists, engineers and students in the future. This impact will radiate throughout the Upstate region.

Introduction

In March 2005, the National Science Foundation awarded Cornell University $18 million to begin prototyping components that could be used in the development of an advanced synchrotron radiation source, the Energy Recovery Linac (ERL). The proposed facility would replace Cornell's existing synchrotron light source, Cornell High Energy Synchrotron Source (CHESS) which has been in use since 1979. If construction of the Energy Recovery Linac starts in the spring of 2011 it would be available to researchers in 2016.

In order to highlight the economic benefits that the proposed facility could bring to New York State, the Cornell Laboratory for Accelerator-based ScienceS and Education (CLASSE) asked Appleseed – a New York City-based firm with extensive experience in economic impact analysis – to estimate the impact of the construction and operation of the ERL on the economies of Central New York and New York State. This report presents the results of Appleseed's analysis.

Part One of the report describes the Cornell High Energy Synchrotron Source, its users and the kinds of research it supports. Part Two discusses the one-time economic impact of construction of the $500 million Energy Recovery Linac facility – and the incremental impact of its ongoing operations – on Central New York and the State. The operational impacts include spending on salaries, goods and services; research spending by New York State users of the facility; and spending by researchers visiting the facility. The ERL will benefit the State in other ways as well, by attracting top faculty and students, helping the State's researchers compete for research funding, and potentially spinning off new companies and technologies.

Synchrotron light sources: A primer

A type of particle accelerator first developed in the 1940s, synchrotrons were primarily used by physicists to study subatomic particles. Put simply, a synchrotron's main feature is a vacuum ring, housed in a large building, within which particles are accelerated to nearly the speed of light. The very bright light – also called synchrotron radiation - that is emitted during this process was first thought of as unwanted loss of energy. By the 1970s, scientists realized that this light – which comes in different wavelengths including infrared, ultraviolet and x-rays – could be used as a tool in research. For instance, when channeled through narrow pipes (called "beam lines"), the bright x-rays emitted by a synchrotron can be used to reveal the structure of molecules, crystals, and cells. Today, synchrotron radiation is used in diverse fields including biology, chemistry, medicine, materials science, and environmental science and plays an important role in several industries such as pharmaceuticals, microelectronics, and the petroleum industry.

There are currently nine synchrotrons in the U.S., several of which are used exclusively as light sources. Only two synchrotrons are located in the Northeast, both of which are in New York State: the Cornell High Energy Synchrotron Source (CHESS) at Cornell University and the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory.

There are 32 major synchrotron sources outside the U.S, including the European Synchrotron Radiation Facility in Grenoble, France and SPring-8 near Himeji, Japan.

Part One: Existing user facilities, funding sources, and research

This part of the report provides a short overview of the Cornell Laboratory for Accelerator-based ScienceS and Education (CLASSE), including a history of the Cornell High Energy Synchrotron Source (CHESS), and discusses how the CLASSE facilities are funded. It also discusses the users of the CHESS facility, the kinds of research supported by the facility, and its implications for New York State.

Pioneering synchrotron radiation at CHESS: a brief history

Since the middle of the 20th century, Cornell University has been a leader in the development of accelerator technology, the use of accelerator-based research to test fundamental theories in physics, and the training of accelerator physics students and researchers.

In 1979, Cornell scientists and engineers completed construction of the Cornell Electron Storage Ring (CESR), an accelerator ring 768 meters in circumference located below the University's Alumni Fields. CESR, funded by the National Science Foundation, was the first large-scale accelerator at Cornell to smash accelerated electrons into positrons, generating subatomic matter for the study of particle physics and powerful synchrotron radiation for the study of the structure of materials.

The National Science Foundation funded a national user facility to make use of these powerful x-ray beams: the Cornell High Energy Synchrotron Source (CHESS). Researchers at Cornell and around the world reserve time at CHESS's "beam lines" to conduct experiments in life science, materials science, physics, chemistry, and environmental science. CHESS was – and remains – the only large-scale synchrotron radiation source located on the central campus of a research university in the U.S.

Since 1980, CHESS has evolved in several ways. Early on biologists realized that the synchrotron radiation could be useful in the study of the structure of proteins – a process called macromolecular crystallography. By better understanding the structure of proteins involved in the spread or progression of a disease, for example, researchers could develop new ways to treat it or prevent its transmission. In 1983, the National Institutes of Health acknowledged CHESS's increasing role in life science research and funded the Macromolecular Diffraction facility and user group at CHESS (MacCHESS), making dedicated tools and expertise available for this kind of research. MacCHESS's three beam lines have been among the most productive in the world: during the 1990s, one out of five of the protein and virus structures published in top journals involved data acquired using CHESS.

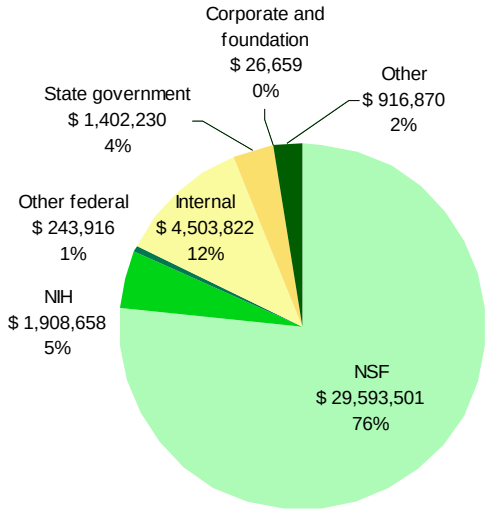
In 2000, CHESS added a new beam line, called the G-line, equipped with 3 x-ray stations. Using special optics, the G-line provides a particularly brilliant source of x-rays that are ideal for examining small specimens and collecting data on physical processes – such as chemical reactions – over time. More important, the G-line ensures that Cornell will remain a leading synchrotron science training center: the G-line was designed and constructed by graduate students, much of the research at the G-line is conducted by graduate students, and graduate students support the G-line's on-going operation.

Researchers now have access to 12 beam lines at CHESS.

CLASSE's sources of funding

In fiscal year 2007, CLASSE's operating expenses were $38.6 million. The sources of funding are highlighted in Figure 1 below. Conservatively, at least 85 percent of CLASSE's revenues come from sources outside New York State, with 82 percent of total revenues coming from the federal government.

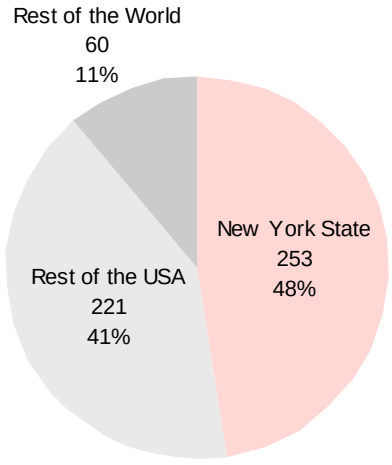
Figure 1: Sources of CLASSE funding, FY 2007 *(Total: 38.6 million)*



CHESS's users and its impact on the State's research institutions

In 2006-07, 534 researchers used Cornell's CHESS facility. As Figure 2 shows, about 48 percent of all CHESS users during 2006-07 were based in New York State.

Figure 2: CHESS users, by location, 2006-07



CHESS users include researchers from 100 universities, national and state laboratories, and private companies. U.S. companies made up 13 percent of the institutions using CHESS during 2006-07. Table 1 shows the distribution of users by type of institution.[1]

Table 1: CHESS user institutions, 2006-07

Type of institution	*Count*
U.S. university	60
U.S. government	9
U.S. industry	13
Foreign university	16
Foreign government	1
Foreign industry	1

New York's universities and research institutes were especially well-represented among CHESS users. Universities whose researchers made use of CHESS facilities included SUNY Buffalo, the University of Rochester, Syracuse University, SUNY Albany, Hamilton College, and CUNY Hunter. The full list of universities in New York State that have made use of the CHESS facilities is included in Appendix A.

Corporate researchers in New York State also made use of the CHESS facility. These companies are listed in Table 2. All New York State CHESS users are shown on the map in Figure 4.

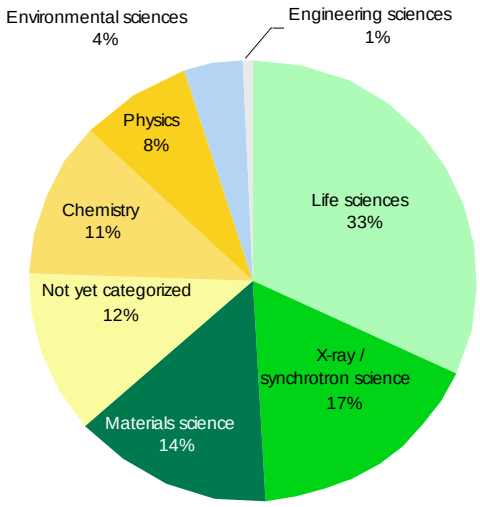
Table 2: New York State companies that used CHESS in 2006-07

Company	*Location*
Advanced Design Consulting	Lansing
Corning	Corning
General Electric	Schenectady
IBM	Yorktown Heights
JAS Scientific	Burnt Hills
MiTeGen	Ithaca
Nutrimed Biotech	Ithaca
Welliver McGuire	Montour Falls

Researchers in the life sciences, including biophysics and biochemistry, led all CHESS users in 2006-07, accounting for 33 percent of all user hours. Figure 3 shows the distribution of CHESS user hours by scientific discipline during 2006-07.

[1] The figures in Table 1 do not total 534 because many institutions had more than one CHESS user in 2006-07.

Figure 3: Distribution of CHESS user hours, by scientific field, 2006-07



A "synchrotron valley" in Central New York

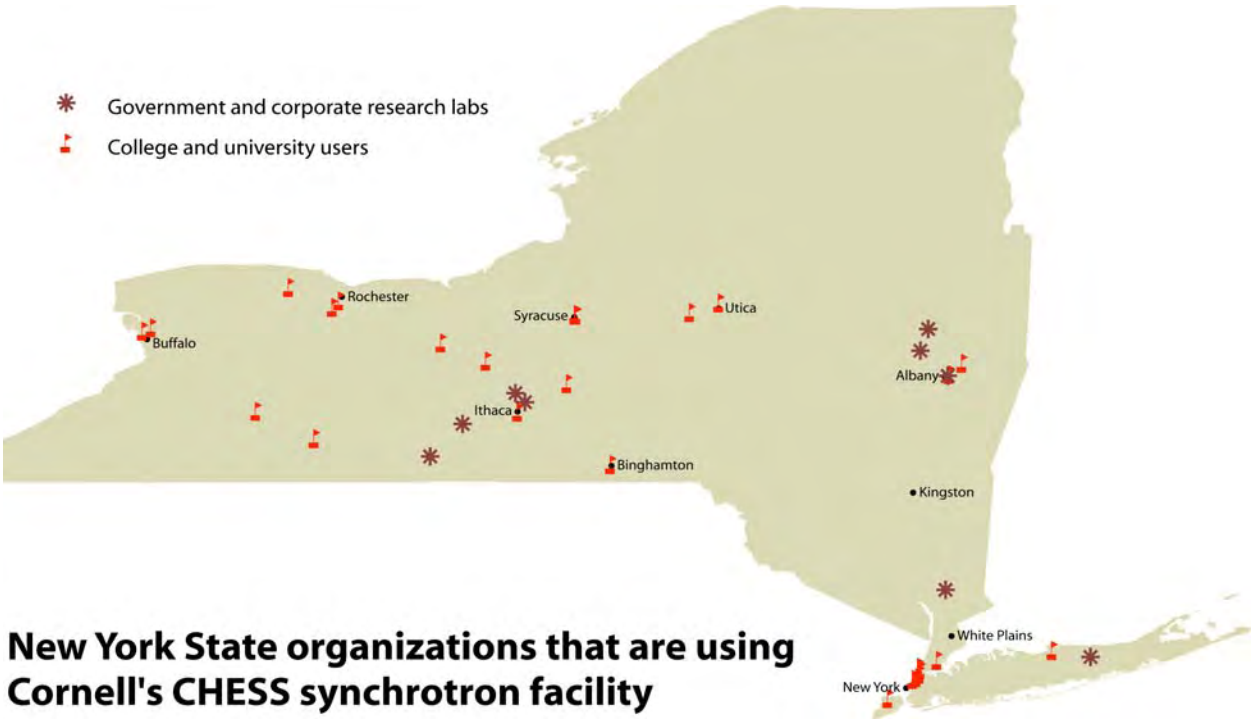
Cornell's long history of synchrotron radiation research has helped the University develop and attract talented scientists, engineers and students. While most of these researchers are drawn to the synchrotron facility by its value in basic science, others have been able to translate their experience into commercial ventures. Here we highlight three Central New York companies that have grown out of Cornell's pool of synchrotron expertise – and continue to grow as a result of collaboration with CHESS faculty and staff.

Founded by a graduate of Cornell's engineering and business schools, ***Advanced Design Consulting (ADC)*** develops products and provides consulting services to commercial, academic and government laboratories. The company has frequently collaborated with CHESS staff and faculty, most recently on an adjustable "x-ray slit" system that is used in the precise setup of experiments using x-rays. ADC has developed five models and sells the units to synchrotron facilities around the world. President Alexander Deyhim estimates that the development of an ERL could help his company expand from 35 to 50 full-time equivalent employees for the production of permanent magnet x-ray undulators needed for the ERL.

Multiwire Laboratories was founded by Donald Bilderback, one of the original designers of CHESS. Founded in 1981, his company manufactures products that help researchers and advanced manufacturers orient crystals for use in x-ray analysis. The company employs two FTEs.

The newest of the three companies, ***MiTeGen*** was founded in 2004 by Cornell professor Robert Thorne. Based on Professor Thorne's work with MacCHESS, the company develops products for use by macromolecular crystallographers. The company's first product, MicroMount, was created to help researchers handle protein crystals smaller than a 10^{th} of a millimeter. The company now employs 4 FTEs.

Figure 4: Map of CHESS users in New York State, by type of user



In addition to the funding that CLASSE receives directly from the National Science Foundation and other agencies to operate its facilities, New York State investigators who conduct experiments using CHESS bring in additional funds – primarily from federal and foreign governments. By enabling New York universities to compete more effectively for research dollars, CHESS serves an important role, not represented by the numbers above, in bringing federal and foreign dollars to New York State.

CLASSE does not track funding received by all CHESS users, but does track funding for users of its macromolecular diffraction facilities, which utilize three out of the twelve available stations, as part of the NIH-supported MacCHESS user group. During 2006-07, MacCHESS-affiliated scientists used CLASSE's facilities in grants totaling about $20.4 million. About $10.2 million in grants were received by scientists in New York-based research institutions – an average of $364,000 per grant for MacCHESS's New York State-based principal investigators.

Supporting education and research

Since it has been operational, CHESS has led to significant discoveries – in disease research, pharmaceutical development, environmental protection and remediation, and even the arts. Here we cite just a few ways in which CHESS has helped researchers and educators can have long-term impacts on the State and Central New York.

Supporting life sciences research

∞ Rockefeller University professor Roderick MacKinnon used the macromolecular diffraction facilities at MacCHESS– in addition to other synchrotron sources – to collect data on the flow of potassium ions within cell channels. For his work, Dr. MacKinnon was awarded the Nobel Prize in chemistry in 2003.

∞ In 2007, researchers at the Hauptman-Woodward Medical Research Institute at SUNY Buffalo "solved" the structure of a protein in the bacterium that is a pathogen in cystic fibrosis (CF) patients. This could lead to a better understanding of the causes of – and possible therapies for – CF and other diseases, including tuberculosis.

∞ In 1985, Purdue Professor Michael Rossmann used data collected from CHESS to build a model of human rhinovirus-14, one of about 100 known cold virus strains. Rossmann's work at CHESS helped to pave the way for the structural biology work that takes place in the MacCHESS group.

∞ Researchers at Genentech used data they collected from CHESS to develop a new medicine that could treat those suffering from asthma and severe allergies.

Contributions to education and training

∞ As the only synchrotron facility on the campus of a major research university, CHESS creates numerous educational opportunities for its users. More than half of the facility's annual users are graduate students conducting doctoral research. CHESS has supported the doctoral research of more than 550 graduate students since 1980.

Access to facilities such as those in CLASSE has helped Cornell's undergraduate engineering physics program earn the U.S. News & World Report's top ranking in the 2006, 2007 and 2008 editions of its *America's Best Colleges* guide.

∞ During the past eight summers, more than 30 high school teachers have spent six weeks working at the CHESS facility as part of an NSF Research Experiences for Teachers program. Together with CHESS staff, faculty and graduate students, the teachers have built tools to improve data collection in CHESS's experimental stations and analyzed the results of synchrotron runs. The participating teachers get direct exposure to the facilities, Cornell faculty and staff, and bring their research experience back to their classrooms.

∞ CHESS has also been a resource for hundreds of Ithaca High School chemistry students during the past two years. In addition to touring the facility, the students used CHESS to collect data on arrowheads and other stone artifacts to identify their mineral composition and geographic origin. The students monitored the x-ray fluorescence spectra that are given off when the artifacts are subjected to the x-rays.

Supporting energy and environmental research

∞ The capabilities of the CHESS facility were cited in a successful proposal to the U.S. Department of Energy to renew support for the Cornell Fuel Cell Institute, established in 2002. CHESS helps the Institute's researchers identify promising characteristics of electrocatalyst materials that can lead to more efficient and durable fuel cells. The award is worth $2.75 million over three years.

∞ Cornell Professor Tammo Steenhuis used CHESS to study the flow of fluids and contaminants in rural watersheds. His work could lead to better techniques for protecting watershed lands – and cleaning up contaminants.

Part Two: Economic impact of the proposed Energy Recovery Linac

This section discusses the proposed Energy Recovery Linac, the one-time impact of its construction, and the on-going impact of its operations on New York State. In addition, this section discusses how the ERL – by attracting some of the brightest minds to Central New York, supporting New York State-based researchers, and potentially leading to breakthroughs in medicine, nanotechnology, and other fields – could lead to even larger impacts in the future.

About the Energy Recovery Linac

Current generation synchrotron facilities, like CHESS, accelerate electrons to high speeds and then send them through circular storage rings, using powerful magnets to guide them. Over time, the beams grow gradually wider, making them unsuitable for the laser-like analysis required by scientists examining the structure of the smallest specimens.

An energy recovery linear accelerator (or "linac") can overcome these limitations. The concept for an energy recovery linac was first conceived at Cornell in 1965 by Maury Tigner, the director of CLASSE. Tigner proposed accelerating electrons in a straight superconducting radio frequency chamber and subsequently decelerating them to create the brightest – and "sharpest" – x-ray source in the world. The resulting beams can be focused into a point one nanometer in diameter, making possible incredibly high resolution analysis of the structure of materials.

The technique that allows electrons to be accelerated in this fashion will also require extremely rapid bursts of electrons – up to 1.3 billion pulses per second. This speed will allow scientists to effectively create sequences – or "movies" – of chemical reactions as they occur.

The development of the Energy Recovery Linac is in its first stage – the design and development of an $18 million prototype, funded by the National Science Foundation. New York State and Cornell University have also provided support for the development of the facility. With the technology proven and financing in place, construction of the $500 million ERL could begin as early as 2011.

Impact of Energy Recovery Linac construction

The construction of the new facility is expected to cost an estimated $500 million, broken down as follows:

- $186 million in hard construction and infrastructure costs;
- $64 million in soft costs, including engineering, design, legal and other professional services; and
- $250 million in equipment costs. [2]

Based on spending data on all Cornell University construction projects during fiscal year 2006, we assume that 72 percent of the hard and soft construction spending will be with firms in Central New York and that 9 percent will be spent with firms elsewhere in New York State. We further assume that roughly 30 percent of equipment purchased for the ERL will be with firms in

[2] These figures – and those that follow – are given in 2007 dollars.

Central New York, and 20 percent with those based in elsewhere in the State. In total, we estimate that the University will spend $256 million with firms in Central New York and $71 million with firms elsewhere in New York State.

Using the IMPLAN input-output modeling system[3], we can estimate the number of jobs and economic output created as a result of construction of the ERL:

∞ In Central New York, we estimate the project will directly generate 897 person-years of employment in construction, 354 person-years of employment in project-related services including design and engineering, legal services, and insurance, and 338 person-years of employment in firms that provide equipment for the facility – a total of 1,589 person-years of employment in Central New York during the five years that would be required to design, build and equip the facility. Through the multiplier effect, the project will generate another 1,810 person-years of employment throughout Central New York and $196 million in economic output.

∞ In New York State, we estimate the project will directly generate 1,104 person-years of employment in construction, 415 person-years of employment in project-related services including design and engineering, legal services, and insurance, and 548 person-years of employment in firms that provide equipment for the facility – a total of 2,067 person-years of employment in New York State. Through the multiplier effect, the project will generate another 2,169 person-years of employment throughout New York State and $267 million in economic output.

The impacts of the ERL's construction on Central New York and New York State are summarized in Table 3.

Table 3: Economic impact of ERL construction: hard costs, soft costs, and equipment

	Construction		Related Services		Equipment		Total	
Employment (person-years)	***Central NY***	***NYS***	***Central NY***	***NYS***	***Central NY***	***NYS***	***Central NY***	***NYS***
Direct	897	1,104	354	415	338	548	1,589	2,067
Indirect	381	444	136	166	174	269	691	879
Induced	648	630	212	274	259	386	1,119	1,290
TOTAL	*1,926*	*2,178*	*702*	*855*	*771*	*1,203*	*3,399*	*4,235*
Output ($ thousands)								
Direct	134,664	149,916	46,336	51,584	75,000	125,000	256,000	326,500
Indirect	42,678	48,058	15,378	18,220	25,730	47,361	83,786	113,639
Induced	65,037	78,699	21,225	26,186	25,970	48,252	112,232	153,137
TOTAL	*$ 242,379*	*$ 276,673*	*$ 82,939*	*$ 95,990*	*$ 126,700*	*$ 220,613*	*$ 452,018*	*$ 593,276*
Compensation ($ thousands)								
Direct	68,865	79,731	22,714	26,610	26,814	46,328	118,393	152,669
Indirect	18,142	21,130	6,565	8,002	9,839	19,202	34,546	48,334
Induced	23,002	29,174	7,510	9,707	9,188	17,887	39,700	56,768
TOTAL	*$ 110,009*	*$ 130,035*	*$ 36,789*	*$ 44,319*	*$ 45,841*	*$ 83,417*	*$ 192,639*	*$ 257,771*
Compensation per worker								
Direct	76,773	76,773	64,164	64,164	79,331	84,540	74,508	73,870
Indirect	47,617	47,617	48,272	48,272	56,546	71,383	49,994	55,018
Induced	35,497	35,497	35,425	35,425	35,475	46,339	35,478	44,006

[3] The IMPLAN modeling system is frequently used in economic analyses of this kind. Along with a discussion of indirect and induced effects (the "multiplier effect"), the IMPLAN system is described in Appendix B.

The proposed ERL facility will require specialized equipment and expertise, some of which will come from out-of-state suppliers. Just as the CHESS facility served as a "proving ground" for New York State engineers during the past three decades, the ERL could have the same effect. Table 4 shows some of the New York State businesses that are expected to provide the equipment and services needed for the project. Experience working on or supplying the development of the facility could strengthen the ability of New York firms to compete successfully for work on other large, technologically-sophisticated facilities.

Table 4: Sample of New York State suppliers of equipment and services for the ERL project

Company	***Location***	***Equipment / services***
Advanced Design Consultants	Dryden	X-ray equipment including undulators
Advanced Energy Systems	Medford	Superconducting microwave equipment
Anaren Microwave	Syracuse	Microwave components
Carrier Corp.	Syracuse	Air conditioning equipment
Brierley Associates	Syracuse	Underground engineering
ARUP	New York City	Architecture and engineering
Goulds Pumps	Seneca Falls	Pump equipment

Impact on New York State tax revenues

For the duration of the project (projected to be about five years), construction of the ERL will also generate tax revenues in New York State. Based on the number of direct and indirect jobs that will be created by the project, and the wage levels that will be paid to those employees, we estimate that construction of the ERL will generate about $12.1 million in direct tax revenues and $10.9 million in indirect tax revenues through the multiplier effect. These tax revenues break down as follows:

- *Personal income taxes* - $9.6 million generated directly by workers in construction and related industries and $6.3 million generated through the multiplier effect;
- *User taxes* – We assume that construction materials purchased will be exempt from State sales taxes, but $2.9 million in sales taxes will be generated through the multiplier effect;
- *Business taxes* - $2.0 million in business taxes and $1.3 million through the multiplier effect; and
- *Other taxes* – about $484,000 in other State taxes generated and $319,000 through the multiplier effect.

The tax revenue impacts of ERL construction are show in Table 5.

Table 5: New York State tax revenues from ERL construction

		Direct		Indirect/ Induced		Total
Personal income tax	$	9,637,339	$	6,338,577	$	15,975,916
User taxes	$	-	$	2,889,779	$	2,889,779
Business taxes	$	2,026,452	$	1,332,818	$	3,359,270
Other taxes	$	484,348	$	318,560	$	802,908
Total	***$***	***12,148,138***	***$***	***10,879,735***	***$***	***23,027,873***

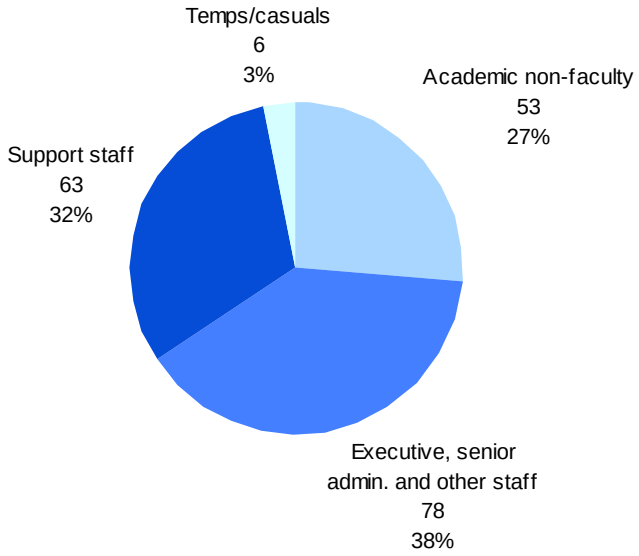
Impact of Energy Recovery Linac operations at CLASSE

In this section, we describe the impact of operations of CLASSE when the ERL is operational, including direct spending on salaries and purchases of goods and services; jobs and economic activity created through the multiplier effect; spending by visitors to the facility; and local and State tax revenues generated as a result of these operations.

Payroll and employment

CLASSE employed 200 people in spring 2007 – all of whom were full-time employees[4]. The distribution by occupational category is shown in Figure 5. The total payroll for 2006-07 was $14.2 million. (Faculty affiliated with CLASSE facilities earned another $645,000, but they are employees of the Physics Department.)

Figure 5: Employment distribution, by occupation (Total employment: 200)



[4] This does not include students working at the facility part-time.

Based on preliminary estimates by CLASSE officials, the operation of an ERL will require 20 more employees than the present CLASSE staff, for a total of 220 employees. The employment mix is expected to remain the same. Assuming that payroll increases by the same proportion as employment (by 10 percent), we can use the IMPLAN input-output modeling system to estimate the impact of household spending by all CLASSE employees.

When the ERL is fully operational, we estimate that household spending by employees of CLASSE will directly create 70 FTE jobs in Central New York. Through the multiplier effect, household spending will generate another 37 FTE jobs and $4.1 million in output. Through the multiplier effect, we estimate that household spending in New York State will generate 47 FTE jobs and $4.9 million in economic output.

The economic impact of household spending on Central New York and New York State is summarized in Table 6.

Table 6: Estimated economic impact of household spending by CLASSE employees when ERL is operational, Central New York and New York State

Employment (FTE)	***Central NYS***	***NYS***
Direct	70	70
Indirect	14	18
Induced	23	29
Total	***107***	***117***
Output ($ 000s)		
Direct	7,190	7,654
Indirect	1,909	2,282
Induced	2,206	2,653
Total	***11,305***	***12,589***
Employee compensation ($ 000s)		
Direct	2,345	2,616
Indirect	677	853
Induced	788	1,001
Total	***3,810***	***4,470***
Compensation per worker		
Direct	33,500	33,500
Indirect	48,357	48,357
Induced	34,261	34,261

Purchasing of goods and services

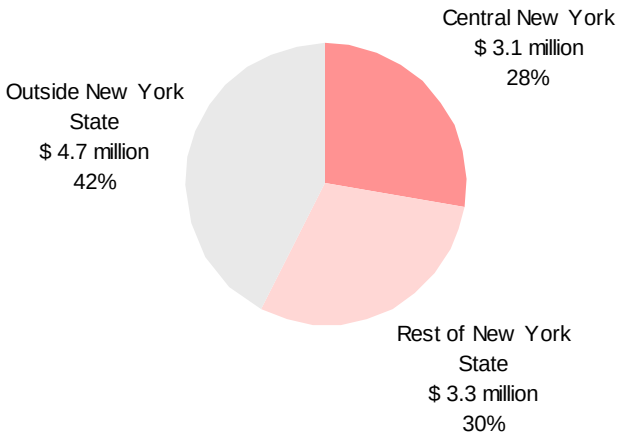
During fiscal year 2007, CLASSE purchased about $11 million in goods and services outside the University. Major categories of purchases include:

- Employee benefit payments, $4.4 million;
- Laboratory equipment and supplies, $2.5 million;
- Electricity purchases, $2.1 million;

∞ Travel and related expenses, $519,000;
∞ Repair and maintenance services, $350,000; and
∞ Telecommunications purchases, $172,000;

We estimate that about $3.1 million (28 percent) was spent with Central New York businesses and an additional $3.3 was spent with suppliers of goods and services located elsewhere in New York State. Figure 6 shows the distribution of fiscal year 2007 purchasing by the location of vendor.

Figure 6: CLASSE purchasing, by location of vendor, FY 2007 (Total: $11 million)



To estimate CLASSE spending when the ERL is operational, we make assumptions about increases in each category of purchasing based on information provided by CLASSE staff and increases in the number of employees and users. These assumptions are shown in Table 7 below.

Table 7: Assumed increases in CLASSE purchasing with ERL, by major category

Category	***% Increase***
Electricity	140%
Telecommunications	140%
Laboratory equipment/supplies	25%
Employee benefits	10%
Travel and related	10%
Repair and maintenance services	25%
Other supplies and services	25%

Based on these assumptions, we estimate that when the ERL is fully operational, CLASSE will purchase about $15.5 million in goods and services, including $10.0 million from New York State vendors and $6.3 million from those in Central New York.

Using the IMPLAN economic modeling system, we can estimate how this spending translates into direct and indirect jobs and economic activity in Central New York and New York State. We

estimate that spending by CLASSE will directly create 14 FTE jobs in Central New York. Through the multiplier effect, the facility will generate another 22 FTE jobs and $2.4 million in economic output.

We estimate that spending by CLASSE in New York State will directly create about 32 FTE jobs statewide. Through the multiplier effect, spending by the facility with create another 46 FTE job and $6.9 million in economic output.

The economic impact of CLASSE's purchasing activity is show in Table 8.

Table 8: Economic impact of CLASSE purchasing with ERL operational

Employment (FTE)	***Central NYS***	***NYS***
Direct	14	32
Indirect	8	18
Induced	14	28
Total	***36***	***78***
Output ($ 000s)		
Direct	6,326	10,027
Indirect	1,083	3,477
Induced	1,366	3,431
Total	***8,775***	***16,935***
Employee compensation ($ 000s)		
Direct	1,443	3,159
Indirect	390	1,370
Induced	483	1,272
Total	***2,316***	***5,801***
Compensation per worker		
Direct	103,071	98,719
Indirect	48,750	76,111
Induced	34,500	45,429

Adding it all up

Taking into account CLASSE's future operations with the Energy Recovery Linac, including its employment, spending on payroll, and spending on goods and services, we estimate that CLASSE will directly create 234 FTE jobs in Central New York and, through the multiplier effect, another 129 FTE jobs and $6.5 million in economic output.

In New York State, we estimate that CLASSE will directly create 252 FTE jobs and, through the multiplier effect, 164 FTE jobs and $11.8 million in economic output.

The annual impact of operation of CLASSE with the Energy Recovery Linac is shown below in Table 9.

Table 9: Total on-going economic impact of CLASSE operations with ERL

	Direct spending		*Indirect/induced impact of spending*		***TOTAL***
	Payroll	*Purchasing*	*Household spending*	*Spending by vendors*	
Central New York					
Output ($000s)	$ 14,153	$ 6,326	$ 4,115	$ 2,449	$ 27,043
Jobs	220 FTE	14 FTE	107 FTE	22 FTE	363 FTE
New York State					
Output ($000s)	$ 14,153	$ 10,027	$ 4,935	$ 6,908	$ 36,024
Jobs	220 FTE	32 FTE	117 FTE	46 FTE	415 FTE

The Energy Recovery Linac's useful life is expected to be twenty to thirty years. Taking into account direct spending and spending through the multiplier effect, we estimate the Energy Recovery Linac could generate more than $953 million in total economic output in New York State over five years of construction and ten years of operations.

X-ray science and technology in New York at a crossroads

Since 1979, Cornell's CHESS facility has been in continuous operation, with regular upgrades to help it remain at the frontier of x-ray science and technology. However, its capabilities relative to newer synchrotron radiation sources are diminishing. And future facilities will have even more powerful x-ray beams than those operating today.

CHESS will close within the next ten years if a substantial upgrade of its x-ray source is not made. The proposed ERL facility upgrade, however, would substantially surpass the capabilities of x-ray sources that could soon come on-line, assuring CHESS a premier role in synchrotron x-ray science for decades to come. When constructed, the Energy Recovery Linac upgrade would again place Cornell University and New York State at the frontier of x-ray science and prevent the loss of 200 high tech jobs and more than $24 million in direct annual spending associated with the facility.

Impact of visitor spending

During 2006-07, the CHESS facility brought in 534 users, 281 of whom came from outside New York State. Using information provided by the Tompkins County Convention and Visitor's Bureau on spending patterns and assuming that the average visit lasts about five days, we estimate that CHESS users visiting from outside New York State spent about $225,000 in 2006-07. With twice as many users (as a result of additional beam lines for more simultaneous experiments) – and the same ratio of New York State users – we estimate that users could spend about $451,000 in Ithaca and Central New York on visits to use the ERL when it is operational.

We can estimate the number of direct and indirect jobs and economic activity created as a result of this spending. Spending by ERL's visitors could directly create 9 FTE jobs in Central New York and New York State. Through the multiplier effect, this spending could generate another 3 FTE jobs and $285,000 in economic output in Central New York and $315,000 in economic output in New York State.

The economic impact of visitor spending is shown in Table 11.

Table 11: Economic impact of visitor spending with proposed ERL

Employment (FTE)	***Central NYS***	***NYS***
Direct	9	9
Indirect	1	1
Induced	2	2
Total	***12***	***12***
Output ($ 000s)		
Direct	451	451
Indirect	123	139
Induced	162	176
Total	***736***	***766***
Employee compensation ($ 000s)		
Direct	179	179
Indirect	44	44
Induced	57	57
Total	***280***	***280***
Compensation per worker		
Direct	19,833	19,833
Indirect	44,200	44,200
Induced	28,650	28,650

Impact on Central New York and New York State tax revenues

Although Cornell University is a tax exempt institution, the CLASSE facility will generate some direct tax revenues in New York State through withholding of its employees' income taxes. The facility will also indirectly generate local and State tax revenues as a result of sales taxes collected from household spending and taxes paid by CLASSE vendors and their employees.

In 2006, the University withheld $828,000 in New York State income tax from its CLASSE employees. Using data generated by IMPLAN on employee compensation, we can estimate the annual direct and indirect New York State tax revenues generated as a result of household spending by CLASSE staff, its vendors, and vendors' employees.

The gross tax impacts on New York State are shown in Table 12 below.

Table 12: Total New York State tax revenues from CLASSE and ERL operations

	CLASSE Staff	Direct	Indirect/ Induced	Total
Personal income taxes	$ 910,800	$ 355,094	$ 482,160	$ 1,748,054
User Taxes	$ 244,928	$ 161,888	$ 219,819	$ 626,635
Business Taxes	$ -	$ 74,666	$ 101,384	$ 176,050
Other Taxes	$ -	$ 17,846	$ 24,232	$ 42,078
Total	***$ 1,155,728***	***$ 609,494***	***$ 827,595***	***$ 2,592,817***

How the ERL could benefit Central New York and New York State

The impacts discussed thus far in Part Two could be claimed by virtually any 200-employee company relocating to a new facility in Central New York. The Energy Recovery Linac is likely to have much greater long-term benefits. Like Cornell University itself, the development of the Energy Recovery Linac will support the growth of science and technology education, research and technology transfer in Central New York and New York State.

Attracting students and faculty

Difficulty attracting and retaining young, college-educated adults has been an important contributor to the pattern of low earnings and slow (or no) growth that characterizes many parts of upstate New York. The *New York Times* took note of the problem in 2006:

> *From 1990 to 2004, the number of 25-to-34-year-old residents in the 52 counties north of Rockland and Putnam declined by more than 25 percent. In 13 counties that include cities like Buffalo, Syracuse and Binghamton, the population of young adults fell by more than 30 percent*. [5]

In part because of Cornell University, Tompkins County was the only county in upstate New York in which the number of 25-to-34-year-olds increased between 1990 and 2004. Tompkins County also has the best-educated workforce in the State. In 2006, 52.3 percent of Tompkins County residents 25-and-older had a bachelor's degree compared with 31.2 percent in New York State. A facility like the Energy Recovery Linac will help Cornell continue to attract the brightest minds in engineering, physics, chemistry and the life sciences to Central New York.

The Energy Recovery Linac will also help Cornell continue to attract top faculty to the University who, in turn, bring in substantial research funding and attract top graduate students. Faculty in the life sciences, accelerator sciences, nanotechnology, materials science and other disciplines will value easy access to the Energy Recovery Linac itself, to the staff and faculty who operate and upgrade it, and to the hundreds of researchers who visit Cornell each year to use it.

[5] Roberts, Sam. "Flight of Young Adults Is Causing Alarm Upstate." New York Times. June 13, 2006. Available on-line: http://www.nytimes.com/2006/06/13/nyregion/13census.html

Helping the State's researchers compete for sponsored research funding

As one of only two synchrotron radiation sources within driving distance of the biomedical research hubs of Boston, New York, and Philadelphia, CHESS has played an especially central role in supporting research in the northeast. CHESS has been an important research tool for the New York State-based researchers who make up nearly half of CHESS's user base.

While synchrotron research can be carried out remotely, proximity allows researchers to obtain more beam time, more often. One researcher at the Hauptman-Woodward Medical Research Institute at SUNY Buffalo put it this way: "Since initiating my independent research career in 2001, my research group has been to Cornell five times for diffraction data collection... The proximity to Buffalo and the rapid access have allowed us to be very successful in our data collection at MacCHESS."

Large-scale federally-funded research facilities, such as the Energy Recovery Linac, typically have operational lifetimes of 20 to 30 years. Just as CHESS has been an advantage for researchers in New York competing for federal research funding for more than 25 years, the Energy Recovery Linac would place it in the leadership position for decades to come.

Further developing the "synchrotron services" cluster in Central New York

Cornell University was the site of the first synchrotron radiation beam line, built in 1952. During the past 30 years, Cornell has been a hub of synchrotron radiation knowledge and innovation. Together with CHESS users, CHESS staff and Cornell University faculty have pioneered techniques used to stabilize specimens, developed new methods of data collection, and built specialized tools for use in the synchrotron's experiment stations. This expertise has helped to improve the quality of synchrotron research and has also led to the founding of several Central New York companies that provide products and services unique to synchrotron science – not only for use by CHESS and its users, but by synchrotron users worldwide.

The current generation of engineers and researchers designing the Energy Recovery Linac will develop the kind of deep knowledge and expertise that could lead to new technologies for the existing firms to commercialize – and could lead to the creation of new companies in the future.

Already, delegates from Japan, China, and the United Kingdom have met with Cornell researchers to learn more about the technology that could make the ERL possible in their own countries.

Appendix A: Universities in New York State with CHESS users

Albert Einstein College of Medicine
Alfred University
Buffalo State College
Columbia University
CUNY College of Staten Island
CUNY Hunter
Hamilton College
Hobart and William Smith Colleges
Houghton College
Ithaca College
Memorial Sloan-Kettering Institute
Mount Sinai School of Medicine
New York University
NYU Medical Center / School of Medicine
Rochester Institute of Technology
Rockefeller University
Rensselaer Polytechnic Institute
SUNY Albany
SUNY Binghamton
SUNY Brockport
SUNY Buffalo
SUNY Cortland
SUNY Institute of Technology
SUNY Stony Brook
SUNY Syracuse
SUNY Upstate Medical University
Syracuse University
University of Rochester
Wells College

Appendix B: About IMPLAN and the multiplier effect

Cornell's spending on payroll; purchasing and construction – and the jobs associated with that spending – provide a direct measure of the University's impact on the economy of the Central New York region and New York State. The University's regional and statewide impacts, however, go beyond these direct measures. Each dollar the University spends produces what economists sometimes call indirect and induced effects – the "multiplier effect."

Cornell's *indirect impact* is a product of spending by the local, regional or New York State companies from which the University buys goods and services. Construction contractors, utility companies, temp services, caterers and other firms use the payments they receive from Cornell to pay their employees, rent space, buy equipment, supplies and telephone services – and all of these expenditures have an impact on the economy. The University's *induced impact* represents the impact of routine household spending by its own employees – for rent, food, clothing, transportation and child care – and by the employees of its suppliers.

There are several quantitative economic models that can provide an approximate measure of indirect and induced effects. Using one of these models – IMPLAN – we have calculated the impact of spending by Cornell University on total economic output, wages and employment in the Central New York region and the state.

Just as the University spends some of its resources within Tompkins County (for example) and some elsewhere, Cornell's local suppliers spend part of *their* revenues within the County, and some is paid to businesses elsewhere in New York, in other states or overseas. Through each successive round of spending, the money that was originally spent within the County is eventually diffused throughout the broader economy.

IMPLAN thus allows us to trace the impact of each dollar of University spending as it ripples through other industry sectors in the Central New York region and New York State, translating the allocation of spending across industries into estimates of employment and wages.

Cornell University

ECONOMIC IMPACT OF CORNELL UNIVERSITY'S PROPOSED ENERGY RECOVERY LINAC FACILITY