

EXECUTIVE SUMMARY

With over \$787 billion in funding, the American Recovery and Reinvestment Act is one of the single boldest and largest investments in the U.S. economy in the nation's history. The Recovery Act's design was three-fold: to *rescue* a rapidly deteriorating economy; put the country on a path to *recovery* by putting Americans back to work quickly; and *reinvest* in the country's long-term economic future, building a foundation for a new, more robust, and competitive American economy.

Within the reinvestment spending of the Recovery Act, over \$100 billion is invested in innovative and transformative programs. This report explores four areas within those innovative programs in which game-changing breakthroughs are being sought, and in some cases, new American industries are being born:

1. Modernizing transportation, including advanced vehicle technology and high-speed rail;
2. Jumpstarting the renewable energy sector through wind and solar energy;
3. Building a platform for private sector innovation through investments in broadband, Smart Grid, and health information technology; and
4. Investing in groundbreaking medical research.

Modernizing Transportation, including Advanced Vehicle Technology and High-Speed Rail

In 2009, the U.S. had only two factories manufacturing advanced vehicle batteries that power electric vehicles and produced less than two percent of the world's advanced vehicle batteries. The Recovery Act is investing over \$2 billion in advanced battery and electric drive component manufacturing.¹ By 2012, 30 factories with the capacity to produce an estimated 20 percent of the world's advanced vehicle batteries will exist in the U.S.² At full scale, they will produce enough batteries and components to support 500,000 plug-in and hybrid electric vehicles.

Between 2009 and 2013, when 20 Recovery-Act funded battery factories will be up and running, battery costs are expected to drop by half – cutting an electric car's cost premium in half. Looking further into the future, Recovery Act-funded start-ups like Envia and FastCAP are pursuing technologies that could take us well beyond today's best lithium-ion batteries. This will create lighter, cheaper, and more powerful electrical energy storage devices such as batteries, allowing for better mileage, greater safety, and better acceleration—putting the U.S. in position to build the best cars in the world.

Outside the Recovery Act, the Advanced Technology Vehicles Manufacturing program is providing over \$2.4 billion in loans to Fisker, Nissan, and Tesla to support three of the world's first electric car factories in Delaware, Tennessee, and California, respectively. These investments will increase U.S. manufacturing capability in the near future.

¹ Funding in the Recovery Act to support advanced vehicle battery manufacturing includes \$2 billion in grants to support battery and component manufacturing and \$45 million in Section 48C Manufacturing Tax Credits.

² Of the 30 new factories, 20 are manufacturing batteries and 10 are manufacturing electric drive components.

The future of transportation in the U.S. will also benefit from better rail travel. With \$8 billion in funds, the Recovery Act is beginning to make high-speed rail a reality across the country. For example, the California high-speed rail mega-project promises to alter significantly the transportation landscape in the state by connecting its largest metropolises with up to 220-mph service.

Jumpstarting the Renewable Energy Sector through Wind and Solar Energy

The Recovery Act is helping to deploy more rapidly the latest generation of solar power technologies while expanding manufacturing of these technologies here in the U.S. The Section 1603 Payments-In-Lieu-Of-Tax-Credits program is supporting more than 200 megawatts (MW) of solar projects that are already delivering solar power to consumers. In Pensacola, Florida, the program has helped fund the 25 MW DeSoto Solar Park, the largest photovoltaic power plant in North America that consists of over 90,000 solar panels. The Section 48C Advanced Energy Manufacturing Tax Credits are helping solar manufacturers like FirstSolar, which is expanding a large manufacturing plant in Perrysburg, Ohio. Loan guarantees are helping innovative thin-film solar manufacturer Solyndra build a high-tech solar module manufacturing facility in Fremont, California, with the capacity to produce modules totaling 230 MW each year. In addition, the U.S. Department of Energy has issued a conditional commitment for a loan guarantee to support the 400 MW BrightSource solar thermal project, the world's largest solar thermal facility with approximately 349,000 mirrors.

In addition, the Recovery Act is helping to ramp up production of wind energy and its component manufacturing base in the U.S., maintaining strong demand and financing for projects and helping attract billions of dollars of additional private investment. The Section 1603 program has provided over \$3 billion in payments-in-lieu-of-tax-credits to more than 100 wind projects in 30 states around the country, totaling 5.3 GW of wind power capacity. The Section 48C Manufacturing Tax Credit program awarded \$346 million in tax credits for 52 wind manufacturing projects across the country, which will substantially increase U.S. wind manufacturing capacity to meet a growing market with domestic production.

The Recovery Act is supporting breakthrough innovations in both solar and wind. FloDesign in Massachusetts is developing a novel shrouded wind turbine design with advanced aerospace technology that should reduce the cost and noise of wind energy dramatically. Likewise, companies like 1366 Technologies and Semprius are developing new approaches to make solar cells much less expensive than today's best thin film technology.

Building a Platform for Private Sector Innovation through Investments in Broadband, Smart Grid, and Health Information Technology

A stronger economy must also rely on smarter energy use, a more efficient health administration system, and more robust and wide-reaching information transmission network. Significant investments in broadband aim to bring America's telecommunications capacity into the 21st century, increasing access, improving quality, and driving down the cost to access broadband for millions of Americans. In addition to the \$4.4 billion provided to the Department of Commerce, \$2.5 billion in funds was provided to the Department of Agriculture to increase broadband access in rural America. Millions of Americans, as well as tens of thousands of anchor institutions will have better access to broadband as a result. Farmers will be able to access real-time weather reports, water conditions, and crop commodity pricing, helping them be as competitive as possible in a global market.

To further empower consumers in their energy usage decisions, increase flexibility, and enhance reliability, a combination of Recovery Act funds and private investments will add 18 million new smart meters to the eight million currently in use. To improve system reliability, the Recovery Act will install more than 875 transmission system sensors that can alert system operators and help prevent minor disturbances from cascading into large outages. Finally, for further system reliability, the Recovery Act funds will help equip approximately 700 substations with automated devices to detect and respond to system irregularities, thereby helping to avoid outages.

The Recovery Act is investing approximately \$20 billion in health information technology to boost significantly advancements in electronic health records, e-prescribing, e-care, and community health initiatives. Through the \$250 million Beacon Communities program, communities will demonstrate the use of new technologies aimed at sustainable improvements in health outcomes, health care quality, safety, and efficiency. These efforts will not only cut certain medical costs, but also improve care. Finally, the rise in e-care technologies or telemedicine will allow medical personnel to treat patients remotely, while being able to monitor conditions and prescribe or administer medications from miles away.

Investing in Groundbreaking Medical Research

The Recovery Act has provided funds to the National Institutes of Health (NIH) to support groundbreaking research that will help to unravel the clues to treating or preventing some of life's most daunting and debilitating diseases, develop powerful new medicines, and even define strategies that will prevent disease from occurring in the first place. Examples of groundbreaking research can be found in the work surrounding human genome sequencing, cardiovascular disease, cancer, and autism.

As a result of these efforts, the number of complete human genomes anticipated to be sequenced in the next few years is expected to dwarf, by 50 times or so, the number of complete human genomes that have been sequenced to date. At the same time, NIH is pursuing multiple avenues of bringing down dramatically the cost to sequence a genome. The goal is to sequence an entire human genome for \$1,000, a cost that now exceeds 50 times that amount. In the field of cancer research, because of Recovery Act funds, NIH will be able to sequence the genes of cancers that affect 10 million Americans, or over five times more affected Americans than otherwise would have been possible. This research could make treating cancers more targeted and more effective.

In short, across areas that have great significance for America's future, the Recovery Act is laying the foundation for a new, more robust American economy. This report provides a deeper look into these areas and the effects being seen because of Recovery Act investments.

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I. An Introduction to Innovation: How and Why the Recovery Act Invests in Innovation

The American Recovery and Reinvestment Act was designed to help the U.S. pull itself out of the worst economic crisis to face the country in generations. The Act had three primary purposes:

1. To *rescue* a failing economy,
2. To put the country on a path to *recovery* by putting Americans back to work immediately, and
3. To *reinvest* in the country's long-term economic future.

Rescue funds, such as unemployment insurance compensation, food stamps, and additional payments to seniors and veterans have helped those most affected by the downturn and those most in need. Recovery funds, such as highway or water infrastructure have directly put Americans across the country back to work. Lastly, reinvestment funds, such as investments in advanced vehicles, renewable energy, Smart Grid, health information technology, and high-speed rail not only put Americans back to work, but also are laying a foundation on which a stronger and more competitive economic future can be built.

This report focuses on this third group of programs – the “Reinvestment” part of the Recovery Act – and on those aspects of these programs that harness the innovative power of the American economy. It also explores the Recovery Act's transformative impact on diverse sectors of the U.S. economy.

Innovation in Context

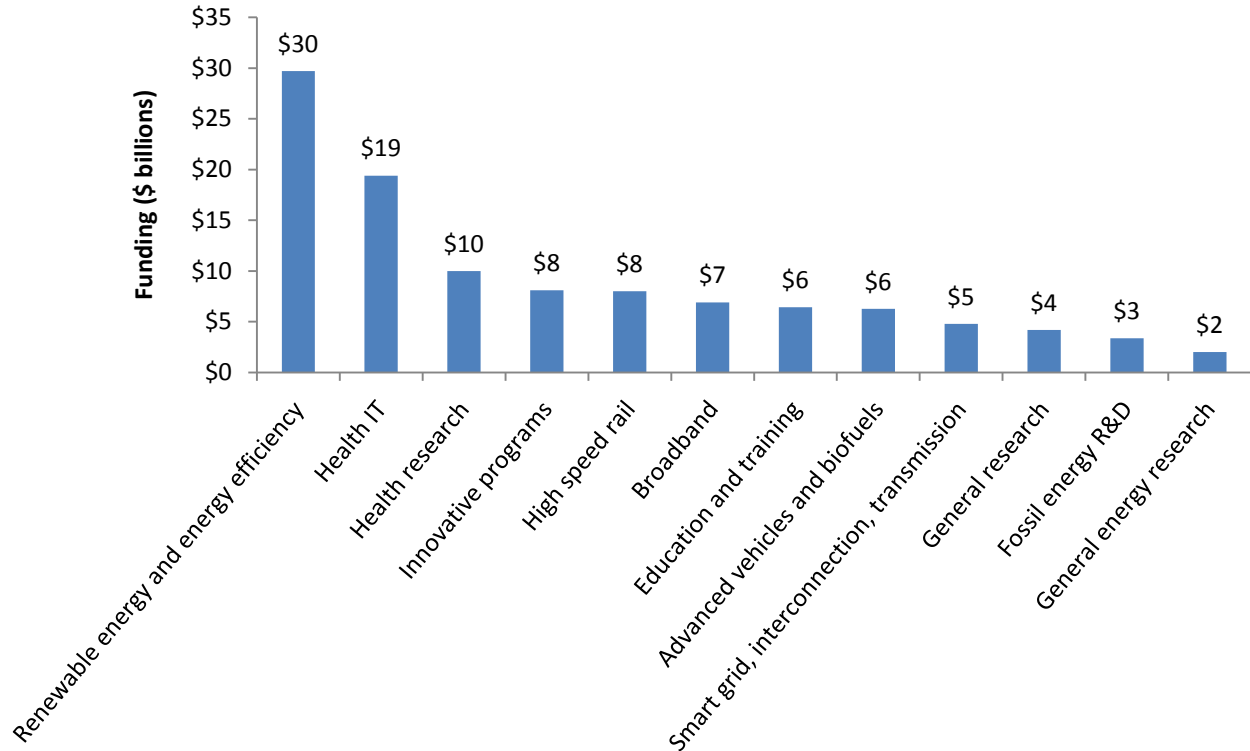
Since its founding, the United States has been a nation built on discovery and innovation. Through its leadership in these areas, the U.S. has changed the way the world thinks about government, industry, and technology.

In the 1930s, faced with some of the darkest days America had seen, President Franklin D. Roosevelt signed the \$50 billion “New Deal” (\$782 billion in today's dollars), despite much opposition and criticism. Through this ambitious series of economic programs, he invested dollars to transform the work place and rural America, believing that their strength would rescue a devastated nation. Decades later, President John F. Kennedy chartered the \$25 billion Apollo Program (\$180 billion in today's dollars), which was charged with one ultimate goal: to land humankind on the moon. The results captured the imagination of America and established the U.S. as the global leader in space exploration.

It was in this spirit of taking bold steps forward in the face of daunting adversity that President Obama signed the \$787 billion Recovery Act over a year ago on February 17, 2009. In the Act's Statement of Purpose, it lists one of its five goals as: “To provide investments needed to increase economic efficiency by spurring technological advances in science and health.”³ In this light, the Recovery Act is investing over \$100 billion in innovative and transformative programs that span industries from Energy to Health Information Technology. A distribution of Recovery Act spending in innovation and transformation can be seen in the chart below.

³ *American Recovery and Reinvestment Act of 2009*, Public Law 111-5, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h1enr.txt.pdf (accessed June 3, 2010).

Funding for Innovation and Technology Deployment in the Recovery Act



Note: EERE and Smart Grid figures estimate impact of Title 17 rescission. Source: OMB analysis

Within three to six years, these funds will lay the seeds for emerging industries and significantly move the needle toward re-shaping the face of the new American economy. Moreover, they will help restore American leadership in industries and sectors where academics and economists from across the ideological spectrum have agreed that America is falling behind.

Why Innovation: The Need for Change

There is widespread agreement in the economic community that innovation is a primary driver of long-term economic growth and prosperity. Robert Solow won the Nobel Prize in economics for his analysis demonstrating that advances in human knowledge and technology were the primary drivers for wealth creation in the 20th century. Years after Solow's pioneering research, Paul Romer, the chief architect of "New Growth Theory," made a profound impact on the economic field by showing once again that "economic growth doesn't arise just from adding more labor to more capital, but from new and better ideas expressed as technological progress."⁴ Speaking about the U.S., Romer stated, "We've got a

⁴ Ronald Bailey, "Post-Scarcity Prophet: Economist Paul Romer on growth, technological change, and an unlimited human future." *Reason Magazine* (December 2001), <http://reason.com/archives/2001/12/01/post-scarcity-prophet/singlepage> (accessed June 3, 2010).

historical precedent for creating institutions which lead to better innovation of the market and strengthen science significantly. We should aim for that kind of improvement again.”⁵

Innovation also drives job creation. Long-term, high-quality jobs stay in industries where there is a high degree of innovative content and where innovation, manufacturing, and end-user demand are tightly integrated. Last September, the White House released “A Strategy for American Innovation.” The strategy outlined the President’s vision for innovation to catalyze long-term, sustainable economic growth that would create new jobs and new industries for American workers. It aims to implement sensible government policies, harness the investments of the private sector, and lay the foundation for innovation, job creation, and American prosperity. To accomplish this objective, it focuses on three areas:

1. Investing in the Building Blocks of American Innovation: Investments in research, development, education, and infrastructure are necessary to set the groundwork for future innovation.
2. Promoting Competitive Markets that Spur Productive Entrepreneurship: Competitive markets foster a national environment ripe for entrepreneurship and risk taking that allows American innovators to grow domestically and compete internationally.
3. Catalyzing Breakthroughs for National Priorities: Some industries of exceptional national importance, such as developing alternative energy, implementing health information technology, and manufacturing advanced vehicles, will likely not produce outcomes in the best interest of society on their own. In these sectors, the government will seek to assist and leverage the market to produce strong results

The Recovery Act does all three. The Act’s investments will accelerate the pace of innovation, helping to establish the U.S. as a global leader in competitive, high-growth industries of the 21st century. It will help make important technologies more affordable in the marketplace and build the nation’s infrastructure to enable further sound economic growth and job creation.

This report explores four areas in which the Recovery Act is helping to create a newer, more efficient economy for decades to come:

1. Modernizing transportation, including advanced vehicle technology and high-speed rail;
2. Jumpstarting the renewable energy sector through wind and solar energy;
3. Building a platform for private sector innovation through investments in:
 - a. Broadband,
 - b. Smart Grid, and
 - c. Health Information Technology; and
4. Investing in groundbreaking medical research.

⁵ Ibid.

II. Modernizing Transportation: Investments in Advanced Vehicle Technology and High Speed Rail

Oil powers 95 percent of America's cars, trucks, ships, planes, and rail cars. Moreover, the United States is the largest oil consumer and importer in the world and relies on imports for more than half of its oil consumption.⁶ This dependence on oil is an energy security threat and increases U.S. economic vulnerability. The environmental impact of petroleum-powered vehicles is also a rising concern. Nevertheless, most Americans cannot afford or access alternatives to petroleum.

Today, an American driving 32 miles a day to and from work⁷ will spend almost \$1,000 a year on gasoline, each day adding to U.S. dependence on foreign oil.⁸ A consumer driving an electric car would save over \$630 per year powering the car with electricity generated in American power plants instead of gasoline made from imported oil.⁹ The only highway-enabled electric vehicle option available today, however, would cost more than \$100,000.

Americans driving longer than a normal commute, such as from Chicago to St. Louis, would face further difficulties. With today's technology, an electric vehicle could not make this 300-mile drive on a single charge. In addition one would not be able to easily recharge an electric vehicle en route since the closest charging station is in Champaign, Illinois, 136 miles from Chicago. If instead one wanted to make this trip *via* train, it would take five and a half hours and cost from up to \$66, thus saving neither time nor money compared to driving a combustion vehicle.

The Recovery Act directly tackles such issues with a multi-pronged approach—investing in technologies that will make alternatively powered vehicles cheaper, technologies that will make an alternative energy vehicle reality structurally feasible, and a high-speed rail network that will reduce travel time.

⁶ U.S. Energy Information Administration (EIA). In 2008, net imports represented 56 percent of U.S. petroleum consumption and 67 percent of oil crude oil consumption. U.S. net imports: <http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mtntus2&f=a> (accessed August 20, 2010). US oil consumption: <http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTUPUS2&f=A> (accessed August 20, 2010).

⁷ According to a 2005 ABC News/Time magazine/Washington Post poll, the average commute for Americans is 32 miles.

⁸ Assumes 32 miles a day, 5 days a week, a vehicle with a fuel economy of 27.5 miles per gallon (CAFE standard for 2010), and \$3 a gallon gasoline.

⁹ Assumes 3 miles a kWh and \$0.10 a kWh. This does not include the additional up-front cost of the electric vehicle.

Advanced Vehicles: Manufacturing and Deploying Today's Technologies

The Recovery Act is helping transform the U.S. automotive sector by investing in a competition among various approaches: electric vehicles, advanced biofuels, natural gas vehicles, hydrogen fuel cells, and more efficient combustion vehicles. Each of these approaches, which include a range of technologies, shows promise to be a significant improvement over current technology. Ultimately, the market will be able to choose different combinations of these technologies.¹⁰ This section will highlight Recovery Act investments in one of these important areas of innovation: electric-drive vehicles.

The Recovery Act and the Advanced Technology Vehicles Manufacturing (ATVM) loan program are investing across the innovation chain – from retooling current auto factories to new manufacturing and commercial deployment to research and development in electric drives and batteries. With these investments, the U.S. is taking significant steps toward affordable electric cars that can drive 300 miles on a single charge, powered by \$10 of clean electricity instead of \$50 dollars of oil. Ultimately this means consumers may have the choice among a range of vehicles from a combustion vehicle with over 50 miles per gallon or an electric-drive vehicle for the same price.

Electric cars need batteries and drive components that are in short supply in the U.S. To stimulate their production, over \$2 billion in Recovery Act funding is being invested in companies like A123 and EnerDel, supporting 30 factories to produce the advanced batteries and electric drive components necessary to power the electric-drive vehicles of the future. In 2009, the U.S. had only two factories manufacturing advanced vehicle batteries and produced less than two percent of the world's

Navistar: Less than one year later, an Electric Vehicle comes off the production line

On May 13, 2010, Navistar International Corporation delivered the first electric vehicle supported by a grant from the Recovery Act's investment in advanced battery manufacturing and transportation electrification.

The electric truck rolled off the production line less than a year after President Obama announced at the company's Wakarusa, Indiana facility the 48 advanced battery manufacturing and transportation electrification awards totaling over \$2.4 billion. The plug-in powered truck, which can carry more than 2 tons of cargo a distance of up to 100 miles per charge, began making customer deliveries immediately.

Navistar, which received \$39.2 million in Recovery Act funds, plans to produce 400 electric trucks, which will be powered by advanced batteries manufactured by Michigan-based A123 Systems, another Recovery Act recipient.

Navistar spent months developing and testing the plug-in technology, as well as retrofitting an old manufacturing plant, to ensure the successful production of the vehicles.

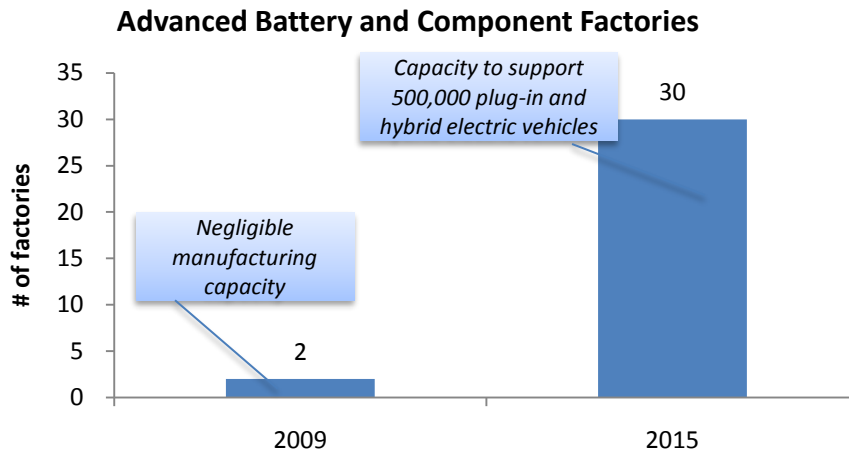
The new Navistar production facility was formerly home to a RV manufacturer that went bankrupt, leaving many in the area without a job. Thanks to the Recovery Act, the old RV facility is now producing the next generation of electric vehicles—all while creating long-lasting, green jobs in the community.



Note: \$2.4 billion includes advanced battery and electric drive component manufacturing as well as transportation electrification funding.

¹⁰ The different approaches can also converge, for example with plug-in hybrid electric vehicles recharged by efficient combustion engines running on cellulosic biofuels.

advanced vehicle batteries.¹¹ By 2012, thanks in part to the Recovery Act, the 30 factories mentioned above will be online. By 2015, when these factories reach scale, they will have the capacity to produce enough batteries and components to support up to 500,000 plug-in hybrid electric vehicles. From a negligible portion of the world's advanced battery manufacturing today, U.S. production capacity for advanced vehicle batteries will amount to more than 20 percent of global production capacity estimated to be online in 2012.¹² Similarly, the Recovery Act is helping to scale production of electric-drive components such as motors and conductors. Companies like UQM, which has long-built only custom prototype parts, are expanding manufacturing capacity to build electric power trains at high volume.



Source: U.S. DOE Vehicle Technologies Program.

In addition, the Department of Energy is directing a large amount of funding outside the Recovery Act to increase U.S. manufacturing capability. Over \$2.4 billion in Advanced Technology Vehicle Manufacturing (ATVM) loans to Fisker, Nissan, and Tesla are supporting three of the world's first electric car factories in Delaware, Tennessee, and California, respectively.¹³ In fact the Nissan Leaf, an affordable and 100 percent electric vehicle with a range of roughly 100 miles on a single charge, is expected to hit the U.S. market at the end of 2010 and will be manufactured in Tennessee beginning in 2012.

This means American workers will soon be working in some of the most cutting edge and competitive factories in the world, including more than 2,000 jobs at Fisker's factory in Delaware, 1,300 new jobs at

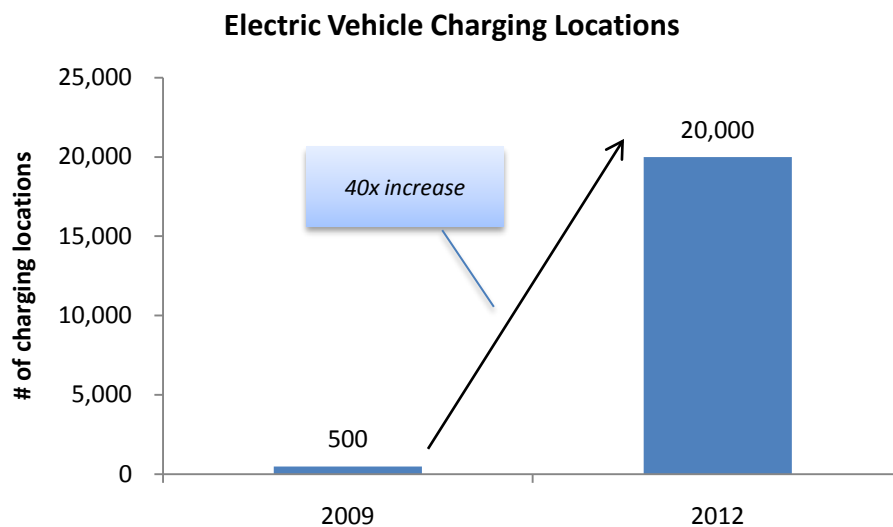
¹¹ In 2008, the U.S. produced less than two percent of the Nickel metal hydride batteries used in hybrid vehicles (www.nrel.gov/docs/fy09osti/46018.pdf, accessed August 20, 2010). U.S. production of lithium-ion batteries was virtually nothing.

¹² Percentage refers to capacity to produce lithium-ion cells intended for advanced vehicle batteries. U.S. production capacity estimated by the Department of Energy Vehicle Technologies Program, based on Recovery Act and ATVM battery factories. Global production capacity estimated by Deutsche Bank.

¹³ The Department of Energy's ATVM Program was not created in the Recovery Act. The program, which announced its first loans in 2009, has been a critical part of the domestic auto industry's efforts to lead the global race to produce advance vehicles.

Nissan's factory in Tennessee, and more than 1,000 jobs at Tesla's factory in southern California.¹⁴ It also means several thousand jobs in Michigan and all over the country at new battery and component factories like East Penn Manufacturing, Celgard, and Delphi Automotive Industries.

Beyond manufacturing, another \$400 million from the Transportation Electrification program is supporting electric vehicle deployment programs. Companies like ETEC in Phoenix, Arizona will move the U.S. from less than 500 electric vehicle charging locations today to over 20,000 by 2012. These programs are also helping put the first 13,000 electric vehicles on the road, in more than a dozen cities. Recovery Act electric vehicle demonstration projects will show how electric cars perform under real driving, traffic, and weather conditions.



Source: U.S. DOE Vehicle Technologies Program.

Advanced Vehicles: Investing in Tomorrow's Technologies

While battery factories and electric vehicle deployments are helping roll out the latest generation of technologies available today, the Recovery Act is also helping develop breakthrough technologies that will keep the U.S. auto sector globally competitive in the future. The Recovery Act is supporting a broad set of technologies to help make electric drive a reality, each with the potential to dramatically lower costs and improve battery performance.

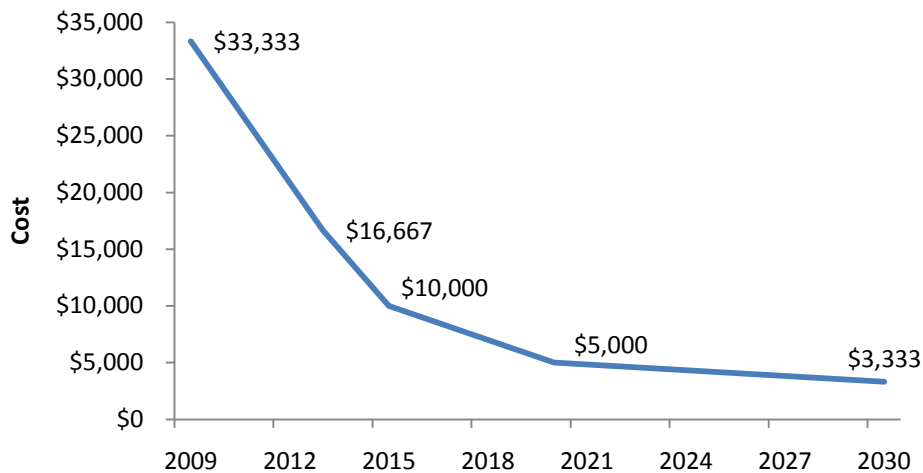
When the Recovery Act passed, battery technology was a key barrier to the widespread use of electric cars: batteries were too costly, too heavy, and too bulky, and would wear out too quickly. The high cost of electric cars resulted mostly from the high cost of the batteries. Between 2009 and 2013, when 20 Recovery-Act funded battery factories will be up and running and these factories begin to achieve economies of scale, battery costs are expected to drop by half, thereby cutting an electric car's cost premium in half. Fisker, GM, Nissan, Tesla, and other automakers have plans to introduce more

¹⁴ ATVM job numbers are company estimates.

affordable electric vehicles. Drivers will be able to save money over a car’s lifetime because electricity is significantly cheaper than gasoline.

The Recovery Act is also funding a set of breakthrough research projects. The Department of Energy’s Advanced Research Projects Agency (ARPA-E) program is supporting potential game-changers like semi-solid flow batteries, ultracapacitors, and “all-electron” batteries that could go well beyond today’s best lithium-ion technologies. ARPA-E funding is allowing startups like Envia, Electroville, Sion Power, and FastCAP to pursue these innovations that otherwise would not have been able to proceed as quickly. If successful, these breakthroughs could cut battery costs by as much as 90 percent and expand range three to six-fold, bringing the up-front cost of electric cars down to that of gas cars and giving them a longer range. This means the savings would begin as soon as the electric vehicles are driven out of the showroom and one would be able to “fill up” at home at night rather than having to stop by the gas station during the commute.

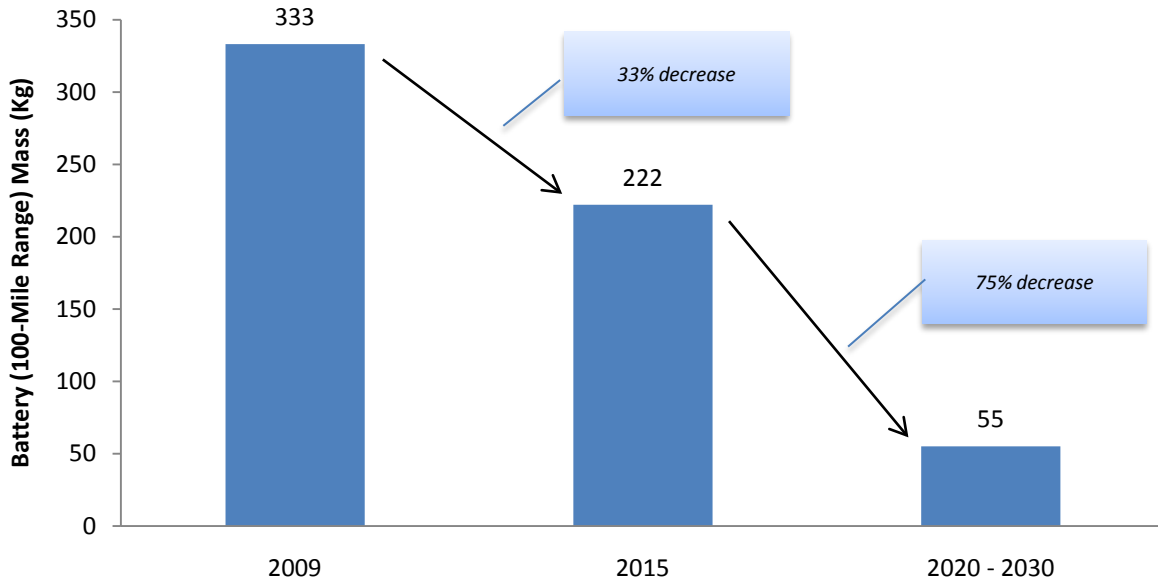
Forecasted Cost of a Typical Electric-Vehicle Battery



Note: Assumes 3 miles per kilowatt hour and 100-mile range. Source: U.S. DOE Vehicle Technologies Program.

The Recovery Act is supporting innovations to improve battery performance and reduce weight. In 2009, heavy batteries limited a vehicle’s range and acceleration. Low cycle-life also meant batteries might wear out in just a few years. Recovery-Act supported projects are making batteries denser. These smaller, lighter batteries mean more power, improved performance, and greater range.

Forecasted Weight of a Typical Electric-Vehicle Battery

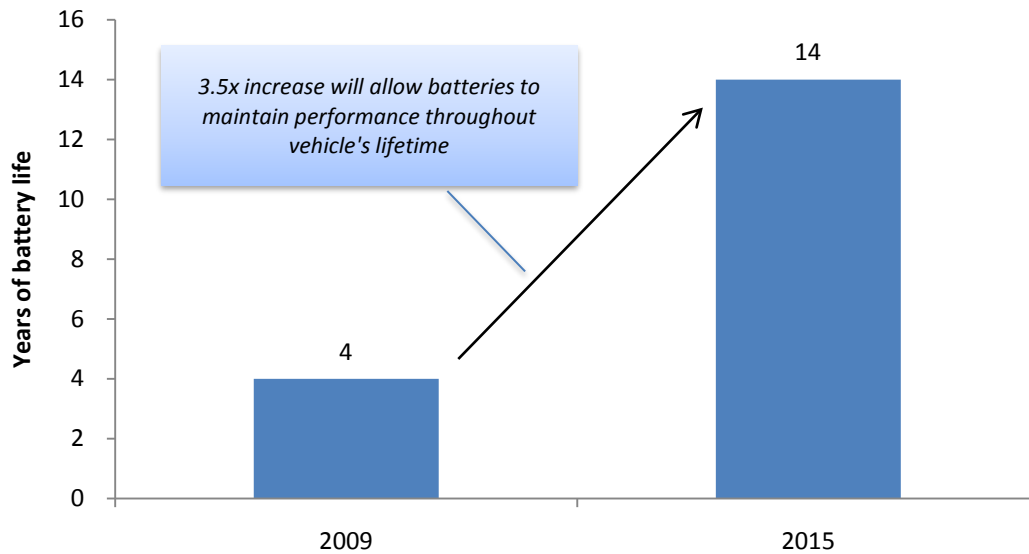


Note: Assumes 3 miles per kilowatt hour and 100-mile range. Source: U.S. DOE Vehicle Technologies Program.

Batteries are also becoming more durable, and in the next few years domestic manufacturers should be able to produce batteries that last up to 14 years. This should give consumers confidence that electric vehicle batteries will last the full life of the vehicle. In addition, longer lasting batteries reduce the potential for used batteries to become waste material.¹⁵

¹⁵ The Department of Energy is also actively coordinating industry efforts to develop a systematic standards and processes to recycle used batteries.

Expected Lifetime of a Typical Electric-Vehicle Battery



Note: Assumes drivers will charge their vehicles 1.5 times per week. Source: U.S. DOE Vehicle Technologies Program.

Investments in High-Speed Rail

Along with investments in vehicle technology, the Recovery Act is investing in world-class public transportation options. With less than 500 miles of high-speed rail with speeds far slower than other countries, the U.S. is significantly behind other nations. China has already completed nearly two-thirds of a planned 8,000-mile high-speed rail network; and geographically smaller countries like Japan, France, and Germany all have over 1,000-mile networks.

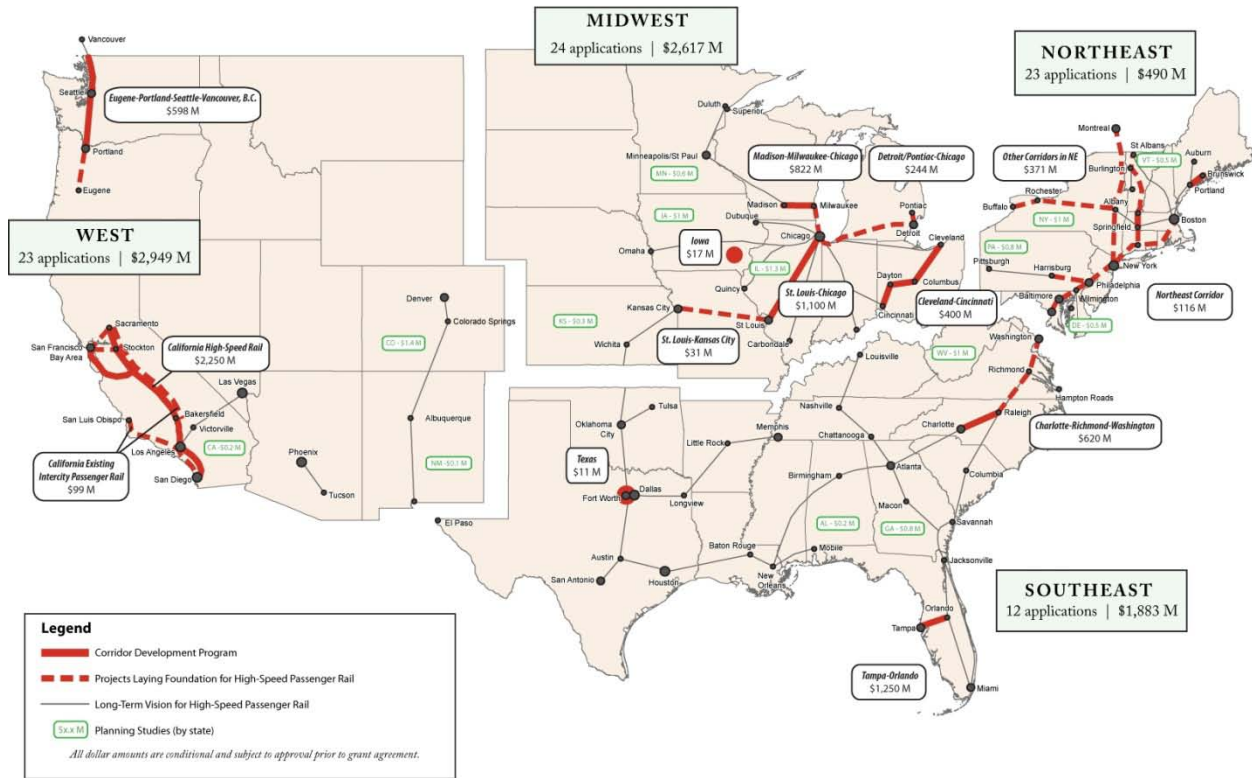
While the overall population density of the U.S. is lower than much of Europe and Asia, there are major metropolitan corridors stretching from 100 to 600 miles that are comparable to corridors around the world where high-speed rail has proven to be a successful addition to transportation networks. In the U.S., several economically interdependent metropolitan regions that face growing highway and aviation congestion are strong candidates for future high-speed rail investment. These include: the Midwest hub, the Pacific Northwest, California, Texas and the Gulf, Florida, and the Southeast and Northeast corridors. The Federal Railroad Administration is employing rigorous planning and cost-effectiveness analysis to ensure Federal investments are targeted at those projects that maximize benefits to transportation systems and overall economic performance.

With \$8 billion in funding, the Recovery Act is beginning to make high-speed rail a reality across the country. The initial projects selected to receive funding represent strategic investments that will ultimately result in new high-speed rail corridors and will upgrade thousands of miles of existing track and services, laying the groundwork for future high-speed rail services.

High-Speed Intercity Passenger Rail Program



National Summary of Selected Projects



Source: U.S. DOT Federal Railroad Administration

California’s high-speed rail mega-project promises to alter significantly the transportation landscape in California by connecting the State’s largest metropolises with up to 220-mph service. Once complete, California anticipates business, leisure, and commuter ridership of up to 100 million passengers a year by 2035, which if realized, would make it one of the busiest passenger rail lines in the world. On August 11, 2010, the Transbay Transit Center in San Francisco, the northern terminus for the California high-speed rail system, broke ground. Touted as the “Grand Central of the West,” it is the first new station on the California high-speed rail system to move into construction. It is expected to serve more than 45 million passengers a year.¹⁶

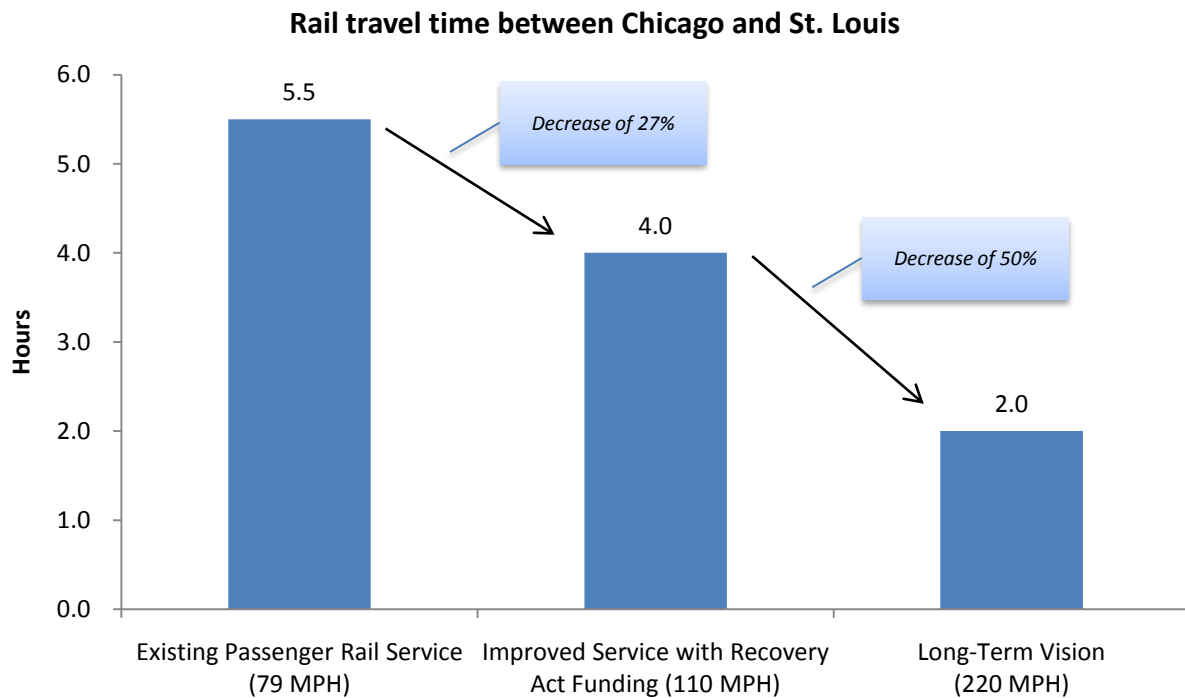
In other parts of the country, Recovery Act investments are laying the groundwork for important improvements to the Nation’s intercity passenger rail network. The direct benefits from just five corridors¹⁷ funded under the Recovery Act’s high-speed rail program include:

¹⁶ Transbay Transit Center, “Historic Groundbreaking of First New High-Speed Rail Station in United States,” (August 11, 2010), http://transbaycenter.org/uploads/2010/08/groundbreaking_press_release_2010-0811.pdf (accessed August 20, 2010).

¹⁷ (1) Charlotte – Raleigh, (2) Tampa – Orlando, (3) Chicago – St. Louis, (4) Milwaukee – Madison, and (5) Seattle – Portland

- 808 route miles of track improvements or new high-speed rail track with 364 route miles operating at speeds of up to 110 mph and 84 route miles operating at speeds of up to 168 mph;
- 95 percent increase in U.S. high-speed rail route miles versus current *Acela* service;
- 26 new or additional round trip service frequencies; and
- 18 percent better trip times, saving an estimated 3.8 million hours for travelers annually.

With Recovery Act funding, the train ride from Chicago to St. Louis referenced earlier will be reduced from five and a half hours to around four hours, a drop of nearly 20 percent. This investment can help build the market for future express high-speed rail service of two hours for that route, with significantly increased speeds of up to 220 mph.



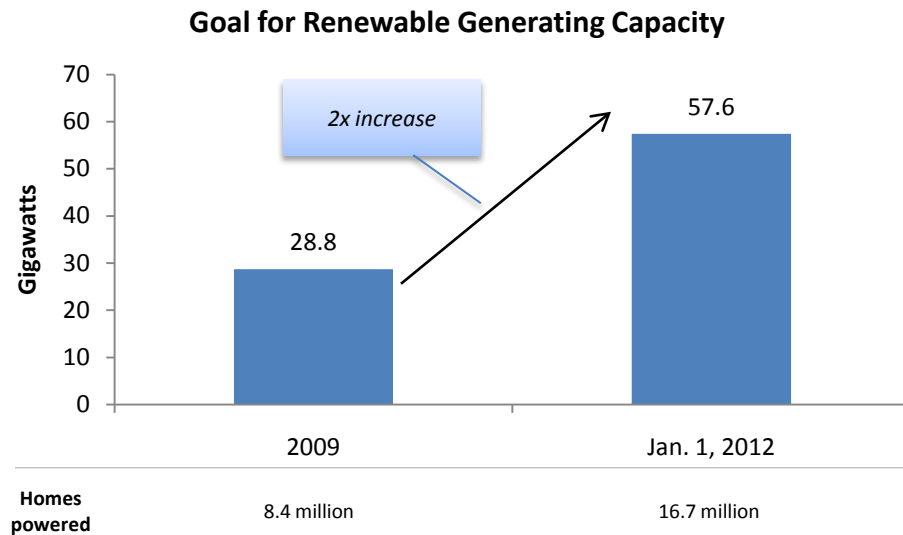
Source: Amtrak timetable for “Lincoln Service” route [existing service]; Illinois Department of Transportation application to the High-Speed Intercity Passenger Rail program, “IL-Dwight-St.Louis-2004 ROD Improvement,” October 4, 2009 [improved service]; Midwest High-Speed Rail Association, “Chicago to St. Louis 220 mph High Speed Rail Alternative Corridor Study,” October 8, 2009 [long-term vision].

III. Promoting Clean, Renewable Energy: Investments in Wind and Solar

Three decades ago, the U.S. led the world in the development of renewable energy, such as wind, solar, and geothermal power. Since then, markets for renewable energy have grown predominantly overseas due to strong, consistent foreign government incentives and policies. As a result, manufacturing of renewable energy equipment has grown largely overseas as well. Recovery Act investments are helping the U.S. re-establish leadership in innovation, manufacturing, and deployment in these fast-growing industries, which will create new jobs, increase access to clean energy, and reduce greenhouse gas emissions.

In the beginning of his Administration, President Obama set a goal of doubling U.S. renewable energy generation capacity from wind, solar, and geothermal by 2012. This was a bold goal – to install as much renewables in the next three years as the U.S. had in the previous thirty. In addition, President Obama set the goal of doubling U.S. renewable manufacturing capacity, so that the U.S. can gain leadership in manufacturing these technologies as well.

Specifically, the goals are to double renewable energy capacity from the 28.8 gigawatts (GW) of solar, wind, and geothermal generation that had been installed in the U.S. as of the end of 2008 to 57.6 GW by the end of 2011¹⁸ – enough to power 16.7 million homes¹⁹ – and to double renewable energy manufacturing capacity from an annual output of 6 GW of renewable equipment (such as wind turbines and solar panels) at the end of 2008 to 12 GW by the end of 2011.



Source: U.S. DOE Energy Information Administration (EIA).

¹⁸ Source for Jan. 1, 2009 baseline: U.S. Department of Energy, Energy Information Administration (EIA), “Annual Energy Outlook 2010.” While electricity generated from biomass is an important component of the renewable goals, it is not included in these figures.

¹⁹ Based on average annual household electricity consumption of 11,040 kWh in 2008. Source: U.S. EIA.

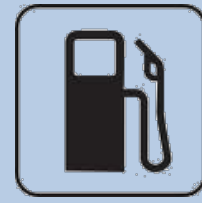
What can one gigawatt (GW) of renewable capacity do?



**Power 290,000
Homes for an
entire year**



**Power 959,000
Electric vehicles
for an entire year,
and thereby...**



**Save 349,000,000
Gallons of gasoline
in a year**

Sources: Energy Information Administration;
Office of Management and Budget; Clean Energy Authority.

Note: Assumes electric vehicle can drive 3 miles per kWh and is driven 10,000 miles per year and that a comparable vehicle has a fuel efficiency of 27.5 miles/gallon (CAFE standard for 2010).

Since 2009, growth in renewable energy has increased, and the U.S. is making significant progress toward meeting both goals, due in large part to support from the Recovery Act. This has happened despite the sharp economic and financial downturn over this period. Without Recovery Act investments, it is likely that the pace of renewable energy project construction and manufacturing growth would have slowed dramatically, and these goals would have been much more difficult to meet.

Not only are these investments in renewable energy projects helping to create tens of thousands of jobs in construction and manufacturing, but they also could help renewable energy technologies achieve economies of scale and bring down costs. Other Recovery Act investments are funding a diverse set of research projects to develop next generation renewable energy technologies, such as solar thin films and new wind turbine designs. These research projects could reduce the cost even further, to the point that electricity from renewable energy technologies could become cost competitive with electricity from coal or natural gas power plants.

There are three key programs through which the Recovery Act is driving manufacturing and deployment of renewable energy technologies:

Payments-In-Lieu-Of-Tax-Credits (1603)	Manufacturing Tax Credits (48C)	Loan Guarantees
<ul style="list-style-type: none"> • Over \$3 billion so far in payments-in-lieu-of-tax - credits to over 500 projects in 44 states to support renewable energy generation projects • Supports more than 10,000 construction jobs and over 2,000 ongoing operating and maintenance jobs • Brings more than 4 GW of new renewable energy online • Leverages \$2 of private capital for every \$1 of tax credits 	<ul style="list-style-type: none"> • Over \$2 billion in tax credits to 183 projects in 43 states for clean energy manufacturing projects • 30 percent tax credit for qualifying advanced energy projects in new, expanded, or re-equipped domestic manufacturing facilities • Competition was more than 3x oversubscribed • Leverages \$2 of private capital for every \$1 of tax credits 	<ul style="list-style-type: none"> • \$2 billion in conditional or closed loan guarantees for renewables deployment and manufacturing projects • Projects will create or save more than 5,000 construction and permanent jobs, lead to more than 3 GW of clean power generating capacity, and avoid more than 30 million tons of CO2 per year, according to company estimates. • Leverages more than \$4 of debt and equity for every \$1 of loan guarantee subsidy

Solar Power: Manufacturing and Deploying Today’s Technologies

Today, solar power is significantly more expensive than electricity from fossil fuels in most regions of the country. All the solar power in the country generates less than one percent of the nation’s electricity. The Recovery Act is helping to deploy the latest generation of solar power technologies more rapidly while also expanding manufacturing of solar technologies here in the U.S. This is helping to increase U.S. solar generating capacity while simultaneously scaling up manufacturing and driving down costs.

- The 1603 Payments-In-Lieu-Of-Tax-Credits program has supported more than 200 megawatts (MW) of solar projects that are already delivering solar power to consumers. These projects are deploying solar panels that generate affordable green power on the rooftops of thousands of homes across the country and in the fields of some of the largest industrial-sized solar generating facilities in the world. For example, in Pensacola, Florida, the program has helped fund the 25 MW DeSoto Solar Park, the largest photovoltaic power plant in North America, which consists of over 90,000 solar panels and provides enough solar power to serve about 3,000 homes.²⁰
- The 48C Manufacturing Tax Credits are helping solar manufacturers like FirstSolar, which is expanding a large manufacturing plant in Perrysburg, Ohio, and Sunpower, which is expanding

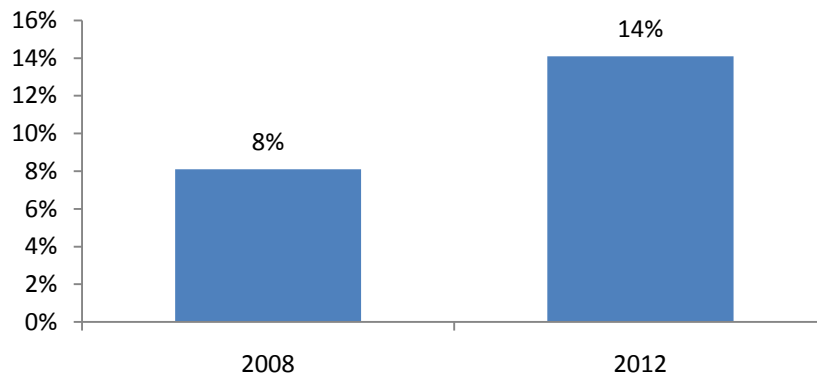
²⁰ Florida Power & Light Company, “DeSoto next Generation Solar Energy Center,” <http://www.fpl.com/environment/solar/desoto.shtml> (accessed August 20, 2010).

its manufacturing in Milpitas, California. Both companies had received earlier Department of Energy research and development grants to help develop the technologies that are now being brought to commercial scale.

- Loan guarantees are helping Solyndra in Fremont, California, build a high-tech, solar panel manufacturing facility with the capacity to build 230 MW a year. The Department of Energy also has issued conditional commitments for BrightSource Energy to build a 377 MW solar power plant in Ivanpah, California. Together, Solyndra and BrightSource estimate that these projects will lead to over 4,000 construction jobs and over 1,000 ongoing manufacturing and operations jobs.²¹

These solar deployments and factories create high-quality jobs today and promise to help re-establish U.S. leadership, reversing years of declining U.S. market share in global solar production. Domestic manufacturing capacity for solar photovoltaic (PV) modules – the panels that convert sunlight into electricity – is forecast to grow from less than one GW per year in 2008 to nearly four GW per year in 2012.²² The U.S. share of global manufacturing capacity is expected to grow from over eight percent in 2008 to over 14 percent in 2012.²³

Forecasted Growth in U.S. Share of Global Manufacturing of Solar PV Modules



Source: GTM Research and U.S. DOE Solar Energy Technologies Program estimates.

Solar Power: Investing in Tomorrow's Technologies

The Recovery Act is accelerating the rate of innovation in solar photovoltaics (PV), by more rapidly deploying today's technologies and by funding a competition among new solar technologies in laboratories and start-ups pursuing tomorrow's breakthroughs. While companies like Sunpower continue to improve and perfect the standard silicon solar panel, companies like FirstSolar and Solyndra are scaling up production of new thin-film chemistries like cadmium telluride (Cd-Te) and copper indium

²¹ Jobs estimates provided by Solyndra and BrightSource.

²² Shyam Mehta, "PV Manufacturing in the United States: Market Outlook, Incentives and Supply Chain Opportunities," (GTM Research, September 2009), 39.

²³ GTM Research and U.S. DOE Solar Energy Technologies Program estimates.

gallium selenide (CIGS). This could help drive down the costs of solar panels by half between 2009 and 2015.

The Department of Energy's solar PV incubator program is continuing to support competition among crystalline silicon, thin-film materials like Cd-Te and CIGS, and concentrating PV. Companies like AltaDevices, SolarJunction, and Semprius are applying novel new technologies to increase the efficiency and lower the cost of solar. In addition, the Department of Energy's Recovery Act pre-incubator and incubator programs are supporting breakthroughs in nanomaterials and organic materials that could drive down costs even further.

If such projects are successful, the cost of solar power could become cheaper than electricity from the grid. Together, these deployment and research and development programs are working towards the goal of bringing down the cost of solar by half over the next five years, from roughly \$0.20/kWh to \$0.10/kWh for solar electricity generated at residences.²⁴ If breakthroughs in technology can bring costs down to \$0.06/kWh by 2030, solar power will be cheaper than retail electricity from the grid, even without government incentives. At that cost, an average household with rooftop solar panels could save more than \$400 each year in electricity bills.²⁵

The cost of solar is forecast to reach grid parity over the next five years in many parts of the country.²⁶ This means homeowners (who pay an average retail cost of about 10 cents/kWh for electricity from the grid) and utility companies (which have average wholesale power costs closer to 5 cents/kWh) can use solar power without paying a premium over fossil-based electricity.

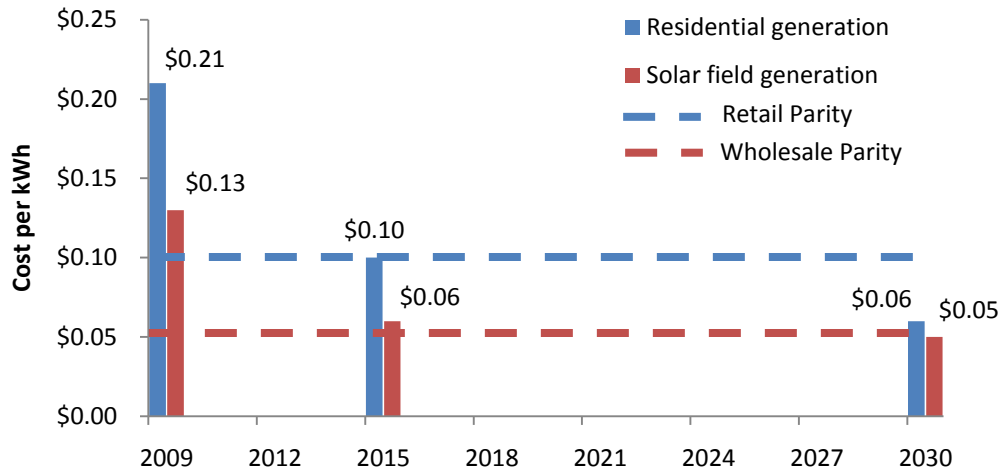
Near-term improvements will be able to cut the cost of solar power in half as second generation thin-film solar panels such as the rapidly emerging CIGS and Cd-Te technologies compete with ever improving traditional silicon-based panels. Beyond that, breakthrough technologies could make solar as cheap as new fossil fuel plants without government incentives.

²⁴ Cost estimates are in 2009 dollars and include the relevant Federal, but not state or local incentives.

²⁵ Assumes a retail electricity rate of \$0.097/kWh in 2030 and average household electricity consumption of 11,040 kWh/year. Source for electric rates: U.S. EIA, *Annual Energy Outlook 2010*. Source for household electricity consumption: U.S. EIA.

²⁶ Grid parity would be reached after including federal, but not state or local, incentives. Source: U.S. DOE Solar Energy Technologies Program.

Cost of Solar Power



Note: Graph shows the leveled cost of electricity for solar photovoltaics, which is the total capital and operating costs over the lifetime of the solar panels, divided by total electricity generated in kWh.²⁷

Source: U.S. DOE Solar Energy Technologies Program.

Wind Power: Manufacturing and Deploying Today's Technologies

Wind is among the most mature of renewable energy technologies and is currently the U.S.'s largest source of renewable power, excluding hydropower, and accounts for nearly two percent of the nation's total electric generation.²⁸ U.S. wind power capacity was 35 GW as of the end of 2009, which was nearly a 40 percent increase from the year before. For the fifth straight year, wind power was second only to natural gas in new electricity generation capacity added.

Over the last 30 years, the cost of wind power in the U.S. has come down by more than 80 percent, from over 30 cents/kWh in 1980, when the first large-scale wind turbines were installed, to less than 5 cents/kWh today, which is roughly competitive with fossil generation from new coal or natural gas plants.²⁹

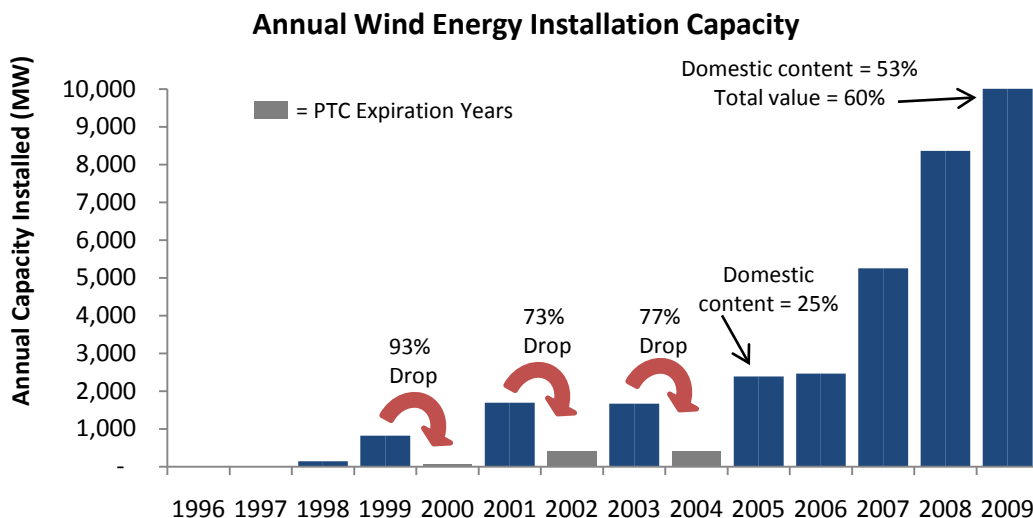
The market for wind power, however, has grown primarily overseas due to strong, consistent foreign government incentives and policies. In the U.S., support for the Production Tax Credit (PTC) has been uncertain and unstable, disrupting domestic wind development. As a result, wind manufacturing, too, has grown largely overseas. Just in the last few years, thanks in large part to consistent U.S. policy

²⁷ Includes federal 30 percent Investment Tax Credit until 2016 (when it is currently set to expire) but not thereafter.

²⁸ Wind power provided 1.8 percent of total U.S. electricity generation in 2009. This is an increase from 1.3 percent of generation at the end of 2008. Source: U.S. DOE, Energy Information Administration (EIA).

²⁹ Cost estimate is for the latest generation of large wind turbines at windy sites in the U.S. and includes the federal Production Tax Credit. Source: U.S. DOE Wind and Water Power Program.

support, the U.S. market for wind power has begun to grow dramatically and in response to that growth, more wind turbine manufacturing has located in the U.S.



Source: American Wind Energy Association (AWEA), “U.S. Wind Industry Annual Market Report – Year Ending 2009.”

The Recovery Act is helping to ramp up manufacturing and deployment of wind power components in the U.S., maintaining strong demand and financing for wind projects and helping to attract billions of dollars of additional investment into U.S. wind manufacturing.

In January of 2009 there was 25 GW of wind energy installed in the U.S. After a few years of strong growth, including 8.5 GW installed in 2008, the wind industry expected a substantial drop in 2009 due to the effects of the economic and financial markets downturn; predictions hovered around five GW of new installations for the year.³⁰ Instead, the U.S. wind industry broke all previous records by installing over ten GW of new generating capacity in 2009, helped greatly by Recovery Act incentives.³¹

Two analyses – by Lawrence Berkeley National Laboratory³² and by Bloomberg New Energy Finance – indicate that, without the Recovery Act’s incentives, wind installations in 2009 could have been 2 GW to 2.4 GW lower. The Council of Economic Advisers in their July 2010 Fourth Quarterly Report find that the

³⁰ American Wind Energy Association, “AWEA Year End 2009 Market Report” (January 2010),

<http://www.awea.org/publications/reports/4Q09.pdf> (accessed August 20, 2010).

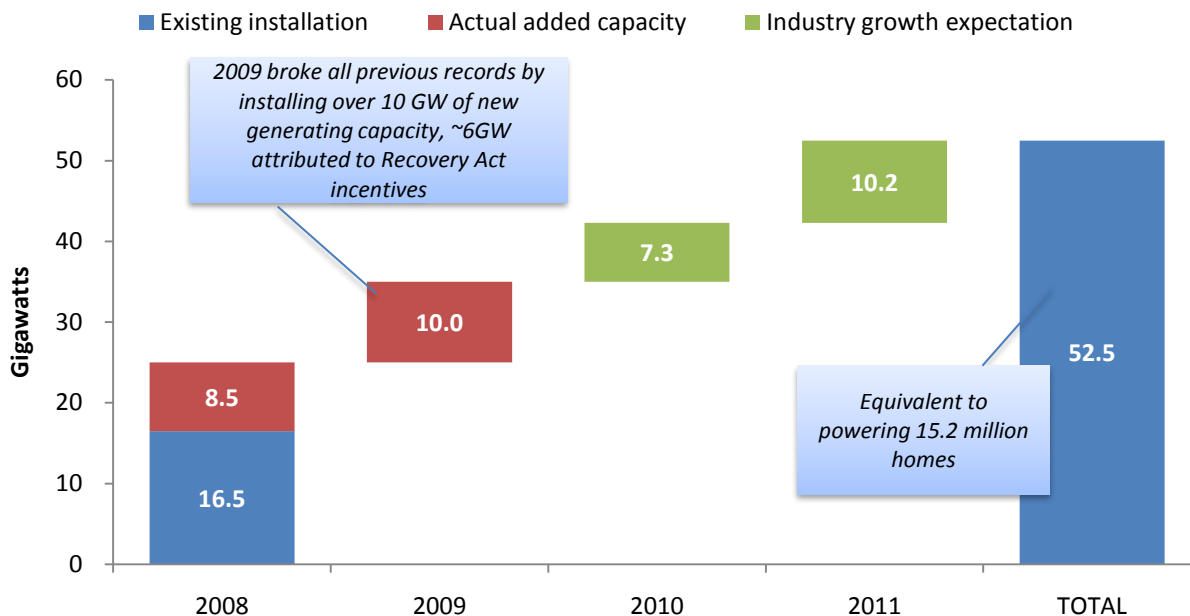
³¹ American Wind Energy Association, “AWEA Year End 2009 Market Report” (January 2010),

<http://www.awea.org/publications/reports/4Q09.pdf> (accessed August 20, 2010) and American Wind Energy Association, “Wind Power Outlook 2009,” http://www.awea.org/pubs/documents/Outlook_2009.pdf (accessed August 20, 2010).

³² Bolinger, Mark, Ryan Wiser, and Naïm Darghouth, “Preliminary Evaluation of the Impact of the Section 1603 Treasury Grant Program on Renewable Energy Deployment in 2009,” Lawrence Berkeley National Laboratory (April 2010).

Recovery Act was responsible for approximately 6 GW of wind capacity installation that might not otherwise have occurred.³³

Total U.S. Wind Energy Installation Capacity



Note: Historical figures from AWEA; forecasts from U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2010."

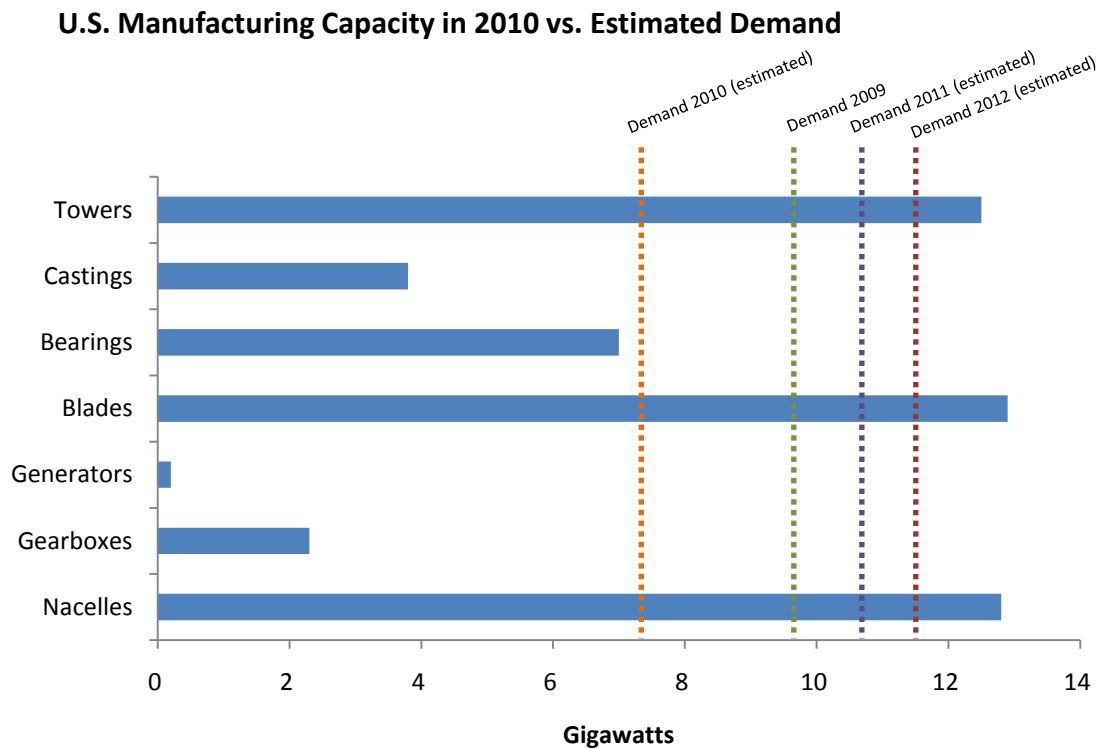
A good portion of the wind installation that comes online in 2010 and beyond will be supported by Recovery Act funding invested in 2009 and 2010. Wind capacity is now expected to grow to over 52.5 GW by the end of 2011. If these projections are met, the U.S. will come close to meeting its goal of doubling renewables in three years through investments in wind alone, and growth in solar and geothermal could take us well beyond the goal.

The 1603 program has provided over \$3 billion in payments-in-lieu-of-tax-credits to more than 100 wind projects in 30 states around the country, totaling 5.3 GW of wind power capacity. The program has directly addressed the freeze in tax equity markets related to the financial crisis, enabling projects to close financing and begin construction again. Since the beginning of the program in the summer of 2009, the U.S. has seen a dramatic increase in clean renewable energy project development despite industry predictions of a sharp slow-down in the face of a challenging economic environment.³⁴

³³ Council of Economic Advisers, Executive Office of the President, "The Economic Impact of the American Recovery and Reinvestment Act of 2009, Fourth Quarterly Report," (July 14, 2010), 44, http://www.whitehouse.gov/files/documents/cea_4th_arra_report.pdf (accessed August 20, 2010).

³⁴ In 2008, wind installations increased by an even larger rate (50 percent with 8,545 MW added) than they did in 2007 (45 percent, with 5,249 MW added), bumping up wind power's five-year average annual growth rate (2004-2008) to 32 percent. The previous five-year average annual growth rate (2003-2007) was 29 percent.

According to the renewables industry consulting firm MAKE Consulting, U.S. manufacturing capacity to produce the various components wind turbine components is uneven; the manufacturing capacity for certain components such as gearboxes, generators, and large casted steel parts, lags behind U.S. demand for those components.



Note: Represents maximum production capacity of existing facilities. Source: MAKE Consulting.

The 48C Manufacturing Tax Credit program has awarded \$346 million in tax credits to 52 wind manufacturing projects across the country. These new facilities, when built and fully online, will add several gigawatts per year of additional U.S. manufacturing capacity for wind components such as towers, blades, gearboxes, and generators to ensure the U.S. is able to supply a growing domestic market through domestic production. For example, these tax credits will support companies such as Alstom, Brevini Wind, Siemens, and Vela Gear Systems in building or expanding several manufacturing plants that will greatly increase the U.S. supply of gearboxes, one of the components that is currently in short supply domestically.

Wind Power: Investing in Tomorrow’s Technologies

Currently the U.S. does not have facilities that are able to fully test the next generation of large wind turbines and blades, putting U.S. wind manufacturers at a competitive disadvantage. The Recovery Act is funding two large wind turbine R&D test centers – one for turbines and one for blades – that will allow development and testing of the next generation of large-scale wind turbine drive-train systems and blades here in the U.S. This will help enhance the performance, durability, and reliability of U.S.-manufactured wind turbines and blades.

Wind turbine sizes have increased with each new generation of turbines and have outgrown the capacity of existing U.S. drive-train testing facilities. The new testing capability will ultimately improve U.S. competitiveness in wind energy technology, lower energy costs for consumers, and maintain rapid growth in the deployment of wind energy systems.

- *Massachusetts' Large Blade Test Facility (Recovery Act award of up to \$25 million):* The Testing Center in Charlestown, Massachusetts will allow the U.S. wind industry to test and certify the performance of the latest generation of very large wind turbine blades. The Test Center will primarily provide certification tests for new blade designs and reliability testing for existing blade designs for wind turbine manufacturers.
- *Clemson University's Large Drive Train Test Facility (Recovery Act award of up to \$45 million):* The Large Wind Turbine Drive Train Test Facility will enable the U.S. to expand development and testing of large-scale wind turbine drive-train systems domestically. The new testing capability will ultimately improve U.S. competitiveness in wind energy technology.

Even with a more mature technology like wind, there is still the potential for breakthroughs that can dramatically improve performance, reduce cost, and give U.S. manufacturers a competitive lead. ARPA-E has invested in two potentially game-changing wind turbine technologies:

- *PAX Streamline Inc.'s Adaptive Turbine Blades (Recovery Act award of up to \$3 million):* PAX Streamline is developing a prototype "blown wing" wind turbine at the 100 kW scale. Unlike typical wind turbine blades, which have fixed airfoils, a "blown wing" turbine blade can be dynamically adjusted to maximize power under a wide range of wind conditions. Blown wing technology has been demonstrated on aircraft by the U.S. military, but it has not yet been demonstrated for wind turbines.
- *FloDesign Wind Turbine Corp.'s Shrouded Wind Turbines (Recovery Act award of up to \$8.3 million):* FloDesign is developing a novel shrouded (enclosed) wind turbine, analogous to jet turbine designs, which may deliver significantly more energy for its size than existing wind turbines.

IV. Building a Platform for Private Sector Innovation: Investments in Broadband, Smart Grid, and Health Information Technology

Just as Recovery Act funds and private dollars are accelerating the rate of technology innovation for vehicles, batteries, and renewable energy, Recovery Act investments are leveraging private funds to accelerate the build-out of a 21st century infrastructure –from fiber lines in underground trenches to wireless towers that beam signals across large distances. Not only are many of these investments innovative, but they can be transformative. They will create a platform for innovation and entrepreneurship across all sectors of the economy and address many of the country’s priorities including clean energy, health care, education, and public safety.

Broadband

High-speed internet, also known as broadband, is one of the great infrastructure challenges of the 21st century, akin to electricity during the last century. By investing in broadband, the U.S. is laying the groundwork for sustainable economic growth, well-paying jobs, and global competitiveness, as well as enabling technologies that will allow for innovations that today cannot be anticipated. Broadband is also a central component to addressing America’s health care, education, and energy challenges.

Fueled primarily by private sector investment and innovation, the American broadband ecosystem has advanced rapidly. The ten largest network service providers have annual capital investments in excess of \$50 billion.³⁵ The results of these investments are impressive: in 2000, only eight million Americans had broadband at home; by 2009, that number had grown to 200 million.³⁶

But more needs to be done. Approximately 100 million Americans still do not have broadband at home.³⁷ They are operating with a 20th century infrastructure in a 21st century economy.

The Recovery Act provides \$6.9 billion to expand broadband access and adoption. More than \$2.5 billion of this

Case Study: *The North GA Network Cooperative*

State: Georgia

Funds:

- Federal Government: \$33 million
- Recipient Match: \$9 million

Award Date: December 17, 2009

Description of Award:

The project—encompassing 42,000 households, 9,200 businesses and 367 community anchor institutions—intends to enable a new technology-based economy in North Georgia by deploying a 260-mile regional fiber-optic ring and improving broadband service in underserved areas, while stimulating economic growth and job creation in eight counties in the North Georgia foothills.

Examples of Benefits:

1. North Georgia College and State University (NGCSU) will be able to offer Internet-based language and other educational programs to numerous high schools in the region.
2. A Lumpkin County business that provides rapid-response laboratory analysis for dozens of rural Georgia hospitals, surgical centers, and doctor’s clinics will be able to expand its business and create 300 new jobs, eventually fueling a new \$40 million dollar economy from its Dahlonega offices.
3. The project will allow for distance learning and parent-student-teacher interaction by bringing broadband to the estimated 13-30 percent of families with children that do not have broadband Internet access at home.
4. The project will give eight counties in the North Georgia region the broadband tools they need for serious economic development.
5. Region will be more competitive in recruiting businesses and allows for current businesses to pursue expansion plans.

³⁵ Mike McConnell, Op-Ed., “Mike McConnell on How to Win the Cyber-War We’re Losing,” *Washington Post* (Feb. 28, 2010), cited in Federal Communications Commission, “Connecting America: The National Broadband Plan (NBP),” 18.

³⁶ Federal Communications Commission, “Connecting America: The National Broadband Plan (NBP),” xi.

³⁷ *Ibid.*

investment has gone to the Department of Agriculture to focus exclusively on infrastructure projects that help bring broadband access to rural and remote communities in America. The remaining \$4.4 billion has gone to the Department of Commerce to support infrastructure projects that benefit anchor community institutions (e.g. hospitals, schools), public safety broadband networks, state broadband mapping and planning efforts, public computing centers, and sustainable broadband adoption. Awardees will build out broadband infrastructure, teach Americans the skills necessary to use high-speed Internet, and outfit public computing centers to provide easier access to high-speed Internet.

Broadband in Rural America

In 1936, as part of his New Deal, President Franklin D. Roosevelt signed the Rural Electrification Act, which brought electricity to rural America and transformed the way business and life was conducted. Today, many Americans still remember the results of those policies – the day their small town lit up for the first time and the 20th century officially arrived.

Decades later, as the U.S. continues to move forward into a new century, the Recovery Act has committed to bring broadband to those same rural areas. As Agriculture Secretary Tom Vilsack stated, this broadband investment "will give rural Americans access to the tools they need to attract new businesses, educational opportunities, and jobs."

Rural residents in particular gain from broadband access. A 2009 report from the Department of Agriculture found that total employment grew faster in counties with robust broadband Internet

access than in similar rural counties with limited broadband Internet access.³⁸ Some experts fear that communities without access to broadband internet are missing important activities in their region that

Broadband in Rural America: One Economy's Greene County Case Study

Greene County, North Carolina is a rural economically distressed county, with 20.2 percent of the population below the poverty line as of 2000. In November of 2003, Greene County leadership teamed up with the One Economy Corporation to implement Internet tools, including a contract to provide high-speed broadband access to everyone in the county.

The results have been dramatic. Within five years, average SAT scores among high school students increased from 930 to 971. Further, 84 percent of the 2007 senior class applied to college, compared to 26 percent in 2003. Within one year, the number of businesses with Internet presence jumped from 2.5 percent to 25 percent. And 20 new businesses were opened within two years, after several years of negative growth.

Inspired by these demonstrated successes, the Department of Commerce's Broadband Technology Opportunities Program (BTOP) announced a \$28.5 million grant to One Economy Corporation, in partnership with the Broadband Opportunity Coalition. They were able to secure \$23 million in private sector matching funds, meaning they will implement \$51.5 million in broadband initiatives throughout the U.S., drawing on lessons learned from Greene County and several other similar broadband projects.

Source: One Economy Corporation, www.one-economy.com.

³⁸ Peter Stenberg, Mitch Morehart, Stephen Vogel, John Cromartie, Vince Breneman, and Dennis Brown for the United States Department of Agriculture, "Broadband Internet's Value for Rural America," USDA Economic Research Service, Report Number 78 (August, 2009).

are largely organized and facilitated online.³⁹ In addition, the use of broadband can reduce the burden and cost of traveling by using telemedicine to bring the best health care to rural America and distance learning to bring the best education to rural America.

In all, USDA's \$2.5 billion from the Recovery Act, together with non-federal leverage, will bring broadband to millions of Americans, hundreds of thousands of businesses and tens of thousands of community anchor institutions like hospitals and schools across rural America.⁴⁰ Because USDA has the benefit of making loans in conjunction with grants, the total amount of money the agency is able to put out the door actually exceeds their \$2.5 billion in authority. This is evident in the numbers already. As of August 18, 2010, USDA had awarded roughly \$3 billion – an investment that is supporting more than \$3.3 billion in total activity. More than 4 million people stand to benefit from these already-awarded projects alone, as do over 25,000 community anchors and more than 310,000 businesses.

"The completed systems will provide a platform for rural economic growth for years to come."
-Agriculture Secretary Tom Vilsack

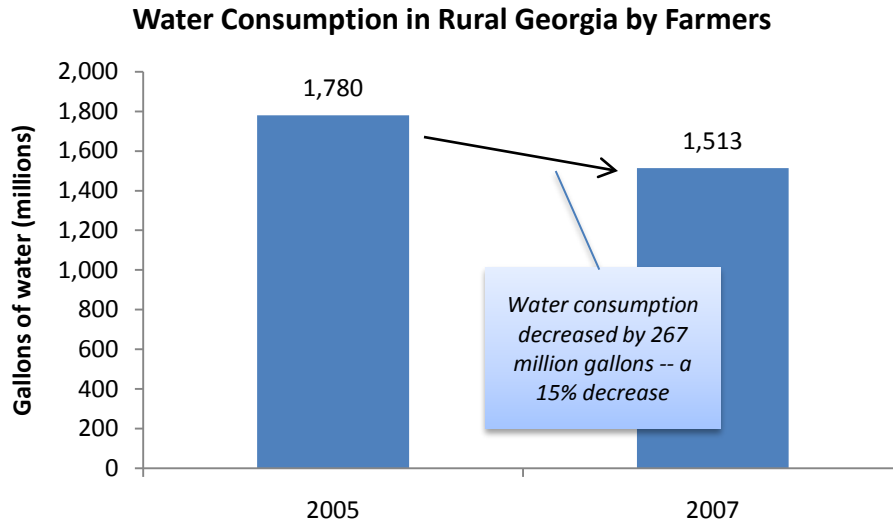
Broadband will help small businesses in rural America thrive and expand by giving them access to global markets. Internet access provides resources to help today's farmers and ranchers compete in an increasingly online world. With broadband access, a producer can now log on to the Internet every day and get immediate access to real-time commodity pricing, as well as consumer information and weather forecasts. This means that a rancher in Iowa can sell cattle to a buyer in Texas without the prohibitive costs of travel or delay of information preventing it. These opportunities allow ranches across the country to compete on a more level playing field with large corporations that have long had these advantages. Broadband has also proven to be an effective venue for advertising, generating business, and identifying new opportunities, especially for small businesses and the self-employed. With the development of these online tools, the face of the agricultural industry is changing; these broadband investments are helping propel America's farmers into that future.

In one instance in rural Georgia, access to broadband has allowed a community to preserve fresh water and manage the water supply efficiently. Farmers have been able to access current data relating to soil moisture readings and rainfall quantities using the broadband network. This information has allowed them to make changes to the amounts of water used to irrigate their crops. The increased data, accessed through the broadband network, has these enabled farmers to save 267 million gallons of water over a two-year period, lowering their costs and decreasing their impact on the environment.⁴¹

³⁹ "Rural Broadband at a Glance, 2009 Edition." USDA Economic Research Service, Economic Bulletin Number 47 (February, 2009).

⁴⁰ USDA's \$2.5 billion is in both grants and loans. Due to the loan portion of the portfolio, USDA's support for broadband expansion could total nearly \$3.6 billion.

⁴¹ Christine Griffiths, "Conservation Goes Wireless to Preserve Fresh Water," *The Nature Conservancy: Where We Work*.



Source: Christine Griffiths, "Conservation Goes Wireless to Preserve Fresh Water," *The Nature Conservancy: Where We Work*.

Better Broadband Everywhere

Rural America is not the only community that would benefit from improved access to broadband. While it is critical to achieve access for Americans who are currently unserved, it is equally important to ensure there are more robust networks throughout the country. And beyond networks, it is important that Americans have the hardware and skills needed to use broadband productively.

Awards from the Department of Commerce target a number of goals: providing a backbone for high-speed connectivity to unserved and underserved areas, offering community institutions affordable bandwidth, promoting sustainable broadband adoption in areas where broadband is available, and supporting public computing centers.

Each of these goals supports and encourages innovation, giving a digital platform and tools to entrepreneurs, creating new markets that increase demand for existing and new products, and offering ultra-high-speed access to researchers who need it.

As of August 18, 2010, the Department of Commerce has invested \$2.78 billion in broadband networks across the country. This includes investments of \$125 million in public computing, and \$157 million in sustainable adoption programs that include digital literacy training and outreach campaigns.

By increasing the amount of broadband capacity to communities throughout the U.S. and increasing the number of people who recognize the value of and can use high-speed Internet, the Recovery Act is laying the foundation for greater economic opportunities.

That foundation enables entrepreneurs and innovative businesses to take risks and make investments. As a consequence, technology is developed, new products are sold, and more private sector capital is brought off the sidelines. In the health sector, broadband usage can improve the quality of health care while reducing health care costs. And in the energy sector, broadband and other communications systems can improve energy usage at home and at the workplace, increasing efficiency and reliability.

Investments in technology like broadband have helped keep the United States at the center of innovation and kept U.S. companies and its workers competitive around the world. The investments

that were started in 2009 and will continue through 2010 will expand and enhance the critical infrastructure that forms the country's information backbone. These enhancements will play a key role in a broader revitalization of communities and businesses across rural America.

Health Information Technology

Broadband enables advancements in health care including electronic health records (EHRs), e-prescribing, and e-care. The Recovery Act itself is investing over \$20 billion in Health Information Technology (IT) that will give a significant boost to these advancements. Approximately \$2 billion is being spent largely to support ready hospitals, providers, states, and other parties to adopt Health IT.⁴² The remaining funds will be used to incentivize physicians and providers to adopt Health IT in 2011 and beyond.⁴³

Beacon Communities

Of the \$2 billion in upfront Health IT spending, approximately \$250 million is dedicated to the Beacon Community program to showcase how Health IT, when used in combination with other delivery system improvements, can transform the ways in which communities manage health and unlock previously unrealized health outcome benefits.

In May 2009, 15 communities from across the country received Beacon Community awards for this purpose. These communities will use data to inform the implementation of their plans, targeting specific, measurable, and innovative health care improvements. These pilot communities will serve as examples for other communities in how to use health IT to make marked and sustainable improvements in health care quality, safety, and efficiency.

Three examples below illustrate the kinds of transformations expected in the health care systems of the selected Beacon Communities.⁴⁴

⁴² These funds will be appropriated to the Office of the National Coordinator of Health Information Technology at the Department of Health and Human Services.

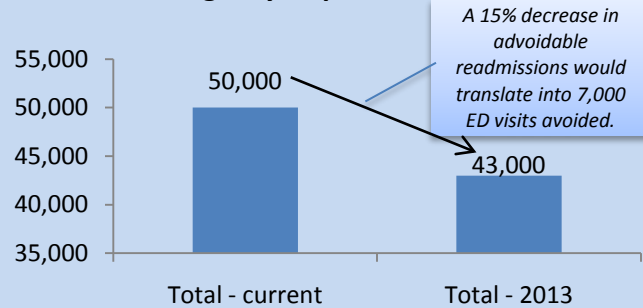
⁴³ The Recovery Act's total Health IT expenditures starting in 2011 will be determined largely on the number and timing of hospitals and providers who meaningfully adopt health IT and thus who qualify to receive incentive payments for doing so, or incur penalty payments for failing to do so.

⁴⁴ Data is drawn from original applications for HHS Recovery Act Health IT Funds.

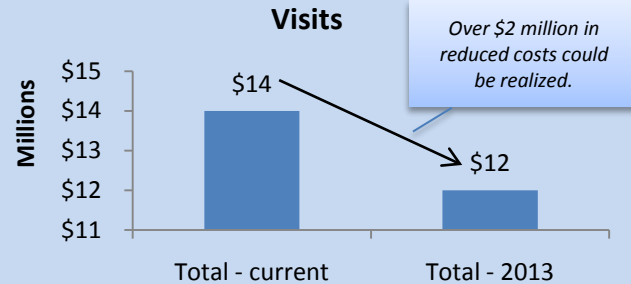
Eastern Maine Healthcare Systems, Bangor, Maine

- Eastern Maine Healthcare Systems in Bangor, Maine is using its \$12.8 million award to improve home-based care and reduce unnecessary Emergency Department (ED) visits.
- The award will be used to link health care providers to the existing Health Information Exchange to promote the use of telemedicine.
- Over the course of three years, they will seek to achieve reductions in avoidable ED visits, among other goals. A 15 percent reduction in avoidable ED visits would translate to a 7,000 visit reduction locally, totaling \$2 million in savings per year.
- *If this reduction were made nationally, it could potentially translate to approximately 18 million fewer ED visits, which could save billions of dollars in health care spending per year⁴⁵.*

Emergency Department Visits



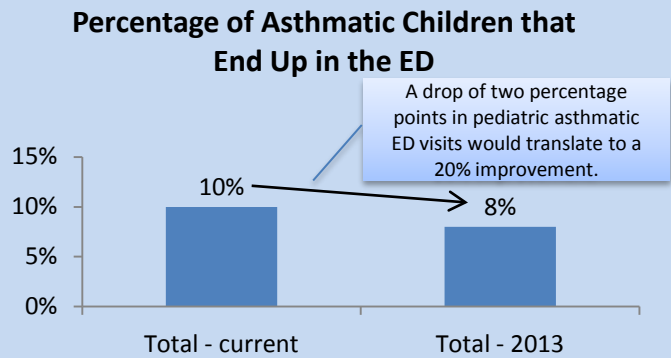
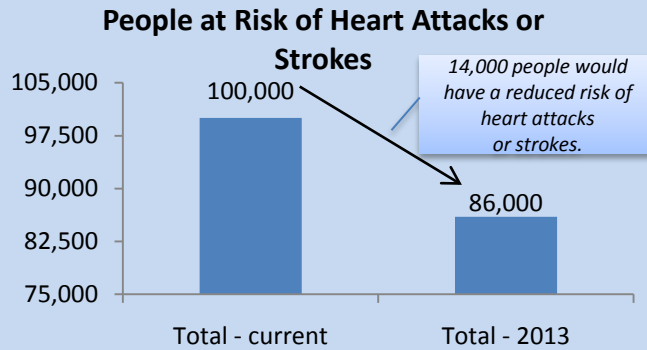
Costs Due to Emergency Department Visits



⁴⁵ National estimate is a preliminary staff estimate extrapolated from Kaiser State Health Facts.

Southern Piedmont Community Care Plan, Concord, North Carolina

- In Concord, North Carolina, the Southern Piedmont Community Care Plan will use its \$15.7 million award to increase the number of patients with well-controlled blood pressure and lipids and reduce the number of children with asthma that end up in the ED.
- The award will fund electronic health record management and telemedicine equipment. Further, they will develop an indexed image repository to avoid unnecessary imaging such as duplicate x-rays.
- This could translate to 14,000 people with reduced risk of heart attacks and strokes and two percent fewer childhood asthma patients in the ED each year.
- *If these gains were achieved nationally, it could mean millions of people would have reduced risks of heart attack and stroke, and could reduce the number of ED visits associated with complications from childhood asthma and other chronic diseases.*⁴⁶

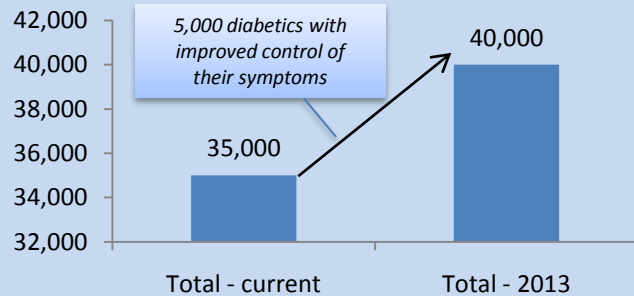


⁴⁶ National estimate is a preliminary staff estimate extrapolated from published industry sources.

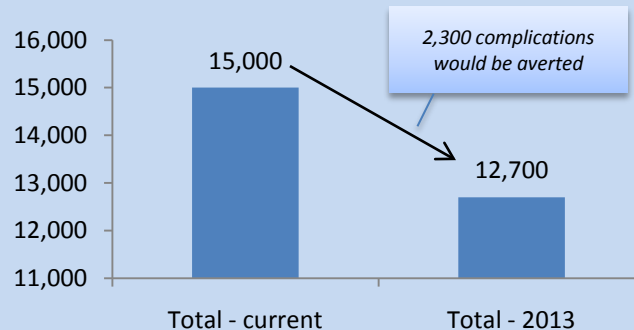
Western New York Clinical Information Exchange, Buffalo, New York

- The Western New York Clinical Information Exchange in Buffalo, New York is using its \$16.1 million award to improve the quality of care provided to chronic disease patients and to reduce costs associated with avoidable hospitalizations and ED visits.
- The award will purchase clinical decision support tools such as registries, point-of-care alerts, and new telemedicine solutions.
- In Western New York, the goal is for 5,000 diabetics to achieve improved control of their blood sugar and other levels, averting as many as 2,300 complications.
- The program will also seek to reduce by 15 percent the number of ED visits, hospitalizations, and re-admissions for individuals with diabetes and congestive heart failure, saving approximately \$1.1 million per year starting in 2012.
- *If these improvements were generalized nationally, approximately 360,000 diabetic Americans could be affected.*⁴⁷

Diabetics with Well-Controlled Blood Sugar Levels



Complications Due to Diabetes

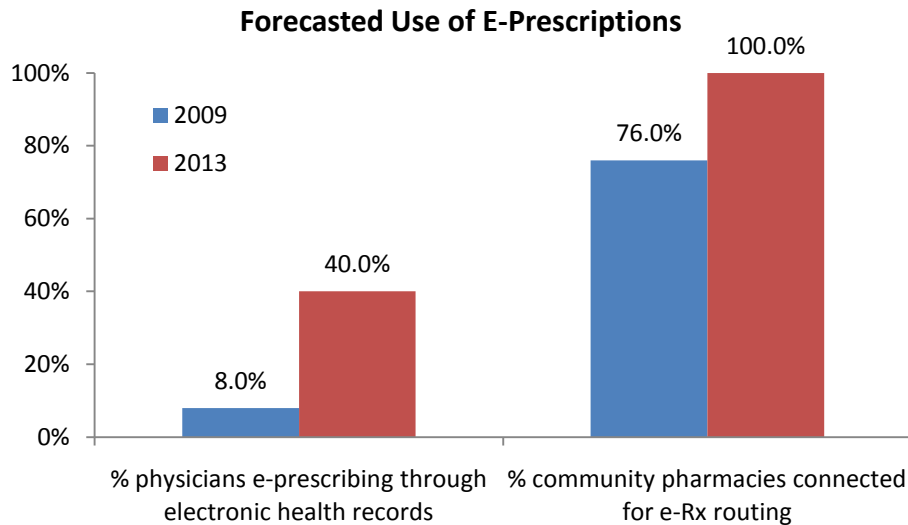


Electronic Health Records and E-prescribing

The Administration is committed to promoting the adoption of electronic health records (EHRs) due to their ability to improve health outcomes and decrease costs. Increasing electronic health record adoption will facilitate medical professionals' use of EHRs to place "e-prescriptions." Much like the advent of bar code scanners in supermarkets, a technology that now most of the country cannot imagine living without, e-prescribing is convenient for consumers; lowers administrative expenses for physicians and pharmacists; and reduces a component of manual error, thereby increasing patient safety. Patients can readily appreciate the convenience of a prescription being sent to their pharmacy of

⁴⁷ National estimate is a preliminary staff estimate extrapolated from CDC diabetes data. <http://apps.nccd.cdc.gov/DDTSTRS/default.aspx> (accessed August 20, 2010).

choice before they even leave the doctor and the security of knowing that the doctors' handwriting will not be misread by the pharmacy staff. Physicians can avoid many of the hassles of pharmacy call-backs for formulary substitutions and refill requests. Both groups can benefit from advanced e-prescribing functions that can, for example, check for potential adverse interactions with other drugs currently prescribed for the patient. Finally, e-prescribing has the potential to reduce certain unnecessary medical costs and improve health outcomes: one study estimates tens of billions of dollars in savings to federal programs over the period 2009-2018 from e-prescribing alone, due to reductions in drug costs, adverse drug events, and better adherence.⁴⁸



2009 Data Source: SureScripts, "Advancing Healthcare in America: 2009 National Progress Report on E-Prescribing, Plus What's Ahead in 2010 and Beyond," http://www.surescripts.com/media/515306/2009_national-progress-report.pdf (accessed August 20, 2010).

2013 Data Source: Health and Human Services, Office of the National Coordinator for Health Information Technology.

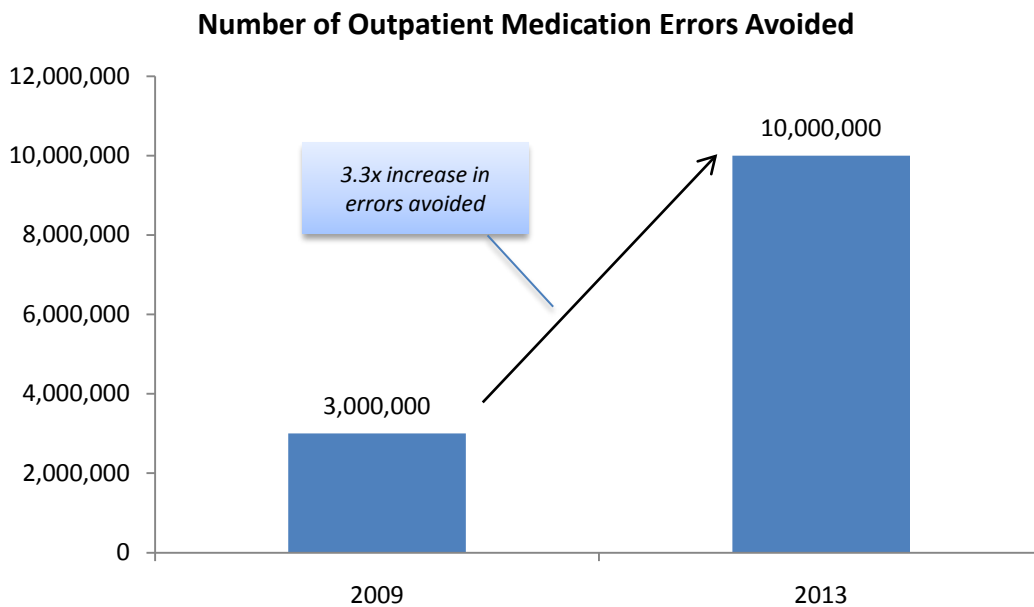
These innovations are important for their demonstrated ability to improve health outcomes and reduce certain costs. Medication errors and the adverse drug events that result from them are common, harmful, and preventable: studies have estimated that 2.4 – 3.6 percent of hospitalizations are caused by adverse drug events of which more than two-thirds could have been prevented.⁴⁹ These events are also costly; the estimated average cost of a preventable adverse drug event in older adults was \$1,983, and the national annual costs were estimated to be \$887 million in 2000.⁵⁰

⁴⁸ Visante, "American Recovery and Reinvestment Act Will Save Billions and Reduce Medication Errors by Accelerating E-Prescribing" (2009), <http://pcmanet.org/wp-content/uploads/2009/03/final-arra-impact-on-eprescribing.pdf> (accessed August 20, 2010).

⁴⁹ Angela Schedlbauer, Vibhore Prasad, Caroline Mulvaney, Shobha Phansalkar, Wendy Stanton, David W. Bates, Anthony J. Avery, "What evidence supports the use of computerized alerts and prompts to improve clinicians' prescribing behavior?," *Journal of the American Medical Informatics Association* 16 (4), (July-August, 2009): 531-8.

⁵⁰ Terry S. Field, Boyd H. Gilman, Sujha Subramanian et al. "The Costs Associated with Adverse Drug Events Among Older Adults in the Ambulatory Setting," *Medical Care* 43, no. 12 (2005): 1171-6.

At the end of 2008, an estimated three million outpatient medication errors were avoided through the use of e-prescribing technology. Supported by funding in the Recovery Act, that number is projected to be over 10 million errors avoided by 2013.⁵¹



Note: These figures are preliminary staff estimates.

As more institutions increase their interest and investments in healthcare information technology, the private sector is responding with investments in innovation. According to Dow Jones VentureSource, in the second quarter of 2010, there was a 91 percent increase in venture capital funding for U.S.-based medical software and information services companies: investments jumped to \$157 million from \$82 million during the same quarter in 2009.⁵²

E-Care Technologies and Telemedicine

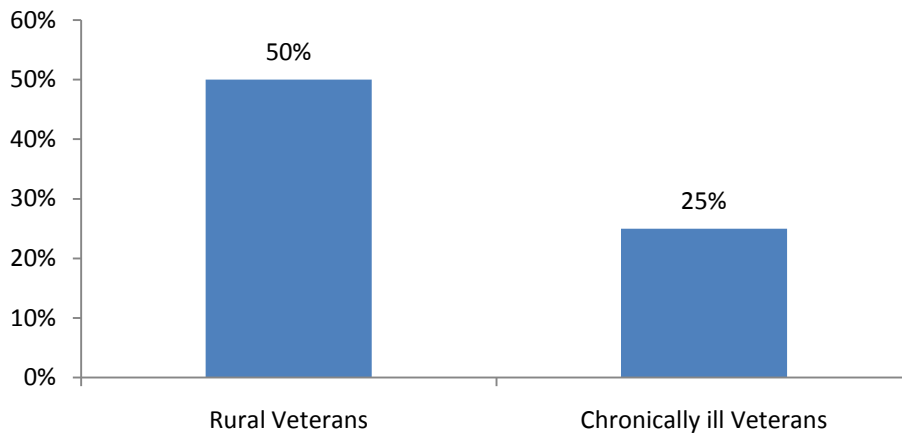
Broadband enables the effective application of e-care technologies and telemedicine. E-care allows medical personnel to treat patients remotely. Specialists located in urban settings can use a high-speed broadband video connection to treat a patient located in a remote town. With high-speed broadband access, health care professionals can read tests and monitor chronic conditions remotely, as well as exchange diagnostic information between patients, their local providers, and specialists from other parts of the country. Studies demonstrate that e-care reduces health care costs and provides the benefits of advanced medical care to previously unserved or underserved populations.

⁵¹ A recent controlled trial of e-prescribing found a baseline rate of prescribing errors of 3.4 percent in an ambulatory setting was reduced to 1.8 percent in the e-prescribing intervention sites. (The rate in the control sites was unchanged during the study period.) Personal communication, David Bates MD, April 19, 2010. These findings were applied to SureScripts data on total medication transactions to extrapolate these estimates.

⁵² Nicole Lewis, "VC Investment in Medical Software, Information Services Soars," *InformationWeek* (July 21, 2010), <http://www.informationweek.com/news/healthcare/EMR/showArticle.jhtml?articleID=226100026&queryText=investment%20and%20in%20and%20healthcare> (accessed August 20, 2010).

Broadband also enables remote monitoring. Currently doctors monitor patients periodically in hospitals or physicians' offices. Remote monitoring (via smart wireless band aids) allows for around the clock observation. The Department of Veterans Affairs has dramatically decreased unnecessary hospitalizations through a wide-ranging effort to help veterans manage chronic conditions at home.^{53,54} Hospital use was decreased 25 percent overall, and 50 percent for patients in highly rural areas, by linking 32,000 chronically ill veterans with health care providers and care managers through video phones, digital cameras, and messaging, and tele-monitoring.

**Percentage Decrease in Hospital Use Among Veterans
After Telemedicine Technology Implementation**



Source: See footnotes 53 and 54.

Smart Grid

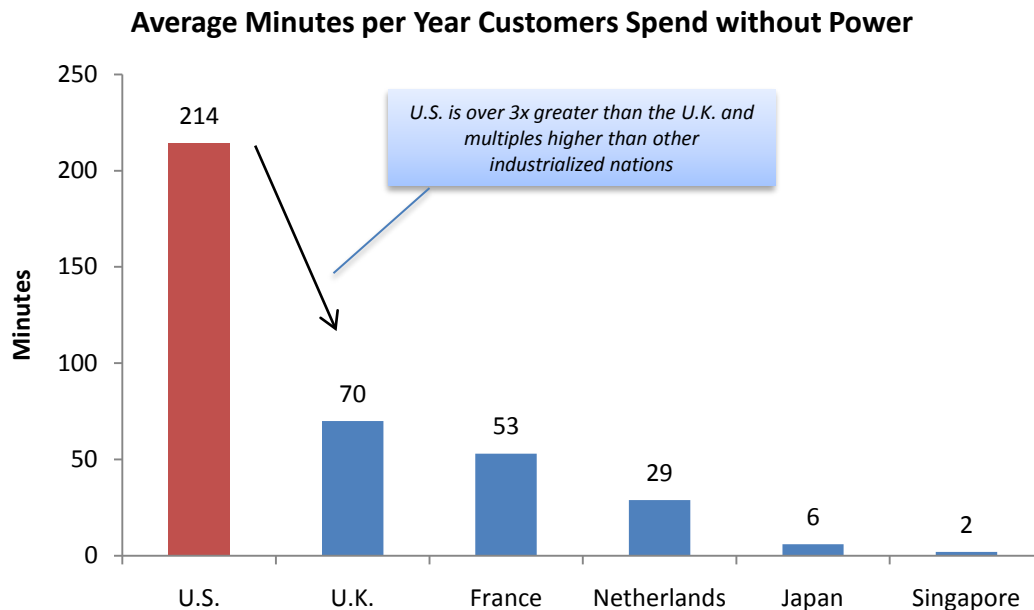
Smart Grid technology, combined with supportive policy, allows for smarter use of energy, largely by increasing the transparency, measurement, and control of energy used by the players who supply, transmit, distribute, and demand it. Through automated sensors and controls as well as dynamic pricing, this intelligent infrastructure will make the electric system more reliable, empower consumers and utilities to use energy more wisely, help manage peak demand, enable larger scale use of renewable energy and electric vehicles, and reduce U.S. dependence on oil.

With the Smart Grid, utilities can significantly reduce service interruptions and the associated economic losses, which is important to both consumers and the economy. The average U.S. customer loses power for 214 minutes per year. That compares to 70 minutes in the United Kingdom, 53 in France, 29 in the Netherlands, six in Japan, and two minutes per year in Singapore. These outage durations tell only part

⁵³ Huanguang Jia, et al. "Long-Term Effect of Home Telehealth Services in Preventable Hospitalization Use," *Journal of Rehabilitation Research and Development* 46, no. 5 (2008): 557-566.

⁵⁴ A. Darkins, et al. "Care Coordination/Home Telehealth: The Systematic Implementation of Health Informatics, Home Telehealth, and Disease Management to Support the Care of Veteran Patients with Chronic Conditions," *Telemedicine and e-Health* 14, no. 10 (2008): 1118-1126.

of the story. In Japan, the average customer loses power once every 20 years. In the United States, it is once every nine months, excluding hurricanes and other strong storms.⁵⁵



Source: Jay Apt, Lester B. Lave, and M. Granger Morgan, "Power Play: A More Reliable U.S. Electric System," *Issues in Science & Technology* (July 1, 2006).

In a 2004 study, the Lawrence Berkeley National Laboratory (LBNL) estimated the annual costs of U.S. power outages to be \$22 to \$135 billion.⁵⁶ However, major black outs like the ones that the U.S. and Canada experienced in 2003 are not the main contributor to this annual cost. The study found that the costs of short interruptions of five minutes duration or less caused two-thirds of the economic losses. And of these losses, 72 percent are borne by commercial customers, whereas industrial customers shoulder 26 percent of the loss and residential users only two percent.

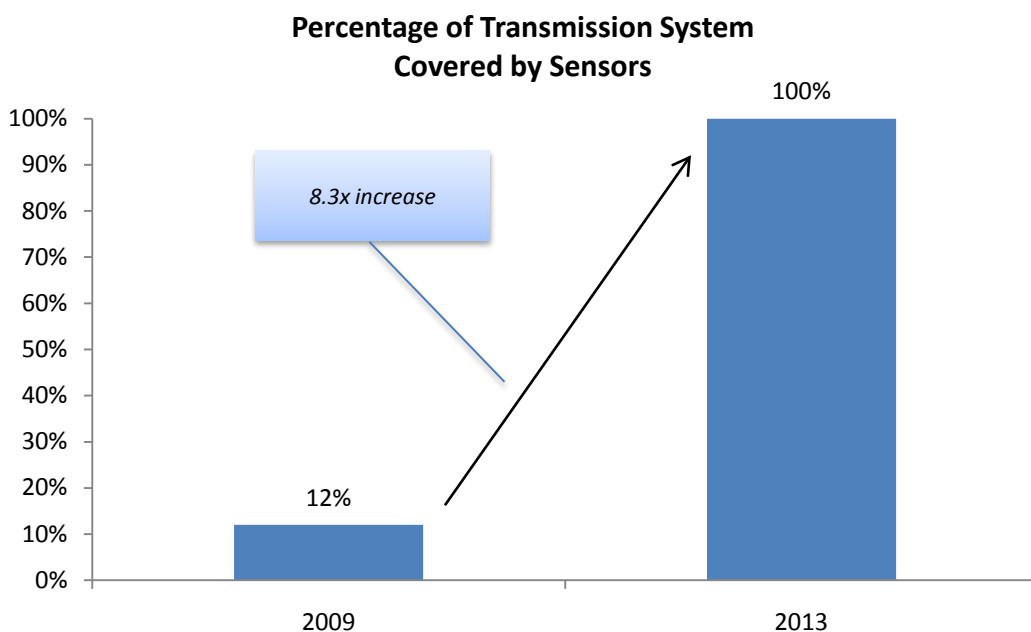
In a push that will bolster the integrity of the U.S. electric grid, the Recovery Act is accelerating the deployment of 21st century Smart Grid technologies in America's electric infrastructure. The U.S. electric grid, named the greatest engineering accomplishment of the 20th century by the National Academy of Engineers, was not designed for today's energy-intensive economy or increased electricity trade. As it operates today, the grid is increasingly stressed, which can result in reliability concerns, vulnerable to storms and human disruptions, and confronting a new series of challenges with the use of more intermittent sources of energy generation such as wind power.

⁵⁵ Jay Apt, Lester B. Lave, and M. Granger Morgan, "Power Play: A More Reliable U.S. Electric System," *Issues in Science & Technology* (July 1, 2006).

⁵⁶ Kristina Hamachi LaCommare and Joseph H. Eto, "Understanding the Cost of Power Interruptions to U.S. Electricity Consumers," Ernest Orlando Lawrence Berkeley National Laboratory, University of California Berkeley, Energy Analysis Department (September 2004).

A smarter grid can help utilities reduce service interruptions and the associated economic losses. For example, smart technologies are capable of detecting events such as a line down due to a fallen tree and then alerting operators or triggering automatic responses. By improving the reliability of power, health and safety threats are lessened, economic losses are reduced, and quality of life improves.

To improve system reliability, the Recovery Act will install an additional 875 transmission system sensors, or “Phasor Measurement Units,” that can alert system operators and help prevent minor disturbances from cascading into large outages. Recovery Act funds will help install enough of these to cover the country’s entire transmission system.

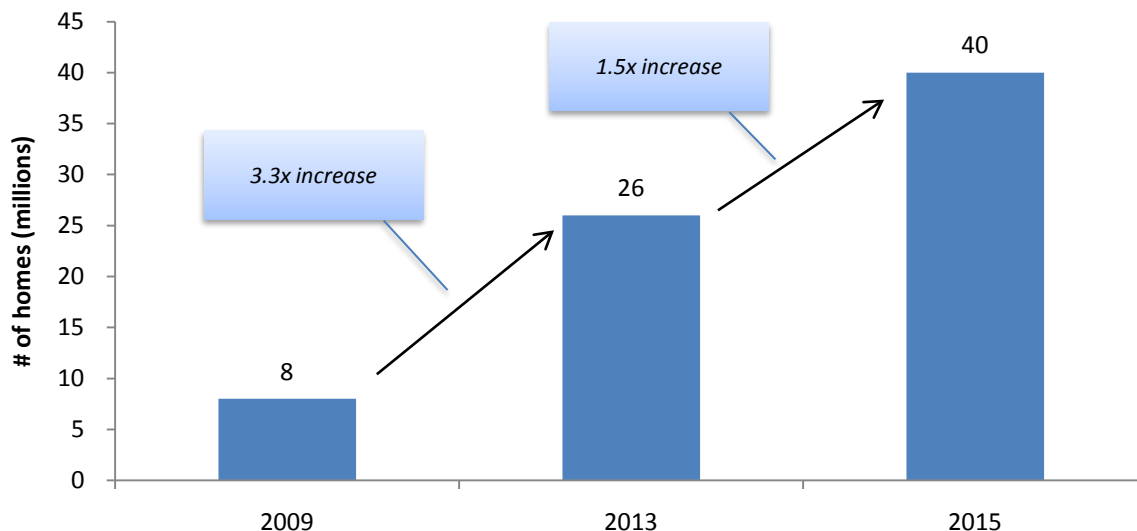


Source: U.S. DOE Office of Electricity Delivery and Energy Reliability.

For further system reliability, the Recovery Act funds will help equip 700 substations with automated devices to detect and respond to system irregularities to help avoid outages. If an outage does occur, smart technologies can potentially speed the restoration of power, minimizing cost and inconvenience. Recovery Act funds also are being invested in the installation of over 200,000 advanced transformers capable of sensing conditions associated with failures and alerting system operators. When an alert is received, crews can be dispatched to repair or replace the transformer, thereby averting an outage.

Moreover, the Recovery Act recognized the opportunity to accelerate the deployment of components that make up a Smart Grid to support a modern, low-carbon economy and create a platform for innovation for new energy management and information services in homes and buildings. The combination of Recovery Act funds and private investments promise to add 18 million new smart meters to the eight million currently in use. This means 26 million smart meters will be in use by 2013, on track to reach 40 million by 2015 through public and private investment.

Projected Growth in Homes with Smart Meters



Source: U.S. DOE Office of Electricity Delivery and Energy Reliability.

The two-way flow of information from the grid to customers creates new opportunities in the private sector for innovation in the development of tools for consumers. The development of these tools will enable both the utilities and consumers to use electricity more efficiently, thereby reducing their costs. Even at this early stage in the development of Smart Grid technology, these challenges have already spurred new technology development and business opportunities. Venture capital backed start-ups like OPower and large companies like GE are developing new products and services such as smart thermostats, smart appliances, in-home energy displays, energy management and information services. These tools utilize information from the Smart Grid to deliver value and convenience to customers.

In an effort to catalyze innovation in the Smart Grid ecosystem, the National Institute of Standards and Technology (NIST) at the Department of Commerce is spearheading the development of open interoperability standards, allowing new technologies and applications to support integration of distributed and renewable resources, give consumers new tools to reduce energy usage, and enhance the reliability and security of the grid. This work is supported by over \$15 million in Recovery Act funding from the Department of Energy and Commerce.⁵⁷

Smart technologies and policies bring the system integration and balancing capabilities also needed for many of the innovations being developed in the renewable energy and electric vehicle fields. Smart Grid technologies allow the reliable integration of energy generated and/or stored at distributed locations and on a smaller scale than considered feasible in the past. This lays the groundwork for “net metering” when consumers can both buy from and sell back to the grid from their own solar, wind, or other energy generation source.

⁵⁷ National Institute of Standards and Technology, “Smart Grid Interoperability Standards Project,” <http://www.nist.gov/smartgrid> (accessed August 20, 2010).

For similar reasons, the Smart Grid can help establish the foundation for a large-scale shift to vehicles fueled by electricity. A smarter grid infrastructure is needed to support the demand for charging stations as more and more electric cars enter the market and reduce our national dependence on oil. Owners of electric vehicles will want the option to charge batteries when prices are low and, eventually, to offer them as energy storage options when generating capacity is at a premium. To make the system sufficiently flexible and responsive to meet these expectations, smart technologies must be in place to collect data and communicate signals to activate controls whenever market signals or owners dictate. There are already a number of innovative companies working on technology solutions to enable the seamless “smart charging” of electric vehicles.

The Recovery Act investment in Smart Grid is proving to have a powerful financial multiplier effect across the economy. In addition to the benefits linked to the deployment of smart devices, there also has been a positive impact on the U.S. manufacturing sector. The Recovery Act has invested \$23.2 million in 48C tax credits to seven companies in Smart Grid-related manufacturing.⁵⁸ A related Smart-Grid supply chain is emerging as a result of the billions of public and private dollars being invested.⁵⁹ Device manufacturers have added workers to meet orders placed by recipients. Technology and software developers are coming up with solutions to new challenges associated with Smart Grid projects.

Orders linked to Recovery Act funding through the Smart Grid Investment, Regional Demonstration, and Storage Demonstration Grants are helping companies like Silver Spring Networks, Itron, and Cooper Power Systems invest in new plant construction as well as plant expansions and new equipment to meet the demand driven by innovation. The accelerating emergence of the Smart Grid devices market has created jobs at these facilities and all along the supply chain.

⁵⁸ Cooper Power Systems, Nacogdoches, TX & Waukesha, WI; Ice Energy, Inc. Hammondsport, NY; Itron, Inc. West Union, S.C.; Metglas, Inc.; Premium Power, North Reading, MA; S&C Electric Company, Chicago, IL.; and Southwire, Carrollton, GA.

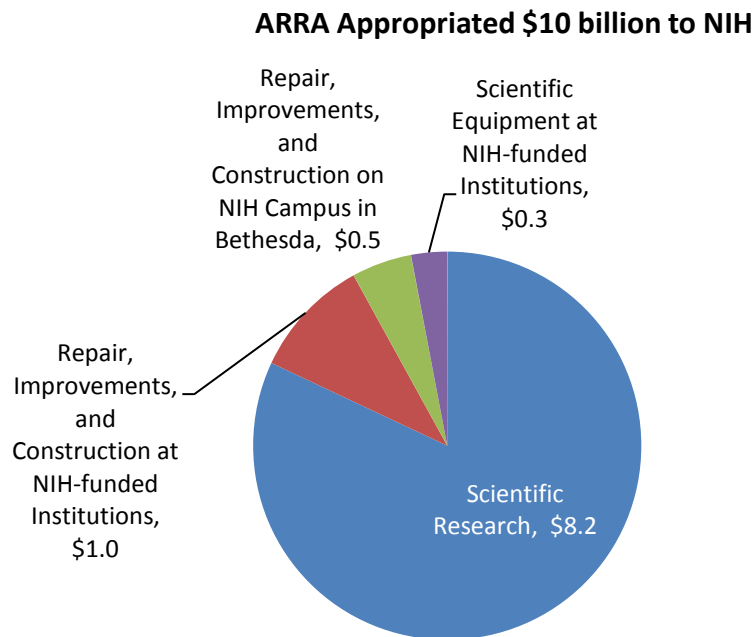
⁵⁹ According to the Council of Economic Advisers’ 2010 Fourth Quarterly Report, the Recovery Act invested \$4.5 billion in Smart Grid, spurring an additional \$6 billion in private sector investment (http://www.whitehouse.gov/files/documents/cea_4th_arra_report.pdf, accessed August 20, 2010).

V. Fostering Groundbreaking Medical Research: Investments in the National Institutes of Health

Last September, while visiting the National Institutes of Health (NIH) and announcing the major milestone of awarding 50 percent of NIH Recovery Act funds in less than eight months after the Act's passage, President Obama noted:

" . . . Here at the National Institutes of Health, and at universities and research institutions across this country, you are demonstrating our capacity not just as a nation but as human beings to harness our creativity and our ingenuity to save lives, to spare suffering – to build a better world for ourselves, our children, and our grandchildren. That is our great promise. And it is one that we've once again begun to fulfill."

The Recovery Act has provided funds to NIH to support groundbreaking research that will help unravel the clues to treating or preventing some of life's most daunting and debilitating diseases, develop powerful new medicines, and even define strategies that will prevent disease from occurring in the first place. NIH Recovery Act funds are divided as follows:



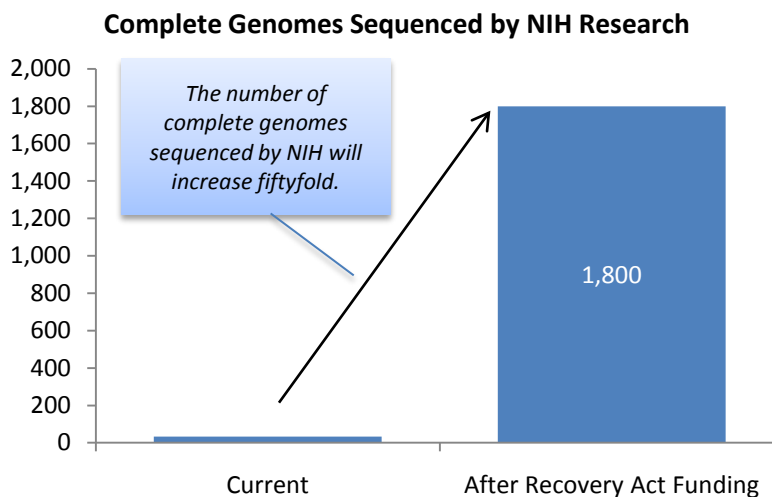
With the over \$8 billion in funds for scientific research, NIH has been able to accelerate ongoing research and fund promising research projects that would not have been able to receive funding otherwise. These funds support key activities, including Challenge Grants aimed at 15 high priority fields of research and Grand Opportunity grants to fund large-scale projects that will have a high impact in two years.

The transformative research happening in the health sector as a result of Recovery Act investments crosses multiple disciplines, dramatically impacting both the quality and scale of today's projects while

laying critical groundwork for the breakthroughs of tomorrow. Examples of these changes can be found in the research in human genome sequencing, cardiovascular disease, cancer, and autism.

In Pursuit of the \$1,000 Genome: Creating DNA Sequencing Solutions

As an extraordinary example of the promise afforded by this opportunity, a decade after the publication of the first draft human genome (a culmination of years of effort by thousands of researchers), Recovery Act dollars will support the sequencing of over 1,800 complete genomes, a more than 50-fold increase over the 34 genomes that have been sequenced to date by non-Recovery Act NIH funding.⁶⁰ This accomplishment will be spread across various studies, projects, and disease groups, and will lend a new level of insight into disease that was previously unattainable.



Source: NIH staff estimates.

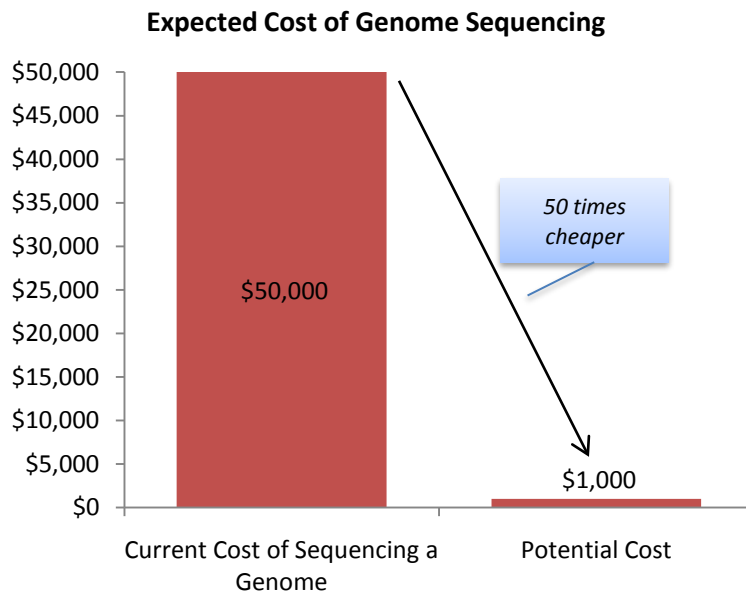
One potential area of impact is the study of schizophrenia. This complex disease is likely caused by a combination of genetic and environmental factors, with no single gene causing schizophrenia. Variants of many genes involved in shaping brain function may contribute to schizophrenia risk, and the effect of any one gene may be small. This makes it very difficult to identify disease-promoting genes using the standard methodology of looking at one –or only a few – genes at a time. Therefore, \$10 million in Recovery Act funding will enable scientists to sequence entire genomes of individuals with schizophrenia and search for rare but important genetic variants with the goal of identifying the most likely genetic targets for treatment.

The promise of being able to compare entire human genomes is boundless. Today, however, the financial cost of doing so is very high and often prohibitive. Therefore, further investments are directed toward the goal of slashing the cost of DNA sequencing to \$1,000 per genome: that's 50 times cheaper than currently possible.⁶¹ Such a goal appears realistic; for example, Dr. Stephen Turner, the Chief

⁶⁰ NIH staff estimates.

⁶¹ The NIH Fiscal Year 2011 Congressional Justification Overview cites the current cost of sequencing a genome at \$50,000.

Technology Officer of Pacific Biosciences, Inc. in Menlo, California, and his team have invented a technique called Single-Molecule Real-Time (SMRT) DNA sequencing.⁶² This DNA-reading method is unique in that it actually mimics what happens in the body as cells divide and copy their DNA with a cellular protein machine called DNA polymerase. SMRT sequencing uses a lab-made version of this DNA-making engine and adds a few adjustments to make the process observable by camera.



Source: The NIH Fiscal Year 2011 Congressional Justification Overview cites the current cost of sequencing a genome at \$50,000.

Research conducted by Dr. Turner and other awardees using Recovery Act funding could lead to a \$1,000 genome. In addition, Dr. Turner predicts that if SMRT DNA sequencing technology works as expected and becomes commercially available to the broader scientific community, it could create hundreds of new jobs as well as a revolutionary tool for researchers to understand the role of chemical switches in gene expression to health and disease.

The Pacific Biosciences project is one of seven projects funded by the Recovery Act to achieve a \$1,000 genome, each with a different technological strategy. With a more affordable price tag for sequencing an entire genome of 20,000 genes in a matter of minutes, DNA information could become a routine part of medical care. Just like a simple blood test, an inexpensive whole-genome DNA scan could help health care providers in the future choose effective, personalized treatments in an office or clinic setting. Moreover, it could unlock cures and insights into some of the most debilitating diseases existing today, while also creating many new skilled jobs in the process.

Cardiovascular Disease

⁶² Alison Davis, "Dr. Stephen Turner: Creating DNA Sequencing Solutions," National Institutes of Health, (December 21, 2009), <http://recovery.nih.gov/stories/genome.php> (accessed August 20, 2010).

Cardiovascular disease is the leading cause of death in the United States and is rapidly becoming the most common cause of death and disability throughout the world. It can cause chest discomfort and activity limitation and, in its more severe forms, heart attacks, strokes, heart failure, and sudden death. Over the past 50 years, death rates from this disease have steadily declined, but the aging U.S. population and increased prevalence of obesity and diabetes threatens to reverse that trend. In Fiscal Year 2009, NIH awarded \$396 million in Recovery Act funds to study this debilitating disorder.

A prime example of the real benefit afforded by these additional funds is the project to sequence the DNA of participants in the Framingham Heart Study. For over sixty years and three generations, the Framingham Heart Study has been identifying the common factors or characteristics that contribute to cardiovascular disease. Through detailed medical histories, physical exams, and laboratory tests, scientists have monitored this disease in over 15,000 participants who had not yet developed overt symptoms or suffered a heart attack or stroke. This research has yielded information about high-blood pressure, high-blood cholesterol, smoking, obesity, diabetes, and physical inactivity – as well as a great deal of valuable information on the effects of related factors such as blood triglyceride and HDL cholesterol levels, age, gender, and psychosocial issues. It has been one of the most comprehensive sources of information about the causes of cardiovascular disease.

With Recovery Act funds, researchers will be able to sequence the DNA of hundreds of participants of this large-scale study and the DNA of participants of several other NIH studies, enabling the wide-scale identification of genetic contributors to cardiovascular disease and the biological pathways that underlie it. Nothing like this has been done before, and the results could uncover the secrets to cardiovascular disease, its causes, and possible approaches to its treatment and prevention.



For over sixty years and three generations, the Framingham Heart Study has been identifying the common factors or characteristics that contribute to cardiovascular disease. With Recovery Act funds, researchers will be able to sequence the DNA of the participants of the famous Framingham Heart Study, enabling the wide-scale identification of genetic contributors to cardiovascular disease and the biological pathways that underlie it.

Photo Credit: Framingham Heart Study
<http://www.framinghamheartstudy.org/>

The Cancer Genome Atlas Project

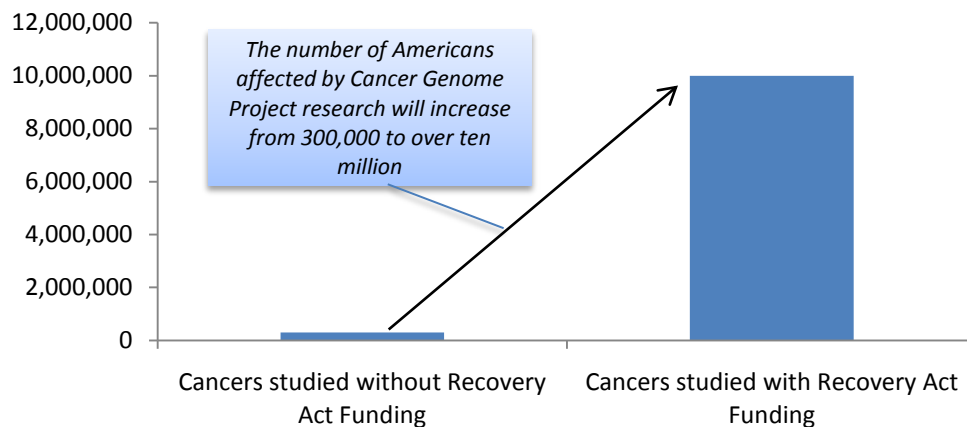
NIH -funded research has inspired a revolution in how one thinks about cancer. Cancer is the second leading cause of death in the United States after heart disease. In 2010, it is estimated that nearly 1.5

million new cases of invasive cancer will be diagnosed in this country and more than 560,000 people will die of the disease.⁶³

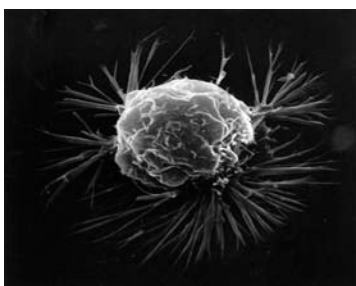
The Cancer Genome Atlas project (TCGA) is a large-scale collaborative effort to comprehensively characterize the genomic alterations and molecular pathways involved in the development of human adult cancers. TCGA was initiated in 2006 as a three-year pilot project that focused on the characterization of three tumor types. Recovery Act funding is allowing the expansion of TCGA to include more than 20 cancer types.

Thanks to Recovery Act funding, NIH is now able to fund research into breast cancer, colon cancer, gastric cancer, brain cancer, and approximately 20 other types of cancer.⁶⁴ In total, it is estimated that more than 10 million Americans will be affected by the 20 plus types of cancer to be studied by TCGA, a 33-fold increase over the 300,000 affected by the three cancers studied in the TCGA Pilot program.⁶⁵

Americans Affected With Cancers Studied in the Cancer Genome Project



Source: NIH staff estimates.



Thanks to Recovery Act-funding, the Cancer Genome Atlas project will be able to conduct research on cells like these breast cancer cells (seen left), leading to advances in the diagnosis and treatment of breast cancer, leukemia, pancreatic cancer, and brain, and other nervous system cancers.

Photo Credit: National Cancer Institute, <http://visualsonline.cancer.gov/details.cfm?imageid=1989> (accessed August 20, 2010).

⁶³ National Institutes of Health, Research Portfolio Online Reporting Tools, “ARRA Investments in the Cancer Genome Atlas Project (TCGA),” <http://report.nih.gov/recovery/investmentreports/ViewARRAInvRpt.aspx?csid=128> (accessed August 20, 2010).

⁶⁴ National Cancer Institute, The Cancer Genome Atlas, “Cancers Selected for Study,” http://tcga.cancer.gov/www/cancers_studied_by_tcga.asp (accessed August 20, 2010).

⁶⁵ NIH Staff estimate

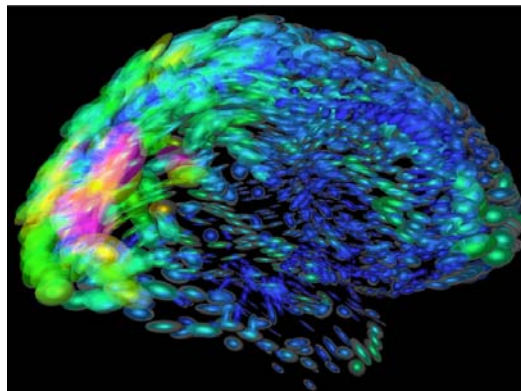
The increase in number of cancers being studied, combined with the emergence of powerful new technologies to sequence and analyze cancer genomes, could fundamentally change cancer research and, ultimately, cancer treatment. For example, TCGA data and insights gained from other Recovery Act-funded research could substantially shorten the time and reduce the costs involved in drug development. The information on genomes generated as a result of this study could eventually allow doctors to identify the genetic subtype of cancer affecting a patient. This means that specific, targeted treatments could be chosen for their efficacy and tailored to the patient in ways never possible before. In addition, this study could help develop preventative measures, and ways to target and intervene with cancer long before any tumor develops or symptoms first appear.

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a complex developmental disability that causes severe and pervasive impairment in thinking, feeling, language, and the ability to relate to others. The Centers for Disease Control and Prevention estimates that between 1 in 80 and 1 in 240 children in the U.S. have been diagnosed with ASD.⁶⁶

In Fiscal Year 2009, NIH awarded \$64 million in Recovery Act funds to research on ASD.⁶⁷ This is an almost 50 percent increase over the amount of non-Recovery Act funds awarded in this area (\$132 million), and represents the largest-ever infusion of funding for ASD research. The investment has enabled NIH to fund groundbreaking research that otherwise would not have been possible, in areas such as improved screening, early detection, potential interventions and therapeutics, and determination of the precise causes and mechanisms underlying this disorder, which are still largely unknown.

For example, a multi-site collaborative network of large-scale DNA sequencing centers, which includes researchers from Massachusetts to Texas, is assessing



This image of the human brain uses shape and color to demonstrate neurological differences between two individuals. According to the National Institute of General Medical Sciences, the front portion of the brain that is associated with complex thought varies the most between the people. Near the back, the blue ovals mark areas of basic function that vary little. Recovery Act-funding is supporting researchers in California who are also using brain imaging techniques such as this to identify changes in infant brain structure and connectivity that may serve as early indicators of ASD.

Source: National Institute of General Medical Sciences, Biomedical Beat, "Cool Image: Mapping Brain Differences," (October 18, 2005), <http://publications.nigms.nih.gov/biobeat/05-10-18/> (accessed August 20, 2010).

Photo Credit: Arthur Toga, University of California, Los Angeles

⁶⁶ Centers for Disease Control and Prevention, "Autism Spectrum Disorders: Data and Statistics," <http://www.cdc.gov/ncbddd/autism/data.html> (accessed August 20, 2010).

⁶⁷ The source of all amounts of NIH funds on specific diseases is <http://report.nih.gov/rcdc/categories/> (accessed August 20, 2010).

their combined study populations to provide unique insights on the biological roots of the disorder and reveal genes and pathways representing high-priority targets for developing novel treatments.^{68, 69} Researchers in California, who have also received funding, are using brain imaging to identify changes in infant brain structure and connectivity that may be early indicators of ASD. This project is aimed at enabling diagnosis of children at a younger age. The results of these and many other studies in this area funded by the Recovery Act have the potential to transform the lives of children and adults living with this disorder.

⁶⁸ National Institutes of Health, Research Portfolio Online Reporting Tools, “ARRA Investments in Autism Spectrum Disorders-1,” <http://report.nih.gov/recovery/investmentreports/ViewARRAInvRpt.aspx?csid=268> (accessed August 20, 2010).

⁶⁹ National Institutes of Health, Research Portfolio Online Reporting Tools, “ARRA Investments in Autism Spectrum Disorders-2,” <http://report.nih.gov/recovery/investmentreports/ViewARRAInvRpt.aspx?csid=179> (accessed August 20, 2010).