Technology21

Innovation and Technology in the 21st Century
Creating Better Jobs for New Mexicans

A Science and Technology Roadmap for New Mexico's Future: Appendices

New Mexico Governor Bill Richardson's Office
and
New Mexico Economic Development Department

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Appendices

The following appendices to Technology21, the State of New Mexico Science and Technology Roadmap for New Mexico's Future, provide more detailed information about cluster areas identified in the S&T Plan, including more information about capabilities that exist in New Mexico along with analyses of the Strengths, Weaknesses, Opportunities, and Threats in various cluster areas. The appendices also include some specific recommendations that were provided by the working groups. Those recommendations are not included in the main body of the S&T Plan as they are specific to particular institutions and projects. They are included here to serve as points to be considered in developing the detailed plans for each cluster area that will be undertaken once the Technology21 Center is stood up and operating.

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Appendix 1a. Aerospace

Issues Assessment

Most of the federal, state or private laboratories in New Mexico are primarily focused on research and development and not necessarily focused on the economic development. There is a greater need for collaboration among these funded research efforts in order to drive the necessary innovation and expand some of the emerging technologies. These emerging technologies include nanotechnology, digital media, intelligent and reconfigurable sensors, and future combat systems. Having a one-stop clearinghouse where usable information is made available to all interested parties for possible collaboration is key to future opportunities regarding technology transfer and other commercial spin-offs. This, coupled with the appropriate mentors and potential state or other venture capital, is an essential tool needed for future economic growth.

Due to the highly technical workforce in the labs and on the military installations, New Mexico found itself second only to California in 2006 in innovation. The strength of the patent performance from the federal labs was partially responsible. The State ranked sixth in the nation for the total number of grants, attributable mainly to the active small tech business community in New Mexico. (SmallTimes magazine, January 2007)

In order to attract and sustain aerospace related businesses in the State, education and training are key discriminators. Companies need to have a skilled workforce - and if respective employees are being recruited to the State, excellent school systems are necessary. The particular emphasis on K-12 aerospace activities that entities such as the Phillips Technology Institute have championed is a key element to foster excellence in education. The opportunity for children of Aerospace employees to attend State run colleges at low cost by maintaining a good grade point average is a definite recruiting incentive.

Strengths, Weaknesses, Opportunities, Threats

(Split up among seven distinct groups: Federal R&D, University R&D, Industry R&D, Space Launch R&D, Space System R&D, Aircraft R&D, and Business Climate)

On the federal facilities side, we are fortunate to have one of the world's greatest concentrations of competitive, easily accessible, state-of-the-art research labs. Unfortunately, some in those labs work too independently instead of collaboratively. We do have some opportunities that lie in the transition of the Battlespace Division from Hanscom to Kirtland by 2011. We must be watchful, however, to guard against fragmentation and loss of focus.

In the Aerospace sector, programs exist at Kirtland Air Force Base, Air Force Research Laboratories, Sandia National Laboratories, University of New Mexico, New Mexico State University, New Mexico Tech, Los Alamos National Laboratories, Holloman AFB, White Sands Missile Range, Spaceport, Space Development and Test Wing, Operationally Responsive Space Office, Eclipse Aviation, and other aerospace industry partners

We have numerous cooperative research and development agreements with the universities, but they do need stronger aerospace and space science programs to reach their full potential. On the

plus side, they are very willing to work with local companies, state and federal governments to foster growth and expansion. Possible threats would include, 'stove-piping' in research areas. Also there is no principal point of contact for research efforts across universities.

In industry, our partners are engaged in high-tech projects, have advanced manufacturing capabilities and relatively low operating costs, though there is no one large production of any single product taking place. Industry should be able to capitalize on commercial spin-offs from electronic components and on the influx of new venture capital. The future threat would be a overall lack of support from primary aerospace suppliers, users, etc.

In Space Launch R&D we have orbital and sub-orbital launch capability at Spaceport America and WSMR. That capability is not yet backed up (at Spaceport America) with significant resources. The opportunities for partnering (with Virgin Galactic and others) on hypersonic transcontinental flights are encouraging. The State must be watchful regarding competition from California and Virginia.

Space System R&D is well funded by AFRL (DOD), but more must be done to secure in-State funding. By having more space science positions in the State, there is a good chance to secure that funding, however the competition from California and Colorado continues to be keen.

On the Aircraft R&D side, we have the largest area in the U.S. with restricted airspace, but no big name manufacturers. The opportunities for near-space observations with UAVs (Unmanned Aerial Vehicles) and balloons continues to be a big draw, but the competition from California, Virginia and Maryland is intense.

Our business climate is appealing and attractive to outside companies, and there are many relocation incentives and support for existing New Mexico companies, too.

Incentives

The State of New Mexico has done an admirable job providing incentives to attract and keep high-tech companies in general and Aerospace companies, specifically. Specific sector-related incentives currently include:

- Research and Development
- Aircraft Manufacturing
- Aircraft Refurbishing or Remodeling
- Space Vehicle Launch, Operation and Recovery
- Payload Preparation
- Spaceport Operations
- Research, Development, Test, and Evaluation Services for the Operationally Responsive Space Program

Several of the general incentives are limited to urban areas (Job Training Incentive Program, for example) or differ in the extent of the incentive to urban and rural areas (i.e. Technology Jobs Tax Credit). A public-private clearinghouse that would disseminate information on these incentives would be of great benefit in growing existing companies and attracting new companies to the State.

	Strengths	Weaknesses	Opportunities	Threats
Federal R&D Facilities	One of the world's greatest concentrations of competitive, easily accessible State-of-the art research labs	Some labs work independently instead of collaboratively	Transition of the Battlespace Environment Division from Hanscom to Kirtland by 2011	Continued fragmentation and lack of focus
University R&D	Numerous cooperative research and development agreements	Need for stronger aerospace and space science programs	Work with local companies, State, Federal Gov. to foster growth and expansion	Stove-piped research areas; no single POC for research efforts across universities
Industry R&D	Partners already engaged in high-tech projects; advanced manufacturing capabilities; low operating costs	No manufacturing of any one large product	Capitalize on commercial spin-offs from electronic components and influx of venture capital	Overall lack of support from primary aerospace suppliers, users, etc.
Space Launch R&D	Orbital, suborbital launch capability at Spaceport America; WSMR	Lack of Spaceport resources	Partner with Virgin Galactic, others; hypersonic transcontinental flights	Virgin Galactic pullout; competition from CA/VA; failure to obtain Spaceport license
Space System R&D	AFRL R&D funding for DOD	Industry funding primarily outside of NM	Space Science positions and ORS ofc can promote more funding staying in NM.	Competition from CA, CO
Aircraft R&D	Largest area in the US with restricted airspace	No big name manufacturers	Near-space observations (UAV's, Balloons)	Competition from CA, VA, MD
Business Climate	Business friendly state, excellent incentives; Low cost of Living	Technology Transfer to business slow	Almost too many patents, technologies to choose among	Lack of comprehensive index of research areas

The New Mexico Aerospace Capabilities Assessment, shown below, lists the extensive aerospace capabilities available within the state from the federal laboratories, industry and universities. The chart below delves into greater detail into top-level Strengths, Weaknesses, Opportunities, and Threats analysis for technology development and insertion in New Mexico.

NEW MEXICO AEROSPACE CAPABILITIES ASSESSMENT

Satellite Technologies
Satellite control
Space communications
Advanced spacecraft dynamics & controls
Deployable structures
Space simulation and control
Advanced space power generation
Guidance, navigation, and control
Interactive control & situational awareness
Radiation hardened electronics
Plug-and-Play avionics

Space Expertise
Astronomy
Space weather
Small satellite development and test
Space situational awareness and control
Space experiments

Communications
High speed communications
Communications security
Communication systems engineering

Testing
Test and evaluation services
Test environments
Ground-based systems
Test Facilities
Test Ranges

Robotics Technologies
Autonomous operation
Intelligent systems
Robtics control systems
Multi-robot control systems
Robotics platforms

Remote Vehicle Operations
Digital Media
Training simulations
Interactive controls
Adaptive interactive games
Media evaluation & validation

Sensor Technologies
Sensor networks
UAV-based Surveillance
Multi-access wide field sensors
GIS mapping
Precision mirrors
Laser based sensors

Modelling and Simulation
Component & system simulations
Incident simulation systems

Information Technologies
Data fusion
Cyber defense /net centric TT&C
Networks, architectures
Knowledge management

Directed Energy
Lasers
High Energy Microwaves

Alternative Platforms
High altitude balloons
UAVs

Aircraft
Avionics development and manufacturing
Aircraft Engines
Manufacturing

**Information obtained through interviews, collateral materials, and electronic media presentations.*

The following lists the strengths of the three major research universities in New Mexico and needed areas of improvement.

New Mexico State University (NMSU):
NMSU is requesting support from the state to further strengthen two, space-related, academic programs: the Aerospace Engineering program in the Mechanical and Aerospace Engineering Department of the College of Engineering (undergraduate program in place and graduate program application under review) and interdisciplinary space research (organized into a formal research cluster). Current departments participating in the aerospace/space research cluster include: Mechanical and Aerospace Engineering, Electrical and Computer Engineering, Astronomy, Physics, and the remote sensing team in the College of Agriculture.

NMSU requires support for both faculty positions and infrastructure. Six positions are requested as follows: two in space sensing and telemetry, two in space weather/space environment and two in aerospace systems engineering. The positions would support interest in the state related to payloads, space applications, spaceport development, movement of personnel from Hanscom to Kirtland, efforts to keep the National Solar Observatory (NSO) headquarters in New Mexico, and general aerospace economic development. Six positions would require recurring funds.

Infrastructure support would include clean-room facilities, test and evaluation facilities, space and aerospace modeling and simulation laboratory (hardware-in-the-loop, solar simulators, systems integration), and technical support staff to maintain the facilities and ensure proper use. Such facilities would serve to attract people to the Spaceport America and to southern New Mexico for aerospace-related activities. They would promote greater economic development, education, and research. These infrastructure projects would require non-recurring funds and recurring funds for technical staff and consumables.

New Mexico School of Mining and Technology (NMT):
NMT has extensive expertise in space situational awareness research. A key aspect to this expertise is the research done at Magdalena Ridge Observatory (MRO). The MRO program

affords great opportunities for students and faculty to perform research in space sciences. NMT looks to the State to continue support of the MRO.

University of New Mexico (UNM):
UNM has strong programs in place that engage in the development of large autonomous space-based sensor systems in the interest of national security. Research currently done in the coordination of multiple satellites or swarms of robots that can automatically plan their interaction toward a common objective is valuable in surveillance applications, the coordination of military and relief operations and in communications. In addition, fundamental studies are being performed to determine the strength-related and failure-related characteristics of polymer and metal-based nanocomposites, metallic alloys, superplastic forming and precision manufacturing, together with an effort in the area of energy supply systems. These studies are backed by extensive expertise in flow heat, mass transfer and turbulence. In the software area, groundbreaking control and coordination algorithms for complex systems and systems performance are being designed and implemented.

To effectively strengthen and direct the above research efforts towards a significant aerospace program that will enhance the existing educational component in the aerospace sciences as well as effectively contribute to a New Mexico Aerospace engineering program, UNM requests the following:

Support and strengthen its existing infrastructure in the form of an additional six faculty (in Engineering and Physics) to increase the efforts in the aerospace systems and space science areas. The aim is to attract nationally and internationally-recognized faculty who will give us high visibility in this area. The areas targeted are as follows:

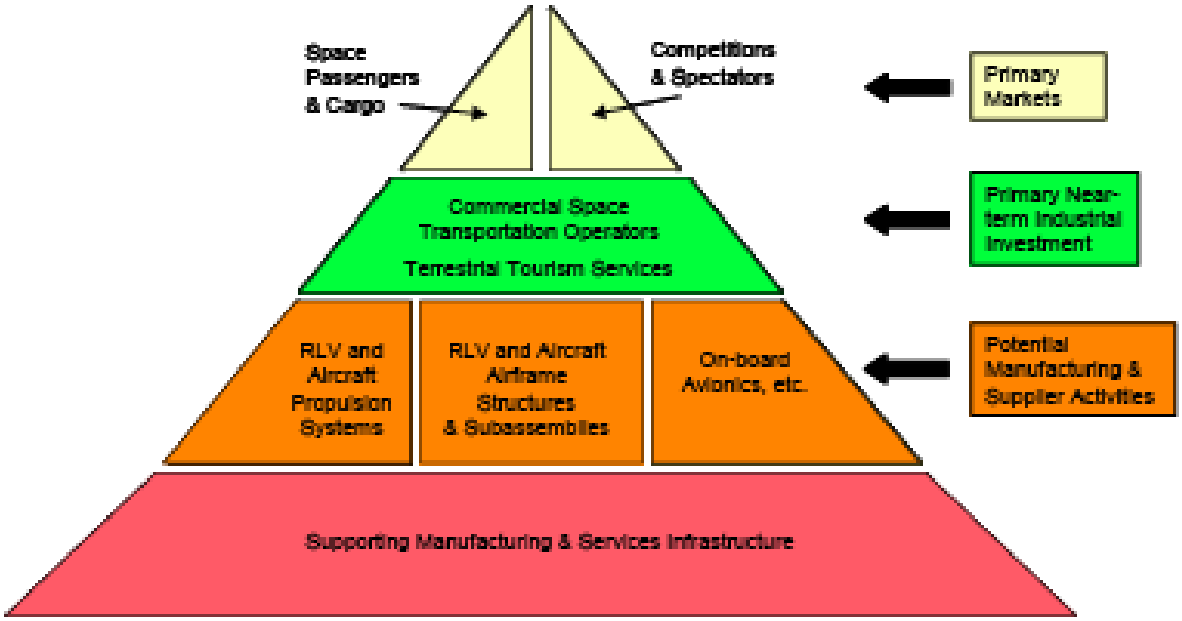
- Two positions in space weather (plasma sciences, GPS and satellite communications)
- Two in space systems (reconfigurable satellites, computing, energy supply, control and coordination)
- One in space materials (nanocomposites, metallic alloys, superplastic forming and precision manufacturing)
- One in space electronics (radiation hardened electronics)

There is also a need for a limited amount of resources to manage the program and recruit more students and engage aerospace engineers with extensive aerospace experience who are already in the Albuquerque area. This will enable us to offer the best possible program to students in the field aerospace sciences and engineering.

Spaceport America

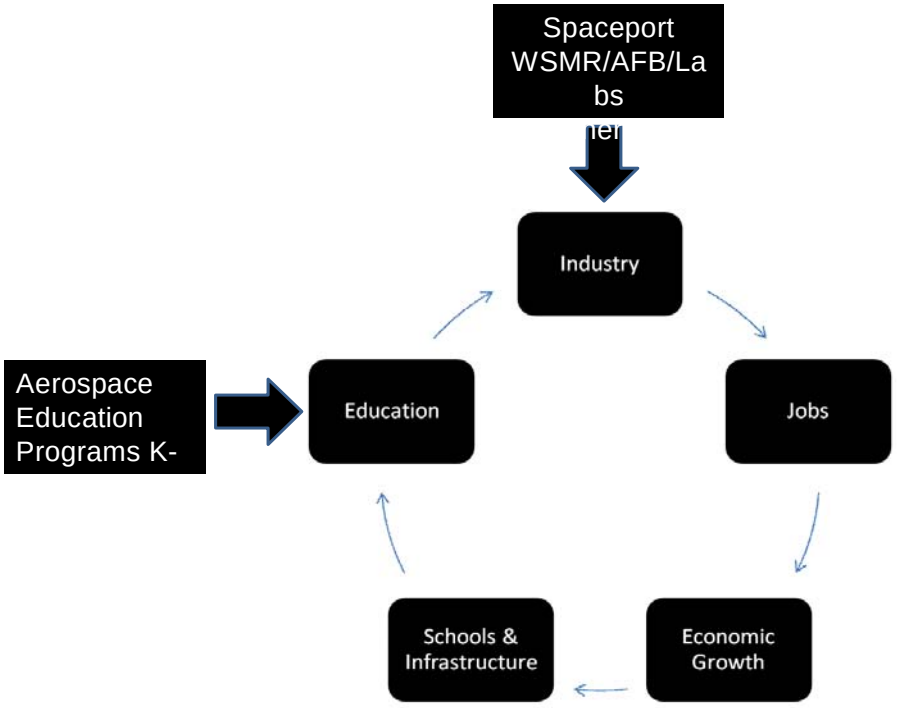
Spaceport America provides a very broad range of capabilities and opportunities that can support economic development in New Mexico, as is shown the figure below:

The ability to build a strong base of economic development on these capabilities has been studied in two economic development assessments that were carried out prior to starting the Spaceport America initiative. The Arrowhead Center (AHC) at New Mexico State University was contracted by the New Mexico Economic Development Department to develop and deliver several reports and services relative to the Southwest Regional Spaceport. Foremost among them were a strategic analysis of the commercial space industry and a business plan for the spaceport to realize the opportunities inherent to the industry. The conclusion of this report was that the total economic impact in New Mexico over the first five years of operation would be between $990M and $1194M and would create between 2284 and 2871 jobs. The second study was carried out in 2005 by Futron Corp (Bethesda, MD) and concluded that by 2020 Spaceport America could account for up to $552M annually in economic impact in New Mexico. The following figure shows the sectors that Futron sees as providing the basis for the estimated growth.



Transportation and Manufacturing Cluster Activities that can be supported by Spaceport America and the New Mexico Aerospace Cluster (courtesy of Futron Corp).

As noted in the main report, the development of the workforce for the aerospace industry is a critical component of this plan. The figure below illustrates the synergies between the commercial development and educational initiatives of this recommendation.



Cycle of New Mexico Aerospace Industry Growth

Appendix 1b. Bioscience and Health

Strengths, Weaknesses, Opportunities, Threats

The New Mexico Center for Biotechnology Enterprises

Strengths

- Fully engages all research units of the UNM Health Science Center (HSC)
- Builds upon already successful collaborations with partners such as Sandia National Laboratory, Loveless Respiratory Research Institute and other partners
- Provides commercialization outlet for existing activities related to bioterroism and emerging infectious diseases (currently over $15 million/year in federal funding), including full utilization of our BSL3 facilities
- Provides the necessary intellectual capital for effective commercialization and economic development
- Provides mechanism and infrastructure to fill current gaps in support of early stage biotechnologies which will increase success of marketing
- Leverages possible financial commitment of federal government.
- Creation of Center for Biotechnology Enterprise will enhance federal funding possibilities of the CTSC.

Weaknesses

- Full leveraging of funds requires full funding of the Clinical and Translational Science Center (CTSC) over the next year
- Intellectual capital in this arena is sparse

Opportunities

- State economic development will occur when technology created by UNM HSC and CTSC are transferred or put into practice.
- Significant improvements in healthcare and health outcome could be realized.
- New Mexico could lead the US in the development of technologies related to improving health care and health care outcomes.
- A mechanism for sustainable development of biotechnologies would be created
- Leverage of existing relationships with other New Mexico Universities and National Laboratories to create new investment opportunities for New Mexico biotechnology

Threats

- Most our new technologies are time sensitive- others will create if we do not bring to market first.
- Recruitment of key intellectual capital is difficult. They provide tremendous benefit, but are difficult to find. Substitution with less skilled individual dramatically decreases economic impact.

Energy, Environment and Water - Algal Biofuels

Strengths:

- ***Location***
  - Its proximity to non-arable land and large quantities of brine groundwater make it ideally suited for developing brine algae as a biodiesel feedstock.
- ***Technical resources***
  - The Center for Excellence of Hazardous Material Management (CEHMM) has developed an excellent staff of field researchers with local expertise in producing biodiesel and growing brine algae.
  - CEHMM has an experienced staff to manage the business aspects of a non-profit research and development organization.
  - CEHMM has the benefit of knowledge acquired from successful past/ongoing applied research.
  - CEHMM has access to world renowned researchers due to the excellent cooperative relationships it has developed with Los Alamos National Laboratory, NMSU, and industrial partners.
- ***Political resources***
  - CEHMM has the attention and support of local, state and U.S. politicians for its biofuels research and development activities. The State of New Mexico Energy Innovation Fund recently awarded $1.0 million to further algae biodiesel research.

Weaknesses:

- ***Barriers to Market Acceptance***
  - **Quality:** Distribution of poor quality biodiesel can create a marketing barrier that is difficult to overcome. Word travels fast when bad fuel creates a problem with fleet operations or individual consumers. On the other hand, the benefits of high quality biodiesel can be used to enhance market acceptance. CEHMM is including quality testing of feedstock oil and produced biodiesel in all development plans to ensure that any commercial production of biodiesel meets the highest standards and maintains consumer confidence.
  - **Price:** The price of biodiesel for consumers is dependent on the price of feedstock and tax incentives. With current feedstock prices and tax incentives, biodiesel is price competitive with petroleum diesel. However, unless renewed, the current tax incentives expire in 2008. Additionally, as more biodiesel production comes online, the competition for existing feedstock will ultimately drive up the price. For these reasons, development of economical ways to produce large quantities of oil from algae will become even more important.
  - **Availability:** CEHMM is currently receiving numerous requests from around the country and world regarding its algae project. Interest is very high, and it is generally acknowledged by the industry that a breakthrough in this area would be a very significant achievement toward making biodiesel available as a mainstream energy source. The New Mexico legislature recently passed measures to encourage use of biodiesel in the state.

With an abundant source of oil and an encouraging political climate, biodiesel availability should increase rapidly.

- ***Technical Challenges***
  - Although much has been accomplished, technical challenges remain in:
    - defining the optimal strains of algae for greatest production capability,
    - selecting/developing the harvesting method,
    - selecting/developing the oil extraction process,
    - managing water resources
    - process engineering and marketing of non-oil algal waste as a value added commodity

Opportunities:

- State economic development will occur when technology and processes developed by CEHMM are transferred to viable commercial enterprises. The new jobs and commodities created by technology transfer will diversify the state's economic base and drive long-term sustainable growth. The following list provides examples of how technology transfer can ripple through the state's economic base:
  - Biodiesel production can be established to provide B100 to regional distributors.
  - Large-scale algae farms can be established on non-arable land to produce oil feedstock – a new commodity that would provide a source of state revenue through corporate taxes.
  - Construction, farming, and refining will create new jobs.
  - New support services (housing, medical, educational, service, etc.) will be necessary to support population growth.
- The environmental benefits of biodiesel have been studied and are generally accepted. In the year 2000, biodiesel became the only alternative fuel in the country to have successfully completed the EPA-required Tier I and Tier II health effects testing under the Clean Air Act. These independent tests conclusively demonstrated biodiesel's significant reduction of virtually all regulated emissions, and showed biodiesel does not pose a threat to human health.

  Biodiesel contains no sulfur or aromatics, and use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter. A DOE study showed that the production and use of biodiesel, compared to petroleum diesel, resulted in a 78.5% reduction in carbon dioxide emissions a major greenhouse gas. Moreover, biodiesel has a positive energy balance.
- Energy security has become a national priority due to current world events and the instability of imported petroleum supply and cost. CEHMM's biodiesel research and development can help address this issue by developing new, non-food feedstock for use in biodiesel production. If CEHMM can successfully demonstrate that algae can be economically grown on non-arable land in the U.S., biodiesel has the potential to displace over 60 billion gallons of imported petroleum annually.

- Algae have yet to be "domesticated" as an agricultural crop. Just as corn yields improved by a factor of six in the last century, we can expect significant, and far more rapid improvements in algal oil yields by combining traditional selection schemes with modern high-throughput "omics" technologies and genetic engineering. State investment in algal strain improvement and agronomic practices will target improvements in growth rate, oil content and quality, and strain stability against ecological competitors in open ponds. These efforts will generate intellectual property and technology transfer opportunities with commercial partners.

Threats:

- Failure to develop economically viable processes for growing, harvesting, and expressing oil from micro-algae or failure to acquire intellectual property rights for those processes.
- Collapse of public and political support.
- Inability to leverage resources of outside organizations that enhance our ability to meet business objectives.
- Inability to secure sustained funding.
- Lack of success in the transfer of technology to commercial ventures.

Public Health

Strengths

NM Center for Isotopes in Medicine:

• LANL has made a $30M investment in unique Isotope Production Facilities (IPS) at LANS IPF; new medically useful isotopes (e.g., CardioGen-82® from Bracco http://www.cardiogen.com/ for heart imaging is currently prepared under contract for private companies); there are many other medically useful isotopes that could be prepared for cancer imaging and therapy; New Mexico Center for Isotopes in Medicine (NMCIM) has already engaged GE Healthcare in the testing and development of a Ga^{68} generator that can be distributed to even small communities for PET imaging (perhaps expand mobile clinics)

• LANS IPF can be the premier facility in the world for medical isotope production; many of the isotopes are of sufficiently short half-lives that it will be advantageous for companies to formulate the isotopes locally and to develop a distribution system in New Mexico; this will lead to the construction of new facilities, new jobs and tax base.

• The UNM College of Pharmacy (COP) Radiopharmacy was the inventor of the concept of centralized nuclear pharmacies in 1972, which has led to several major companies operating over 600 nuclear pharmacies in the U.S.

• Utilize the $2.0 million investment at UNM COP Keck-UNM Small-Animal Imaging Resource (KUSAIR) facility ($1M given by Keck)

• Utilize the new Cancer Research and Treatment Center (CRTC) II Facility and new RFP partnerships with cyclotron and radiopharmacy operator private partner.

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- The New Mexico Digital Media Initiative and the UNM Arts, Research, Technology, and Science (ARTS) Lab, supported by Governor Richardson and the State legislature, offer conduits to form these partnerships.

- Senator Domenici has supported these efforts and has been a sponsor of the national Advance Initiatives for Medical Simulation (AIMS) based in Washington DC, and UNM participates on the Board of Directors.

- UNM has published and presented this work nationally and internationally and holds a unique, respected position in the field of virtual realty simulation and visualization.

- Other Universities and institutions, nationally and internationally, recognize the University of New Mexico's unique advanced efforts and progress in this field and express continued interest in collaboration.

- New Mexico's investments in Internet2 and National Lambda Rail (NLR) provide the network infrastructure for collaboration between stakeholders, as well as a distribution system for research, development, and evaluation.

Genome New Mexico

- The Human Genome Project started at DOE under Governor Richardson's tenure as Secretary of Energy
- Senator Domenici was instrumental in starting the Human Genome Project at LANL and in creating the National Center for Genomic Research (NCGR)
- A new genome project – focused on identifying the causes of major human traits and diseases – is starting, fuelled by next-generation genome sequencing
- The New Mexico legislature has provided $1.3 million to establish a New Mexico Genome Sequencing Center to ensure that New Mexico does not miss out on this new genome project
- New Mexico has an emerging molecular diagnostics industry (Genzyme, Tricore, Exagen etc.)
- New Mexico has unique population structure; population resources available here are unavailable anywhere else in the US
- The genetic basis of common diseases and traits is population-specific; findings in Northern Europeans or African Americans will largely be non-applicable to Hispanic and Native American populations

NM Center for Research on Emerging Infectious Diseases:

- The new Institute of Applied Biosciences is in the process of hiring one-two researchers with expertise in emerging infectious disease (EID) in order to increase the profile of EID research at the institution and target federal grants for EID research.

- The new "Systems Evolution" program at NMSU will build research strength in the "omics" and computational approaches needed to modernize current practices in pathogen surveillance and prediction of disease emergence.

- The two NSF-funded long-term ecological research (LTER) sites in the state provide a wealth of background data and ecological expertise.

• The IAB hire(s) will complement existing research strengths at NMSU in the evolution and control of emerging pathogens. NMSU researchers have been particularly successful in the design of vaccines, antivirals and antibiotics.

• Several biosafety level (BSL) II and one BSLIII lab are already certified and functioning on the NMSU campus, and a BSLII insectary is under construction.

• As noted earlier, New Mexico's extreme climate makes it a "natural laboratory" in which to study the impact of climate change on disease emergence.

• NMSU faculty have a history of productive collaborations with EID researchers at UNM, LANL, the NIH Western Regional Center of Excellence at UT Medical Branch, and the National Institute of Allergy and Infectious Diseases. Two key individuals at UNM have agreed to participate in this initiative.

Weaknesses

NM Center for Isotopes in Medicine:

- Lack of established radiopharmaceutical business infrastructure in New Mexico
- Need for expanded facilities and additional faculty at UNM; need for additional radiochemistry faculty and facilities at UNM and NMSU
- Small clinical market in New Mexico

Genome New Mexico

- New Mexico did not participate in the benefits of the Human Genome Project – the biotechnology companies that started here moved to California, Boston and Washington, DC.

NM Center for Research on Emerging Infectious Diseases due to:

• Lack of coordination and communication among EID researchers and public health officials in the state, particularly in southern NM.

• Insufficient number of EID researchers to achieve the "critical mass" needed to compete for large, multi-institution federal grants.

• Expertise gaps in critical areas including epidemiological modeling, vector biology, vector control, wildlife disease ecology, GIS, landscape ecology, biosensor development, and climatology.

Opportunities

NM Center for Isotopes in Medicine:

- New generation imaging equipment, especially PET requires new PET-emitting radioisotopes and generators.
- TRC collaboration began a partnership with GE Healthcare to develop, test, build and sell the next generation of radiopharmaceutical generators; GE Healthcare wants a US partner for Ga68 production; GE is interested in other isotopes and imaging technology at LANL - major Tech Transfer opportunity
- Several new imaging companies have already signed important agreements with UNM Radiopharmacy (Bioscan, AMI/Gamma Medica, Molecular Insights Pharma, NuView, etc.); new companies are being formed in the digital imaging data processing area

• UNM is developing a unique small animal and clinical testing facilities to develop new products; major new products are on the horizon; it is more cost effective and rapid for companies to deal with established facilities than to build their own; many new opportunities for partnership development.

• DOE is interested in new medical isotopes facilities to reduce the U.S. dependence on foreign suppliers; Congress is in the process of allocating new resources for medical isotope research and production.

NM Center for Research on Emerging Infectious Diseases:

• Numerous federal agencies offer grants to support research into emerging infectious diseases. Table 1 lists representative agencies and programs, though it is not an exhaustive list.

Table 1: Representative Agencies and Programs that Fund Research Relevant to Emerging Infectious Disease Prediction and Prevention.

Agency	Program	RFA/PA/Solicitation/web site
NIH	Biodefense and Emerging Infectious Disease Research Opportunities	PA-04-119
NIH	Non-Biodefense Emerging Infectious Disease Research Opportunities	PA-07-246
NSF	Ecology of Infectious Diseases	NSF 06-506
WRCE	Biodefense and Emerging Infectious Disease Research Awards	http://rce.swmed.edu/rce6/fundingopps.htm
EPA	Science to Achieve Results (STAR)	http://www.epa.gov/ogd/
USDA	National Research Initiative - Global and Climate Change: Invasive Species and Land Use	http://www.csrees.usda.gov/fo/globalchangeinvasivesnri.cfm

• Patented vaccines, antivirals, etc. developed by NM-CREID researchers will be licensed to appropriate pharmaceutical companies for development.

• Technologies such as biosensors will also be developed for commercial use.

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• There are organizations and institutions that have approached Project TOUCH to develop new scenarios and work in collaboration for future improvements of the FLATLAND environment, among theses are: Stanford University, University of Buffalo, University of Michigan, Tallahassee Community College in conjunction with Florida State University, The Army's Advanced Medical Testing Support Group at Ft. Gordon and Uniformed Services University for the Health Services (USUHS), The Pacific telehealth and technology Hui at Tripler Army Medical Center and VA in Hawaii.

• International interest is increasing from organizations such as University of Western Australia, Universidad de Guadalajara, and educational institutions in Columbia, Venezuela, and Ecuador.

• Software development companies also have expressed interest in working in collaboration to further develop medical applications, along with other video gaming and digital media companies.

• These interactions offer prospects to partner with industry; including digital entertainment and video-gaming, and in so doing, offer opportunities to create professional quality, high fidelity 3-D animated models more efficiently. The New Mexico's Digital Media Initiative and the UNM ARTS Lab offer conduits to form these partnerships. The Science Technology Corporation (STC) has also expressed interest in supporting the development of a "start-up business" for production of professional quality, high fidelity, virtual reality simulations in conjunction with ongoing research and development at UNM, as well as development of business agreements with the digital media and video gaming industry as indicated.

Threats

NM Center for Isotopes in Medicine:

• Well-established and well-financed competition located in major business centers worldwide

• A Ga^{68} generator is already available for research in Europe (the Ga^{68} source is Russian), but has not been clinically approved in the U.S.

• Requires a major clinical and industry partner for FDA approval of new isotopes and generators ($50M?)

• ^{18}F-deoxyglucose (^{18}FDG) currently dominates the market and is currently the only FDA-approved PET imaging agent; development of other cyclotron-based agents (C^{11} an O^{15})

• Other imaging modalities: MRI, CT, ultrasound

FLATLAND

• Although collaboration with other institutions and industry outside of New Mexico offers an opportunity, there is the threat that other stakeholders may seize this opportunity without including New Mexico.

• UNM does not currently have the capacity for high-scale production of these interactive virtual reality serious games to meet the increasing interest and emerging demand.

• There is currently a lack of funding to support continued work in this arena in New Mexico.

Genome New Mexico

• Similar biorepositories and sequencing projects are being established or have been established in the UK, Iceland, Finland, Quebec, Newfoundland, China, Massachusetts and North Carolina.

NM Center for Research on Emerging Infectious Diseases:

• The NIH-Western Regional Center of Excellence (WRCE) is mandated to generate "new diagnostic, therapeutic and vaccine countermeasures for Category A, B, and C pathogens posing threats as agents of bioterrorism" and thus might be viewed as a competitor to NM-CREID. It is important to note, however, that the focus of NM-CREID is not on agents of bioterrorism but pathogens and pre-pathogenic organisms that pose a risk to the citizens of New Mexico. Thus, the activities of NM-CREID will be specifically and continuously informed by field studies within the state. Furthermore, NM-CREID emphasizes understanding the environmental drivers of pathogens emergence, particularly under conditions of climate change, a critical line of enquiry that is not covered by the WRCE mandate.

Appendix 1c. Energy, Environment, and Water

New Mexico's Energy Present

New Mexico is a significant producer of transportation fuels, and as with electrical power, we are a net exporter of these fuels (at present exporting approximately 30% of the crude oil produced and approximately 85% of the natural gas produced). Natural gas production in New Mexico is relatively flat and will likely become increasingly important to New Mexico's energy future during the transition to renewable fuel. This is particularly true since natural gas is a much cleaner fuel than coal, gasoline, or diesel. However, our oil production in the State is declining at about 3.5% per year while total usage is projected to increase at a rate of 1.9% per year for gasoline and 3.6% per year for diesel. Based on current trends, we estimate that New Mexico total usage will equal production in 2015. Thus, our challenge is to quickly transition to clean and renewable forms of fuels.

New Mexico natural gas production accounts for 9% of the U.S.' total, and New Mexico is ranked fourth in terms of natural gas reserves, nationwide. While we export a large portion of our natural gas, about 15% of it is used for peak load electricity generation and for heating of buildings. The Department of Energy projects a 20% increase in national demand for natural gas production by 2030. In New Mexico, we plan on controlling our use of natural gas through the implementation of aggressive energy efficiency standards. In line with the goal to reduce total energy usage per capita stated in the main body of the S&T Plan, we have recommended an energy efficiency goal of a 40% reduction in the use of energy for heating and lighting in buildings in New Mexico by 2025.

New Mexico's Energy Future - Clean Energy and a Clean Environment

Our first recommendation for clean energy production in New Mexico is to produce as much electricity by 2025 from clean and/or renewable sources as we presently use from fossil fuels. This corresponds to an average capability of about 2200 MW.

To meet this goal will require the development of cost-effective technologies for storing energy from wind and solar. Storage will allow high capacity factors so that the peak capability for wind and solar energy needed is close to the average capability required.

Nuclear power is an important economic driver in achieving clean energy goals in the U.S. New Mexico has strong institutional capabilities that can, and should, address the development of safe and proliferation-resistant technologies for the next generation of nuclear power plants. At the same time, we have the second largest reserves of uranium in the U.S. It is important for the future of our State and for the country's that we find environmentally responsible means of mining uranium that allow us to benefit economically from our uranium resources. Over the longer term, we may want to consider constructing Gen-III or Gen-IV nuclear power plants.

Our second recommendation for clean in New Mexico is to develop and implement cost-effective storage of wind and solar energy with a capacity factor of 80% by 2030. Meeting the

longer-term goal of a 80% reduction in GHG emissions by 2050 will require us to develop economically viable carbon capture and sequestration technologies.

Our third recommendation for clean energy in New Mexico is to develop and install economically viable carbon capture and sequestration technologies for 60% of the GHG emissions from our existing and new coal and natural gas-fired power plants by 2050. Achieving this goal will require significant Federal investment in R&D, a role that our national laboratories in New Mexico are well equipped to fulfill.

Transition from Fossil Fuels to Biofuels

New Mexico natural gas production accounts for 9% of the U.S.' total, and New Mexico is ranked fourth in terms of natural gas reserves, nationwide. While we export a large portion of our natural gas, about 15% of it is used for peak load electricity generation and for heating of buildings. The Department of Energy projects a 20% increase in national demand for natural gas production by 2030. In New Mexico, we plan on controlling our use of natural gas through the implementation of aggressive energy efficiency standards. In line with our previously-stated goal to reduce total energy usage per capita, we have recommended an energy efficiency goal of a 40% reduction in the use of energy for heating and lighting in buildings in New Mexico by 2025.

Our first recommendation for transportation fuels is to reduce our per capita usage of gasoline and diesel by at least 10% from 2005 levels by 2012 and 20% from present levels by 2020. The reduction in gasoline consumption can be accomplished through a combination of improved fuel efficiency and transitioning to hybrid and electric vehicles as well as use of public transportation (such as the Rail Runner). While we expect there to be some use of E-10 fuel, the limited availability of water precludes large-scale production of ethanol in New Mexico. The reduction in diesel consumption can be accomplished through a combination of improved fuel efficiency and energy-efficient idling systems.

Our second recommendation for transportation fuels is to switch from petrodiesel to 100% use of biodiesel in New Mexico by 2025. Meeting this goal requires a biodiesel production level of about 25 million barrels per year. This will be possible only if an economical means is developed of producing biodiesel from microalgae in New Mexico. Since microalgae grow well in highly saline waters, we propose to use the large volume of deep saline water that exists in New Mexico without adversely affecting our fresh water supply.

The New Energy Economy in New Mexico

Transmitting the Energy

A critical element in meeting our clean energy and economic goals is our ability to develop new transmission lines in New Mexico and in the southwestern U.S. It's worth noting that the most effective means of meeting energy demands is not to build new sources and transmission lines, but to reduce demand through aggressive energy efficiency measures. However, given the minimal investments made in electricity infrastructure in the U.S. over the last two decades, coupled with population growth in new areas, it will be necessary to make significant investments in electricity transmission and distribution. This development should fully incorporate smart grid technology. This will require not only significant capital investments, but also consistent regulatory policies throughout the Southwest. We believe that New Mexico

should be a strong leader in advocating for and helping realize the regional development of new infrastructure for electricity transmission and distribution. The Renewable Energy Transmission Authority (RETA) is a good step in this direction, and there are positive signs of regional cooperation. However, a detailed and progressive plan must be developed and implemented if we are to succeed. Our ability to attract the necessary capital will depend in large part on the policies we adopt as well as the regulatory environment in New Mexico and the Southwest.

Finally, we note that the cost of carbon will be an important consideration in developing a clean energy economy for New Mexico. There is virtually no doubt that the cost of carbon (through taxes, credits, etc.) will play an increasingly more important role in the future. By adopting and implementing the recommendations presented in this plan, New Mexico will be optimally positioned to play a leadership role in the new energy economy.

Clean and Renewable Energy R&D in New Mexico

If we are to achieve a clean and sustainable energy future for New Mexico, a number of technology gaps must be addressed. Some of the areas require breakthroughs either in technologies or in economic viability while others are incremental in nature.
Commercially-relevant R&D Areas to pursue include:
Energy efficiency - improved materials for use in buildings, combined use (e.g., combined solar heat and electricity) with natural lighting and ventilation design; increased efficiency for chilled air and heating

Transportation – biofuels (see recommendation below), improved engine efficiencies and in hybrid vehicles, development of total electric vehicles, expansion and optimal usage of public transportation, improved energy storage, fuel cell development, reduction of losses when vehicles are idling,

Materials Use - Efficient use of materials - zero waste technologies, biomass

Transmission and distribution - modeling of performance of micro grids and smart grids, net metering technology development, direct current high-voltage transmission, superconducting elements for transmission

Advisory Group Recommendation - Support and fund algal biofuels efforts in New Mexico.

The Center of Excellence for Hazardous Materials Management (CEHMM) is leading a collaborative project in southeastern New Mexico to produce biodiesel fuel from microalgae. This collaboration includes: the City of Carlsbad, New Mexico State University, Los Alamos National Laboratory, and private companies. The project's innovative approach, coupled with New Mexico's natural resources, make this an ideal and unique opportunity to create jobs in rural areas and develop a strong, new industry for the state and, ultimately, the nation. In a complementary effort, New Mexico State University is partnering with Sapphire Energy to use microalgae to produce gasoline and aviation fuel. Again, this effort draws on considerable expertise at NMSU along with venture capital investments in Sapphire Energy and some advanced technologies to position New Mexico to become a leader in algal biofuels.

The use of microalgae as a feedstock has the potential to make biogasoline, biodiesel, and bioaviation fuels a viable replacement for significant quantities of fossil fuels, thereby supporting State efforts, reducing American dependence on foreign oil, and reducing global CO_2 emissions. When this technology matures, the effect on New Mexico's economy could be dramatic.

Hydrogen Fuel Cells

New Mexico has had distinct technological leads in several key areas of hydrogen energy research and applications at the federal labs, primarily in storage, fuel cells, and safety. The state risks losing those competitive edges unless the full resources of industry, government, and universities are deployed. New Mexico must invest resources to fully leverage R&D at the two national labs and three research universities to benefit future economic development. Other states and regions have funded and implemented initiatives that significantly raise the competitive ante and take away our hydrogen energy assets.

Background

New Mexico's hydrogen energy R&D and industrial organizations, while active and engaged as ever, have slipped behind more aggressive, legislatively supported regions. New Mexico has not slowed down so much as other states have sped up their partnerships, as the world works to transform its future energy sources to hydrogen and other alternatives to oil.

Technical Information and Challenges

Hydrogen is the most abundant element on earth and has the highest energy content, by weight, of all common fuels, nearly three times that of gasoline, but it has a very low energy content by volume. Hydrogen's most efficient use as a fuel is in the generation of electricity through fuel cells. Hydrogen production requires no imports, mitigates greenhouse gas emissions and other pollutants, and is produced through a variety of technologies and sources.

Hydrogen faces two significant hurdles: Cost reductions and performance improvements in production and storage technologies, as well as fuel cell technologies that generate electricity; and, determining its economic value for setting energy policy. New Mexico is well positioned to play a significant role in overcoming the first hurdle, but not the second hurdle in the near term,

State-to-State Comparisons

Approximately half of the states have active hydrogen research and/or commercialization efforts, the active states into four tiers of activity. The most competitive hydrogen economy states, *Tier One* states, generally have a broad range of initiatives and best practices in common.

Tier One states include Connecticut, California, Ohio, and Michigan. Ohio established a $103 million state fuel cell initiative. Connecticut bills itself as the "fuel cell capital of the world" and arguably has the largest concentration of fuel cell related OEM's, suppliers, and services firms.

Tier Two states have several or more of the aforementioned efforts, and have state-funding commitments of $10 to $50 million. *Tier Two* states include Florida, Hawaii, Illinois, Massachusetts, Minnesota, New York, Pennsylvania, and Texas.

Tier Three states, including New Mexico, have less than $10 million in state-funding commitments, but have notable R&D bases, either federally or otherwise, and have organized their efforts. Other *Tier Three* states also include Colorado, South Carolina, and New Jersey.

Tier Four states report token research projects at state universities, or other small demonstration projects and generally do not have well-coordinated programs or an industry base.

New Mexico Opportunities Matrix

		Fuel Cell Power Application Segments		
		Portable Low Power small electronics/cell phones, military (Direct Methanol Fuel Cells DMFC)	**Stationary Power** residential, business/industry, military buildings and other apps	**Transportation Power** electric fuel cell vehicles
Main Process Areas	**Hydrogen Production** methods and machinery for reforming hydrogen from base sources	Intelligent Energy, UNM	Intelligent Energy, LANL, Sandia-CA, UNM	LANL, Sandia-CA
	Storage methods and equipment for storing reformed hydrogen		LANL, Sandia-CA, NASA White Sands, WSMR, Army NAC/SES	LANL, Sandia-CA, NASA White Sands, WSMR, Army NAC/SES
	Distribution methods and infrastructure for distributing H^2 to point of use		LANL, Sandia-CA, NM Tech, Army NAC/SES	LANL, Sandia-CA NM Tech, Army NAC/SES
	Fuel Cells power producing devices – hydrogen "batteries" or "motors"	Cabot SMP Energy Related Devices UNM	LANL, Sandia-CA, UNM, NMSU, NM Tech, Army NAC/SES	LANL, Sandia-CA, UNM, NMSU, NM Tech, Army NAC/SES
	Safety Codes and Standards regs for safe hydrogen management practices		NASA White Sands, WSMR LANL, Sandia-CA, Army NAC/SES, ARES	NASA White Sands. WSMR LANL, Sandia-CA, Army NAC/SES, ARES
Opportunities	**Market Opportunities**	Fastest growing NM commercial manufacturing segment in H^2 markets for small "battery-scale" power applications.	Remote power, backup power. Wide range of demonstration projects possible, some are in planning stages in NM.	Still developing with basic and applied R&D. Some demonstration vehicles and service stations. Stimulated international research and industry partnership with Japanese R&D orgs.
	Commercial Market Timing	Immediate/Emerging	Near term – 3-8 years	Long term – 10-15 years
	Potential Market Size	Smallest – low billions $ partially realized & projected	Medium – mid to high billions $ projected	Largest – high billions $ projected
	Applicable State Incentives	Basic and Applied Research Grants, Business Development Grants: Labor Training; Start-up, Retention Expansion, Recruitment	Basic and Applied Research Grants, Demonstration Projects, Business Development Grants, Codes and Standards	Basic and Applied Research Grants, Demonstration Projects, Business Development Grants, Codes and Standards

New Mexico's Opportunity

The *New Mexico Hydrogen Energy Transformation Plan* proposes legislative actions, made in concert with research and industry actions, to advance New Mexico to *Tier Two* status among the hierarchy of state hydrogen programs – a bold, yet achievable goal that will determine New Mexico's future economic opportunities and roles in the coming hydrogen economy.

This section covers perspectives on these opportunities. First, state government support opportunities are described followed by a matrix of technical and business opportunities.

State Governmental Support Opportunities
The State of New Mexico, working through the executive and legislative branches of government and the state's three research universities, has the opportunity to support this hydrogen energy industry transformation in New Mexico. Primarily, this support would be given by authorizing state matching funds and other incentives in these strategic areas:

- Applied Research Grants
- Demonstration Projects
- Business Development Grants and Incentives
- Codes and Standards Development

Affordable widespread commercial hydrogen energy solutions in stationary and transportation power applications are projected in the future, although some stationary power applications for back-up and remote hydrogen power systems are being sold now. The pending markets for both of these power segments is projected to be multi-billions of dollars, if the corollary markets for existing stationary and transportation power systems are considered.

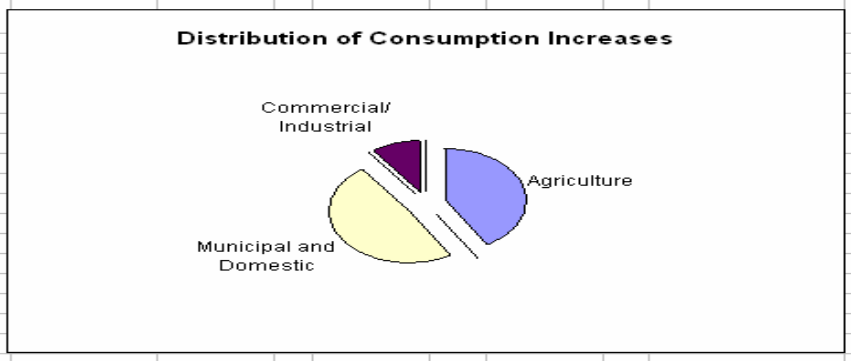
New Mexico's two national energy laboratories and the NASA test facility provide major research and recruiting anchors to global industry. LANL recently announced a groundbreaking partnership with Japan's national laboratory and national energy laboratory for joint R&D, for example, opening new opportunities for Japanese companies to establish facilities here.

This research infrastructure has and will continue to attract the major industrial and research players in the stationary and transportation fuel cell market segments to the region, providing New Mexico with ample recruitment opportunities that demonstration projects help stimulate.

The New Mexico's hydrogen energy coalition recommends a comprehensive multi-year strategic program funding by the State of New Mexico starting at a level of $4M per year and growing to several times that per year in the future.

Increased Water Supply and Clean Water
Promoting conservation and the efficient use of water
At present, even during periods of average water supply, demand in many parts of the State would exceed supply if all water rights and permits were fully exercised. As New Mexico's population grows and demands for water increase, more conservation and efficient use of water will be necessary to meet the State's present and future needs for water. Thus, New Mexico's water conservation programs must be strengthened and adequately funded.

AF Per Year	Agriculture	Municipal and Domestic	Commercial/ Industrial	Total
Year 2000	2,765,879	307,716	208,382	3,281,977
Year 2040*	3,054,937	644,846	278,260	3,978,043
Absolute Increase 2040 over 2000	289,057	337,130	69,878	696,066
Percentage Increase 2040 over 2000	10%	110%	34%	21%



Projected water demand by sector *(from the 2003 New Mexico Water Plan)*

The chart above projects a large supply deficiency by the year 2040. Demand is expected to increase from about 3,300,000 acre-feet per year (afy) in the year 2000 to about 4,000,000 afy in 2040. The increase in demand for agricultural use is difficult to predict but will be limited by available supplies, augmented by water from low-cost solutions such as conservation, cloud seeding and perhaps large-scale surface-capture. The more costly solutions for increasing water supply are not practical for the agriculture sector for economic reasons.

The most serious deficiency will be in municipal and industrial water use, which is projected to nearly double, an increase of about 400,000 afy. These figures do not include replacement of aquifer depletion, which has been occurring over the past 50 to 100 years. When this is factored in, the increase in demand may be in the order of 500,000 afy. Meeting this demand presents real challenges. The State Water Regions agree that no single supply alternative will satisfy their future needs for more water. It will require careful planning and employment of multiple alternatives. For example, cloud seeding could potentially meet 20% of the projected deficit.

Implementation Strategies

The Office of the State Engineer/Interstate Stream Commission will coordinate the creation of a multi-agency taskforce to identify, focus, and prioritize studies and research in cooperation with State research institutions, national laboratories and others institutions.

Our research institutions, universities, and national labs are a valuable resource for the latest scientific knowledge and competence. These institutions are capable of bringing the highest level of scientific and technical competence to bear on water issues within the State.

Appendix 1d. Information Technology

New Mexico Computing Applications Center

Overview

The New Mexico Computing Applications Center (NMCAC) will apply the power of supercomputing to drive high-tech business and job growth in New Mexico. The Center will also address important State needs in energy, environment, water, and health. To achieve these goals, a critical function of the Center will be to support and strengthen science and technology education throughout our State in order to build the future high technology workforce.

The Center offers three key advantages to New Mexico - it will: 1) enhance our ability to draw on the world-class local talent at our national laboratories and universities; 2) connect the State through a network of more than 40 gateways around New Mexico; and 3) serve as a bridge between our colleges, research universities, national labs, businesses, and communities. Through 'New Mexico Lambda Rail' and 'Wire New Mexico', the Center will be connected to the State and the world. Finally, the Center has 'Encanto', one of the worlds' most powerful computing systems. It is this combination that allows us to take advantage of the capabilities that exist throughout New Mexico to meet the needs of our businesses, communities, and schools.

The NMCAC is being organized by the New Mexico University Research Consortium and will be incorporated as a 501(c)(3) corporation with oversight by a Board of Directors. The Center's plan requires an investment from the State of $36 million of capital funding and operating expenses. This will be leveraged by $61.5M of non-state funds and more than $50.3M in-kind contributions. The Center is designed to financially sustain itself after six years.

The Center’s focus on applications and the use of private enterprise as an important funding source sets us apart from other supercomputing centers (which have fewer funding opportunities due to their lack of connections to national laboratories) and positions us to be more efficient.

A key element of this plan is to grow and attract industry to New Mexico. The Center's business plan draws on a market analysis of many industries and the opportunities they present in areas such as health, medical, bio med/tech, pharmaceutical sectors, and digital film and media sector. These areas stand out due to their robust market dynamics and the resident professional expertise in the State. The energy and environment market sector and in particular, alternative energy, oil and gas and water, hold promise for utilizing a high performance computing resource. The Center’s partners are already working on projects in energy and environment and will integrate these efforts in the NMCAC, where they can be performed most cost effectively. Other potential markets include nano-materials, remote sensing networks, and the financial investment sector. The Center will support (on a competitive basis) the development of new technologies by New Mexican companies. It will also partner externally to bring new companies into New Mexico.

In summary, the Center targets a sustainable business model that involves a combination of commercial, federal and state funding. The investment made by the State in the first five years is being leveraged to result in a self-sustaining operation. The Center will drive economic development, job creation, and the generation of spin-offs that will contribute significantly to the

State's Gross Domestic Product. To achieve this, the Center will integrate and support important efforts in STEM education and community development. This is all possible by coupling the computing power of the Center with the world-class scientific talent we have in New Mexico.

Renewable Energy - Green Grid

Implementing renewable energy in the U.S. in a cost-effective manner cannot be done without drawing on the capabilities of high performance computing. Virtually all aspects of renewable energy, from modeling of physical processes involved in solar cell performance, to determining optimal genetic engineering of microalgae used to produce biodiesel, to determining the best routing of new transmission lines, to designing control systems for the smart grid, and many other applications. Supercomputing will play a critical role in integrating efforts in New Mexico for the Green Grid, as is detailed below.

Developing and implementing a New Mexico statewide green grid is a tremendous opportunity but it may require investment running in the billions of dollars. It will also be a very complex dynamical system with multiple time and implementation scales. It will therefore be a significant technical challenge to predict the changes in operational and planning practices needed in existing infrastructure as well as anticipating new issues. To anticipate, understand and address various issues it is essential that we understand as much of the system, at all levels of depth and description, through modeling and simulations.

The goal of the modeling and simulation effort will be to create an integrated capability that can address the following issues and provide validated results for:

- What components (controls, appliances, generation, storage, transmission, communication) will be required at user, sub-station and utility level?
- What data generation and capture capability will be required?
- How will these components function and evolve as the fraction of power produced by renewables and storage capability increases at various levels?
- What operational parameters will be used to control the reliability and stability of the grid and how can they be incorporated into existing controls and enhanced?
- What controls and mitigation strategies will be required to increase resilience to natural and man-made threats and disruptions?
- What extra measures will be required to guarantee the security of the hardware and communications and control network?
- What is the most effective way to manage green grid operation at all levels, starting with automated management of distributed controls between utility operator and substation, then investigating lower levels of control?
- What will induce people to buy into the green grid concept (policies, incentives)? How will a green grid affect people's lifestyles and what training (workforce development) and education will be required to facilitate the change?
- What will be the cost at the residential, commercial, industrial, sub-station and utility level?
- What investment and regulatory policies will attract business and VC?

The last four issues have traditionally not been part of planning and analysis by utilities. These will, however, need to be included with the addition of distributed generation, storage and smart

appliances with two-way control at the user level as anticipated in the implementation of the green grid.

Digital Media

The State of New Mexico has made a large commitment to expanding the digital media industry in the state. What started as incentives for the film industry has expanded to a recognition that the film is a small part of a much larger and growing media industry. It is also an industry that matches the State's strengths in arts and technology. Efforts to foster this industry have ranged from having the incentives apply to post production, interactive games, and animation to support of education through the Governor's Media Education Fund. Many of the opportunities and a strategy are incorporated in the Governor's Media Industry Strategic Plan (MISP).

Not only has the State attracted Sony Imageworks to Mesa del Sol, other major players such as Albuquerque Studios and LionsGate are here, each of which will support digital efforts in post production and animation. In addition, many smaller companies in the interactive game, simulation, and animation are either here or in the process of moving here (Abalone Studios, Raventales, Novint, WorldScape, CafeFX, Extreme AI).

One characteristic of the digital media industry is the need for high performance computing. For example Weta in New Zealand (Return of the King, King Kong) has a 4400 processor rendering farm that is available commercially. Pixar Animation claims the average frame takes 6 hours to render, which would leads to about 30,000 days of computing on a single processor to render a fully animated movie. Clusters to support these kinds of jobs are not only large but required as sophisticated software as the supercomputers in our national labs.

New Mexico has a long history of involvement with simulation, primarily through SNL, LANL, and WSMR. The field is undergoing revolutionary changes due to the advances in commodity graphics hardware. Simulations that used to require expensive specialized workstations now use commodity graphics cards whose designs are based on the demands of interactive game users. Consequently, the simulation and game industries have merged and we see the National Labs being heavily involved in game development.

The increase in computing speed and power leads to another observation that is especially relevant to New Mexico. Until now the special effects that we see in movies while requiring a tremendous amount of computing are not based on physical reality. The basic philosophy has been "if it looks good, that's OK." Now we can produce effects for movies (and other purposes) that are driven by the real physics, a capability that New Mexico has within in technical community, particularly within the National Laboratories.

To foster the industry in the State, we need to look at some of the IT requirements of the industry

The digital media industry requires the availability very high bandwidth. For example, rather than fly the dailies back to LA, they will be sent over high bandwidth networks. Future work will be collaborative with groups located globally and requiring real time high bandwidth communication. For example, UNM's fulldome development projects are moving into projects that will involve multiple domes for both education and research.

Not only will the area require the full capabilities of the National Lambda Rail, many of the smaller companies will need the same bandwidth. Although there will be clusters for media-oriented companies at locations such as Mesa del Sol, one of the key attractions of the state is the potential to live in non-urban environments, i.e. not in Albuquerque or Santa Fe. Consequently, the first/last mile problem is significant. Such companies will not be satisfied with the bandwidth presently offered to consumers at a reasonable cost.

Media companies require a high degree of network security. While the traditional film industry was able to control the access to work in progress if it were in film, digital media poses all kinds of potential security issues. If the industry is to thrive in New Mexico, we must be able to provide security for our networks and central facilities.

There will still be a need for central computing resources. Smaller companies will need access to such things as large rendering farms. However, it is not clear how much will be needed since the Internet provides access to resources around the world. Although the incentives that were first used to attract film productions to New Mexico clearly apply to certain part of the media industry, it is not clear how they apply to many of the activities described above. For example, it will be increasingly difficult to distinguish between a company producing digital content and a software company.

Education has to be part of any IT planning for digital media. Unlike the film industry where programs such as the Film Crew Training Program that the State has supported at community colleges (CNM, SFCC) and can train people from scratch, the media industry needs a highly educated pool to draw on. Most will be college graduates. Educational programs that will produce the necessary workforce will have to start with K-12.

Education

It is only through growing our economy by providing high-paying, challenging jobs that New Mexico will be able to address the wide range of issues we face in poverty, health care, and education. Further, we can only address such high technology economic development with a well-educated technical workforce. For this reason, NMCAC integrates educational and economic development to support excellence in technology in New Mexico. Education and workforce development are a critical part of growing technology-based economic development. By connecting students to supercomputers and full three-dimensional (3D) visualization, we can provide an attractive and effective means of motivating students to begin careers in science, engineering, and technology.

For additional information on the educational activities of the NMCAC, see Appendix 3.

Partnering with Businesses

The NMCAC will build and support appropriate development projects with New Mexico commercial companies as part of its economic development efforts. The Center will provide both technical and computing resources on a competed basis to New Mexico companies in return for equity in the technologies developed by the companies. The Center will also be able to bridge the

divide between laboratory and university research and the needs of companies for competitive advantage. The Center will also consider R&D partnerships with New Mexico companies on a sustaining membership basis as long as the Center is not competing with private computing companies in New Mexico. The type of financial relationship will range from a sustaining membership in NMCAC to specific short-term contracts.

An important aspect of the economic development model of the Center is its ability to attract large companies from outside of New Mexico into partnering with the Center. The Center does not simply provide a business with access to the computer - our primary business model is to partner with a business to develop new applications that are of importance to New Mexico. While we will assist companies in moving from the development stage to the production stage, our primary value is in our intellectual resources - the supercomputer is simply a tool that the R&D staff use in achieving our objectives of technology-based economic and workforce development.

The Center has developed a set of criteria by which it assesses the merits of working with specific businesses in accomplishing its goal of high-tech-based economic development:

- The R&D is in an area that is important to future economic growth in New Mexico
- The Center can provide both the technical expertise as well as computing resources required for the project
- The project demonstrates reasonable prospects to lead to job growth and/or educational opportunity in New Mexico within a reasonable timeframe
- The partnering organizations agree to have their personnel spend time in New Mexico working directly with the staff at the Center
- The proposed effort does not compete with private companies in New Mexico
- The State receives adequate return on investment through a variety of possible mechanism that could include direct investment, a share in the Intellectual Property, royalties, and other revenues.

Computer Platform

The central supercomputer and the smaller computers of the same architecture distributed to the three universities form the main assets and tools that NMCAC experts will apply to the mission. Of the $14M allocated by the legislature for FY2008, the Center reserved $11M for the procurement of these computers. Starting in May 2007 in preparation for the 2008 fiscal year the founding partners of the Center wrote a request for proposals to the national computer vendors to provide these machines. After a competitive solicitation the winning vendor was selected who has provided a 172 TeraFlop (172 trillion calculations per second) computer, siting, power and cooling for the central machine, and system administration through the first year as well as three smaller examples (each 2.1 TeraFlops) of the same architecture to the universities to serve as high performance computing gateways. At the time the computer was procured in November, 2007, it was the third fastest computer in the world.

The specifications for the computing system as procured are:
172 Teraflops (peak theoretical speed) Altix ICE 8200 cluster peak theoretical speed
(132 Teraflops sustained operation measured using standard Linpack tests)

Consists of 1792 nodes (14,336 cores) of quad Xeon 3.0 GHz processors housed in 28 racks
28.7 TeraByte of local memory (2 GB/core)
20 TeraByte NSF storage system
172 TeraByte parallel file system with 12 GigaByte/sec bandwidth
GigE connectivity to Lambda Rail (available up to 10 Gigabits/s)

Three exemplar systems (2.1 Tflops peak speed) have also been procured and installed at the three major research universities:

22 nodes (176 cores) in a single rack
352 GigaByte memory (2 GB/core)
16 TeraByte raw NSF storage system

The contract negotiations were completed and the computers tested by the first user in February 2008 during the legislative session. Full-time "friendly user" mode started in May 2008. A transition to production running is expected to occur on August 1, 2008. This has been a very successful procurement reaching a “stellar deal” in which New Mexico has received remarkably good value for an $11M investment. When the supercomputer was procured in November, 2007, it was the third fastest computer in the world. In the June 2008 "Top 500" rankings, it is listed as the 7th fastest computer in the world. In a ceremony held in January, it was named 'Encanto'. Encanto will provide an incredibly strong foundation for the Center to promote economic development and education.

Gateways

It is critically important to the success of the Center that it be able to connect to all the Science and Technology and STEM Education initiatives throughout New Mexico. In order to meet this need, the NMCAC will implement gateways at all the institutions of higher learning throughout New Mexico. This results in approximately 44 gateways located throughout New Mexico (as shown in Figure 2). Each gateway will be connected to the Center in Albuquerque by high-speed connectivity (primarily fiber and digital microwave) that is part of the Wire New Mexico initiative. All of the gateways will have high-speed, high-definition videoconferencing, 3-D visualization capabilities, and desktop computers. In addition, the primary gateways located at the institutions of the founding members (NMSU, NMT, UNM, LANL, and SNL) will have “exemplar” computers, which are small clones of the primary Center supercomputer. These “exemplars” have 2.1 Teraflops of computing speed along with a local file storage system. They will be used by the institutions to develop and test new applications before they are run on the supercomputer. They will also be used to train students in parallel computing, visualization, and systems administration. Smaller “microclusters” will be used at other gateways for similar purposes.
The State will initially equip the gateways with the following elements:

- High-speed connectivity to the core facility located in Albuquerque
- Micro cluster with the same architecture as Encanto
- 3-D visualization wall screen
- Desktop computers (as needed)
- High-speed, high-resolution video teleconferencing
- Software required for the systems

In addition, the Center will be providing access to time on the mainframe computer and support from the computing staff located at the core facility. The state will provide repair parts and equipment upgrades on an ongoing-basis.

Location of NMCAC gateways in New Mexico.

There are two important elements of this arrangement. First, all the institutions must become members of the NMCAC. This will ensure that we have synergy among efforts across the state and leverage effectively the resources of the Center. This will allow institutions to partner more effectively in joint research as well as to develop and share distance teaching courses that are targeted at meeting the state's future workforce needs. Second, by locating the gateways at institutions of higher learning, we will be bringing our K-12 students onto campus and familiarizing them with life on campus and the opportunities that exist there. This will play an important role when the students are considering whether or not they want to attend college and

where. It will also bring together faculty, students, and R&D businesses on campus, thus leading to the possibility of fellowships and jobs for students.

Appendix 1e. Nanotechnology

Issues, Needs, and Opportunities (SWOT Analysis)

- Outstanding high tech and nanotechnology research capabilities exist in the state
    - Sandia National Laboratories
    - Los Alamos National Laboratories
    - University of New Mexico
    - New Mexico Tech
    - New Mexico State
    - Center for Integrated Nanotechnologies (jointly operated by SNL and LANL)
    - SNL's MESA, the Microelectronics Engineering, Sciences, and Applications complex, a $600M complex of state-of-the-art clean rooms and laboratories
    - UNM's Center for High Technology Materials
    - National Institute for Nanoengineering
    - Science Parks at SNL, LANL, UNM, AFRL, etc.
- Numerous high tech companies with expertise in semiconductors and semiconductor based energy technologies
    - Large company: Intel for computing
    - Small but growing companies in solar photovoltaics (Emcore, Advent), solid state lighting (Insight Lighting, a company expressing interest in opening a branch), and other nano-energy technologies (NanoPore for superinsulation).
- Current relationships with companies in the energy sector (Sharp, ExxonMobil, etc) exist at various levels of maturity.
- Past National lab participation in DOE-sponsored technology roadmapping and workshop reports for Solid State Lighting, Solar Energy, Superconductors, Catalysis, Electrical Energy Storage
- Current activities with Industrial partners on NINE provide nascent industrial partnerships
- Opportunity for the DOE Labs to provide facilities and expertise to new start-up companies that need assistance (similar to current state assistance program but with an increase in the funding limit per project)
- Need to differentiate from activities in other states: What does NM have that is differentiating from large and powerful states who are investing, like CA and TN?
- Interest of an engaged and energetic Governor
- Ready access to the NM Congressional delegation, far beyond what is typically available in other states.
- Major interest of NM Congressional delegation in energy issues, with the two NM Senators being chair and ranking member of the Energy and Natural Resources Committee, and one Senator being ranking member of the Energy and Water Appropriations Subcommittee.

Issue of Branding, Differentiation, and Size and Scope. In order to have a dramatic effect on economic development in NM, it is critical that any initiative be bold enough that it captures the imagination and attention of potential corporate participants nationwide. In effect, it needs to perform a ***branding of the state of NM*** as the place where new energy/nanotechnologies are being incubated. It needs to engender the feeling amongst companies that by not participating in

the initiative, they will be left out – NM is *the* place to be for companies serious about work in this area.

To capture the kind of attention needed, the initiative will need to be large and bold, but also sufficiently focused so as to be credible and compelling. Nanotechnology – as well as materials science, microfabrication, simulation and modeling, etc. – is expected to have impact on a very broad range of applications, including telecommunications, computing, medical sciences, and on a constellation of energy efficiency and renewable energy technologies. In order to select a good application area on which to focus, the following considerations should be kept in mind:

- The area should be one that is not already taken by another team in another state. Thus, for instance, the Nanoscale Science Research Center at Lawrence Berkeley Nation Lab in California is already focusing on bio fuels, and has a huge repository of investments and expertise on which to draw. They have begun the Helios project to focus on this area. While the Helios project may be an excellent model for how partnerships might be structured in NM and how IP might be handled, we should select a different application area as our flagship effort, so that we are not forever playing catch-up with the state of California.
- The applications area should be one in which substantial differentiating expertise is already present in the state, both at the National Labs and at universities. This also enhances the credibility of the proposed initiative, and enables the rapid mobilization of resources and expertise for the project.
- The applications area should be one in which New Mexican companies already have substantial presence and expertise. This would allow us to build upon their momentum, expanding the existing companies and using them to attract additional partnering companies in the future. It also further enhances the credibility of the proposed initiative.
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Proposed Area for New Mexico's Nano Initiative: Given the above considerations, we propose that an initiative be launched in the area of nanoscience and nanotechnology transfer to accelerate the development of reliable, cost effective efficient and renewable energy. The State of New Mexico would establish an initiative for Nanotechnology for Efficient and Renewable Energy (NEARE) that will leverage the large federal investment in S&T made at New Mexico's federal laboratories Sandia, Los Alamos, and the AFRL, and the state's investment in S&T at its institutions of higher education. The focus of the initiative would be on nanomaterials to achieve greater efficiencies and performance. The development and insertion of cutting edge science and technology would enable a constellation of efficient solutions to the nations energy problems, that will also capture the attention of industry in photovoltaics, solid state lighting, refrigeration and insulation, electricity transmission, and electrical energy storage. The initiative will result in thousands of new jobs for the state.

In order to avoid competing with the ongoing initiatives in California (Helios and the DOE Joint BioEnergy Institute) and in Tennessee (the DOE BioEnergy Science Center), the center of gravity of the effort would be in nanomaterials for the following technology areas:

- Solar photovoltaics based on inorganic semiconductors, for high efficiency concentrated solar power
- Solar photovoltaics based on inorganic/organic hybrids, e.g. Gretzel cell and similar technologies involving conducting polymers and quantum dots, for low cost distributed solar power
- Solar production of hydrogen and/or CO for transportation fuels using nano-engineered materials
- Solid state lighting, including both wide band-gap semiconductors and organic OLED materials, quantum dots for phosphor materials, photonic lattices for light extraction and control over the photonic density of states, etc., for dramatic increases in lighting efficiency
- Nanoelectronic and nano-engineered materials for electrical energy storage, including supercapacitors and ultra-batteries
- Advanced materials, and characterization for increased reliability of renewable energy
- Advanced testing and integration strategies
- Nanoengineered high-temperature superconducting materials, for low-loss distribution of electrical power over the grid, low loss transformer stations, ultra efficient electrical motors, etc.
- Nanoengineered thermoelectric materials, for ultra-efficient refrigeration and the harvesting of waste heat for electricity
- Fuel-cell membranes with nano-engineered porosity and conducting properties, for dramatic increases in efficiency
- Nanoporous materials for ultra-efficient insulation and heat transfer via evaporative cooling
- etc….

We propose that, like the Helios project in California, New Mexico should establish NEARE in such a way that the substantial DOE investments in New Mexico's science and technology be leveraged. This would include not only the DOE Nanoscale Science Research Center (NSRC) Center for Integrated NanoTechnology (CINT), but also the broad array of world-class facilities and expertise across the full breadth SNL and LANL programs.

However, our feeling is that CINT might provide a natural nucleation point for a larger New Mexico initiative in nano-for-energy, NEARE. Several of the other NSRCs have already been successful in putting together federal, state, and private sector partnerships for energy, and have used their NSRCs as anchor points. Perhaps the most successful is the Helios Project in California, which might serve as a starting model for the New Mexico initiative. The reason that we are proposing that CINT be a nucleation point is that we feel that this will be the most effective in attracting the attention of businesses. However, it should be noted that the initiative itself should be broadly inclusive of all NM institutions and capabilities that can participate.

Action Items

1. **Establishment of a NM State Technology Authority.** We recommend the establishment of a NM State Technology Authority. The Authority would oversee a state technology investment and incubation fund of $100M/year, making decisions about how to distribute the funds amongst different State-sponsored Technology Areas, including Energy, Bioscience, Aerospace, and Nanotechnology. The Council would be appointed by the governor, and would include representation from state government, large and small businesses located in the state, the NM university system, and the federal laboratories located in the state (Sandia, LANL, and AFRL).
2. **Establishment of a NM Technology Development Grant Program.** We also recommend the establishment of a NM Technology Development Grant Program. This would be an expansion of the existing Governor's Energy Innovation fund. However, we recommend that considerably larger Grants be considered in the case of larger companies willing to open branches in New Mexico. These grants would be given to businesses to help them develop new technology concepts in the areas of Energy, Bioscience, Aerospace, and Nanotechnology. Grants would be given for innovative new product development, and would require substantial matching funds. *We recommend that this program be a large enough size to attract international attention:* ***$50M/year.***
3. **Establishment of a Federal Technology Transfer Program.** In conjunction with the NM Technology Development Grant Program, we recommend that a parallel federal program be established for the transfer of technology from National Labs to businesses. This program would provide funds to the National Labs to enable National Lab scientists to work with businesses to develop new technologies in the key technology areas identified with the aid of the State. These federal funds would require matching funds from the state, as well as matching funds from the businesses working on the technology. The State could provide funds through the Grant program mentioned above, as well as through the NM Small Business Assistance program. (The NMSBA program should itself be expanded so that the maximum size of a project is increased to $50K.) The matching requirements would help to establish a three-way partnership, with the state incubating economic expansion in New Mexico, the National Labs providing access to world-class expertise and resources, and the businesses encouraged to take risks they might not otherwise take in developing profitable new products leading to new jobs and economic growth. We note that the recently passed America Competes Act authorizing the establishment of Discovery Institutes provides one possible mechanism for such a federal tech transfer program. By devoting a portion of the Discovery Institute funding to tech transfer (either existing funding or through a supplemental appropriation), a significant program could be started.
4. **A Paramount role for Energy Efficiency and Renewable Energy.** While we have discussed the key technology areas of Nanotechnology, Bioscience, and Energy, a flagship program on Nanotechnology for Efficient and Renewable Energy should be considered. Nanotechnology is a broad topical area, and has wide ranging applications in such areas as medicine, computing, national security, and industrial production. Bioscience is similarly broad in potential applications, impacting areas such as agriculture, medicine, and homeland security. Because of the breadth of possible ways that investments in nanotechnology and bioscience could be implemented, there is a

danger that any state effort in this nano could become defocused, investing in many different small projects with no coherent theme. This could lead to a hodge-podge of different efforts, each too small to draw attention. ***Rather, we recommend that the state pick a small number of flagship areas, where the effort is substantial.*** This increases the likelihood of success, and is more likely to draw national attention and attract the participation of large corporations. Our recommendation is that one of these key areas be Nanotechnology for Efficient and Renewable Energy (NEARE), the use of nanoengineered semiconductors and other materials to control their physical properties so as to achieve futuristic energy performance. Nanotechnology can make major impact in the areas of solid state lighting, and in photovoltaics; each of these applications require the efficient conversion of electrons and holes into photons or vice versa, and the efficiency can be improved by the nanoscale patterning of materials to manipulate the physics of these microscopic particles. Bioscience can make major impact through the development of biodiesel and cellulosic ethanol. This overall energy focus for nanotechnology is in keeping with the Governor's focus on Energy, and can help brand New Mexico as the leader in emerging energy technologies.

Best practices that are in place or could be adopted by NM

The Helios Project is a state-leveraged activity that links to the Energy Biosciences Institute funded by BP, and is an aggressive approach to driving state economic investments, through leveraging state, federal and industrial investments in emerging technology development. Helios is an emerging research program, based at the University of California-Berkeley and Lawrence Berkeley National Laboratory that leverages Berkeley's Molecular Foundry, their NSRC equivalent to CINT. (Helios also links to many other facilities and activities in the area and is fairly broad in how it links to UCB and LBNL.) The Helios Project targets the research and development of new efficient processes to produce transportation fuel from biomass or from solar-energy-driven electrochemistry. Helios is developing an innovative management plan for integrating the efforts of leading scientists and engineers from disparate disciplines into a single large program. Partnerships will be developed with researchers from a broad base: universities, other national laboratories, and industry. Funding for the project will be similarly broad-based: $500M over 10 years has already been committed by industry (BP, formerly British Petroleum), up to $70M may be provided by the State of California, and up to $15M may be provided by private donors. The federal government (through the DOE Office of Basic Energy Sciences) is also playing a key role through the Molecular Foundry Nanoscale Science Research Center and a solar energy research institute, and thus will provide substantial funding. The expectation is that the Helios Project will maximize the innovation and scientific and engineering strengths of its researchers to produce solutions to problems encountered on the route to efficient and scalable solar fuels, on a time scale of five to 20 years.

Vision for the Future.

As HELIOS moves forward, the hope is that it will hasten scientific breakthroughs and carry them through to the practical applications that are required to resolve the energy issues facing our nation and our planet. Of course, every state is different, and each state must consider its unique needs, resources, and institutions. Other examples of successful state-federal partnering include the DOE Center for Nanoscale Materials at Argonne National Laboratory, which includes funding from the State of Illinois, and the DOE Bio-energy Science Center at Oak

Ridge National Laboratory, which leverages $80M in state and private-sector sources. In an effort to accelerate renewable energy technologies, it would make sense for the state of NM to consider collaboration with the State of Colorado, at least as far as including the National Renewable Energy Laboratory (NREL) in Golden, CO in this initiative. SNL and NREL are currently collaborating on solar projects and both labs offer fairly different facilities and expertise, although there are also substantial areas of synergy. We propose that the State of New Mexico, building on the expertise and investments of the national laboratories and other resources in the state, undertake an emerging energy initiative project of similarly bold scope as Helios. Our focus, however, should be in an arena where we have unique differentiating strengths: materials for energy efficient technologies (lighting, refrigeration, electrical motors, capacitors, fuel cells, electrical grid power distribution, etc) and renewable energy technologies.

Stakeholders and Partners :

- Technology representatives from SNL and LANL
- Regional small business partners
- State of New Mexico economic development
- Representatives from large industrial partners
- New Mexico State Universities, this will help reach out to different parts of the state
- State Investors (Angels, etc)

Identification of areas in which existing resources in NM could drive economic development.

There are many examples where federal investments at the national laboratories have resulted in start-up companies located in New Mexico. Increased partnerships and investment between industry, state and federal, something NINE is working hard to develop, is expected to accelerate the development of intellectual property that could drive increased opportunities for economic development. The state currently has a small amount of funding and the mechanism in place (the New Mexico Small Business Assistance program) that allows for small companies to access the National Laboratories facilities and staff to address critical technical issues. It appears that this activity continues to be successful, especially with regard to increasing the viability of new businesses, and it should be included as a part of the NEARE initiative. However, it is clear that to make a real impact any future program needs to be much more bold and ambitious.

Background on DOE NSRCs.

In FY 2001 the U.S. Government launched the interagency National Nanotechnology Initiative (NNI) to accelerate the pace of revolutionary discoveries in nanoscale science and engineering and to facilitate the incorporation of these scientific advances into beneficial technologies. As part of the NNI, DOE's Office of Basic Energy Sciences (BES) has established five new Nanoscale Science Research Centers (NSRCs) located at DOE laboratories. These five Centers, each housed in a new laboratory building with new scientific equipment, are BES national user facilities. The capital investment in these Centers is roughly $100M each. CINT, with a facility in Albuquerque and another one in Los Alamos, is one of the five NSRCs and is jointly operated by Sandia and Los Alamos National Laboratory. CINT has state-of-the-art facilities staffed by laboratory scientists, post-doctoral fellows, and technical support personnel. Users can obtain access to CINT capabilities through a peer-reviewed technical proposal for either independent or collaborative research submitted through the web in response to semiannual Calls for User

Proposals. Precompetitive research that will be published in the open literature can receive no-fee access to CINT, while proprietary research can be conducted on a cost-recovery basis. CINT has already approved and undertaken over 200 user projects, with the in-kind labor of CINT scientists typically valued at ~30K for each project.

The four scientific thrust areas of CINT are Nanophotonics and Optical Nanomaterials; Nanoscale Electronics, Mechanics, and Systems; Soft, Biological and Composite Nanomaterials; and Theory and Simulation of Nanoscale Phenomena. Thus while there is overlap between CINT and the other four NSRCs, it is widely acknowledged that CINT's differentiating strengths lie in (1) semiconductor materials growth and processing, in part through access to MESA, and (2) a focus on the integration of nanotechnology into applications.

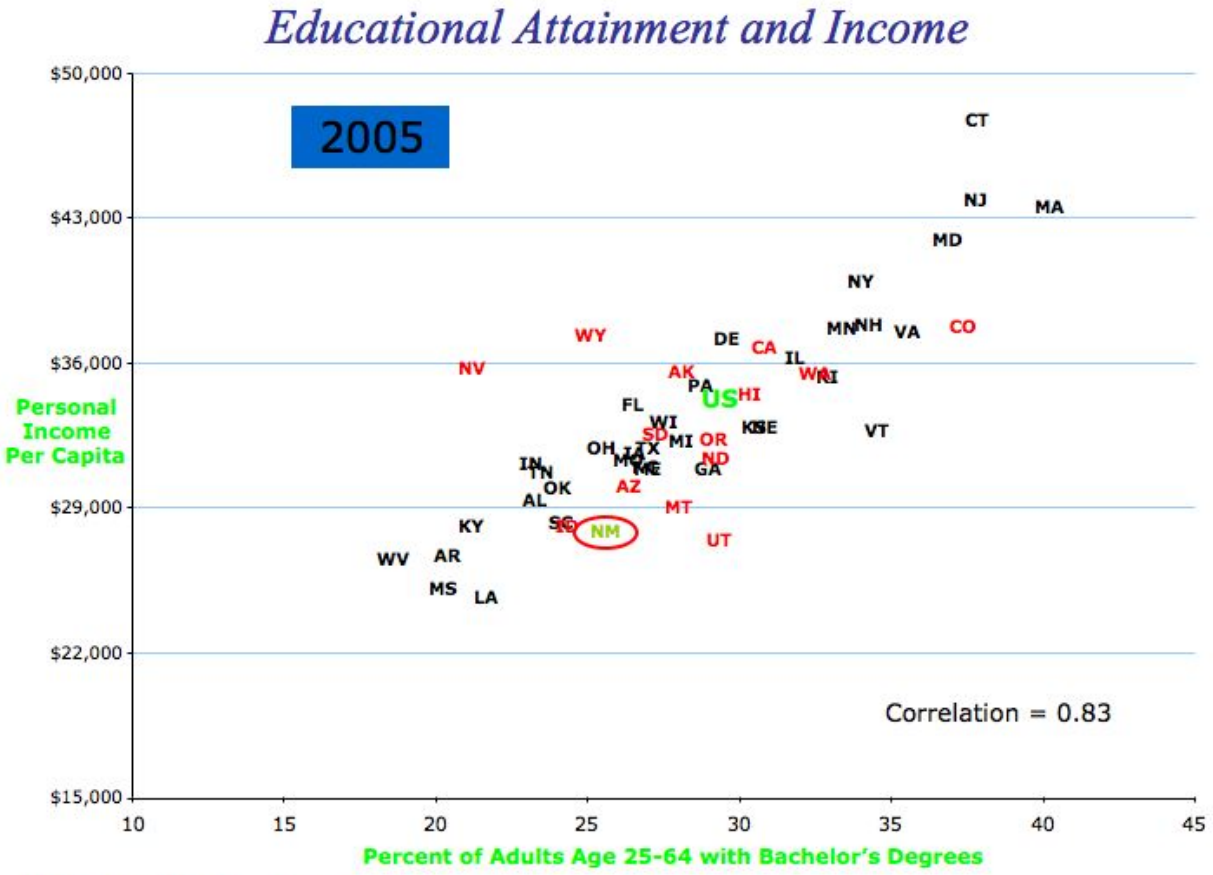
Indeed, it is because of this differentiating strength that the National Center for Solid State Lighting (NCSSL) is affiliated with CINT. The NCSSL, established in October of 2006, is a virtual research center involving the five DOE NSRCs. Funded by the DOE's Office of Energy Efficiency and Renewable Energy, the NCSSL program seeks to build upon the investments made by the DOE/BES by performing targeted research in nanotechnology in areas that could increase the efficiency and lower the cost of LED-based lighting. Projects are selected from the five NSRCs by a competitive proposal process. Sandia has been named the Lead Laboratory in the NCSSL. With proposals from both Sandia and Los Alamos, CINT captured 5 of the 7 projects awarded ($3.4M of the $5M appropriated) in FY06.

This example shows how the emergence of new energy technologies can be aided by leveraging existing investments and expertise, resulting in the creation of something that is greater than the sum of its parts. In this case one part of DOE was leveraging investments made by another part. However, by broadly involving the National Labs, local industry, regional universities, and the state, it should be possible to accomplish something that is more visionary and much larger.

Appendix 2a. Education and New Mexico Development

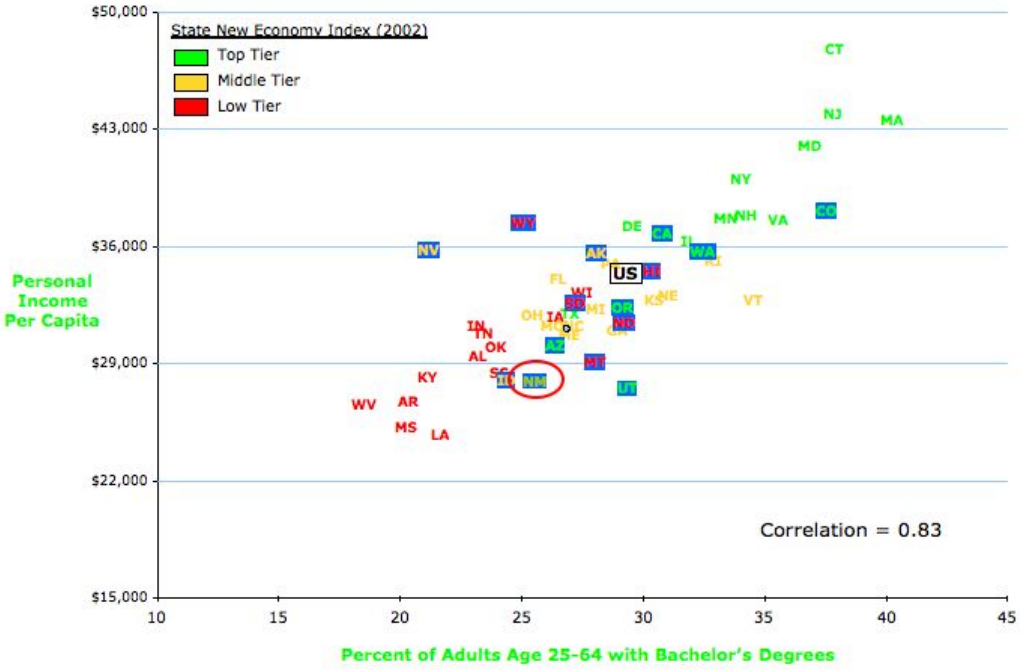
Education is the key to the 21st century, both in terms of economic prosperity and personal achievement. Today's new economy is knowledge-based, entrepreneurial, and globally competitive to an extent that was almost unimaginable even a decade ago. Addressing our challenges in per-capita income, health care, and crime is dependent on a high level of achievement in education. Yet New Mexico students lag significantly in many measures of K-20 academic success, thus imperiling our prospects.

There are striking correlations between having an educated populace and their economic and health prosperity as well as the level of crime experienced. Finally, education attainment is strongly tied to salary levels. The following charts show these correlations for the 50 states and point out where New Mexico ranks. The underlying challenge that we face in New Mexico is improving the performance of our students, which is a critical element in increasing our citizens income, health, and prosperity while also reducing crime in the State.

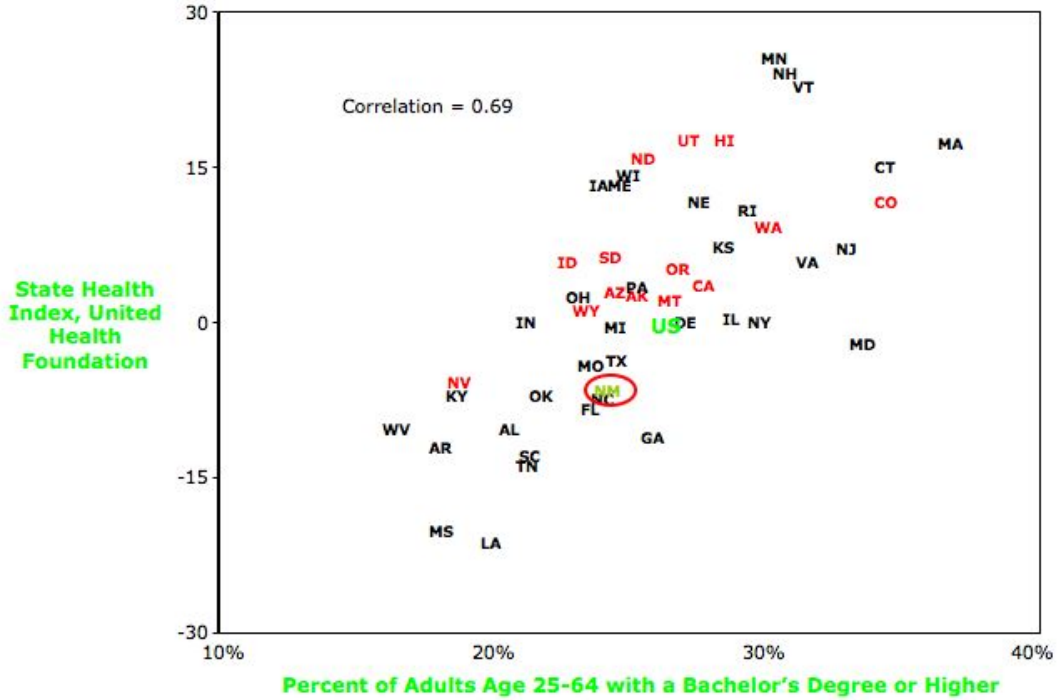


Source: U.S. Census Bureau, Decennial Census' and American Community Survey

Relationship Between Educational Attainment, Personal Income, and Economic Strength, 2005

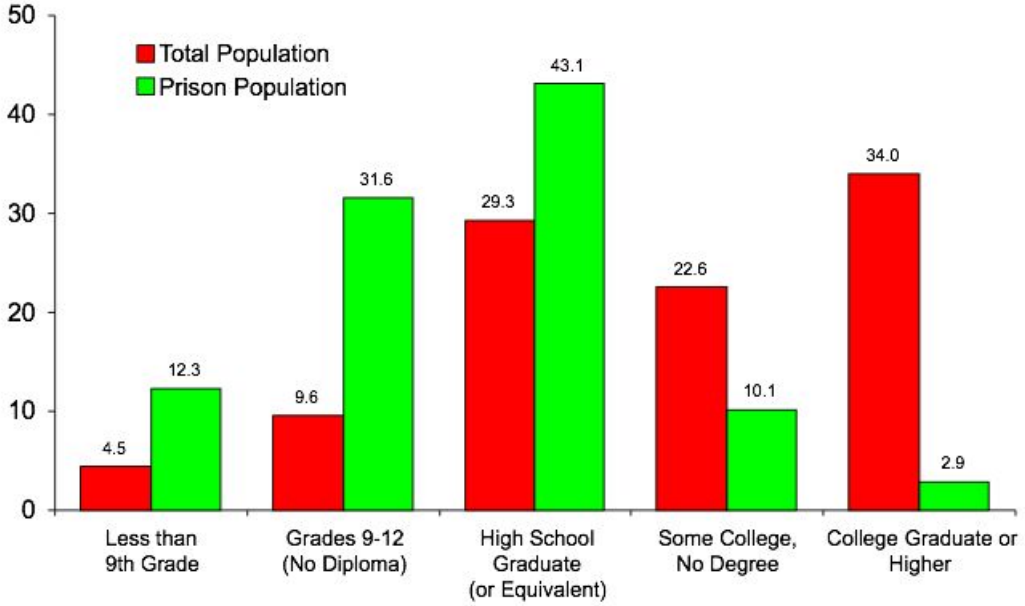


Relationship Between Educational Attainment and Health



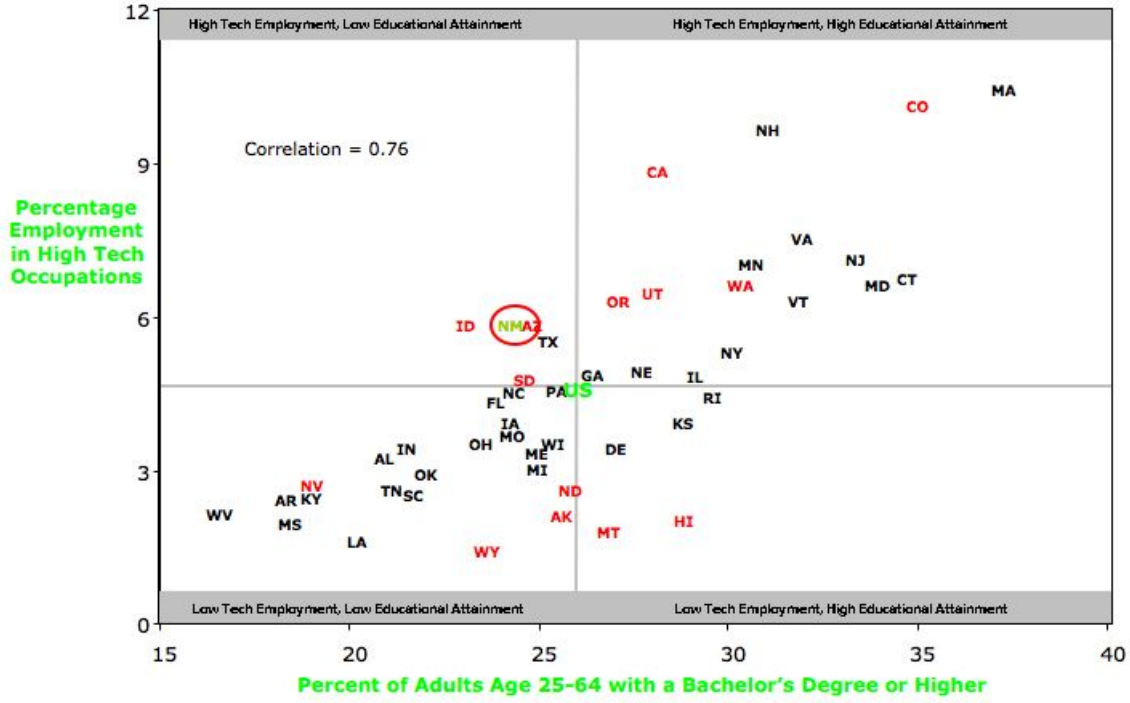
Source: United Health Foundation, U.S. Census Bureau

Educational Attainment of Adults Age 18-64 — Total U.S. Population vs. Prison Population (Percent)

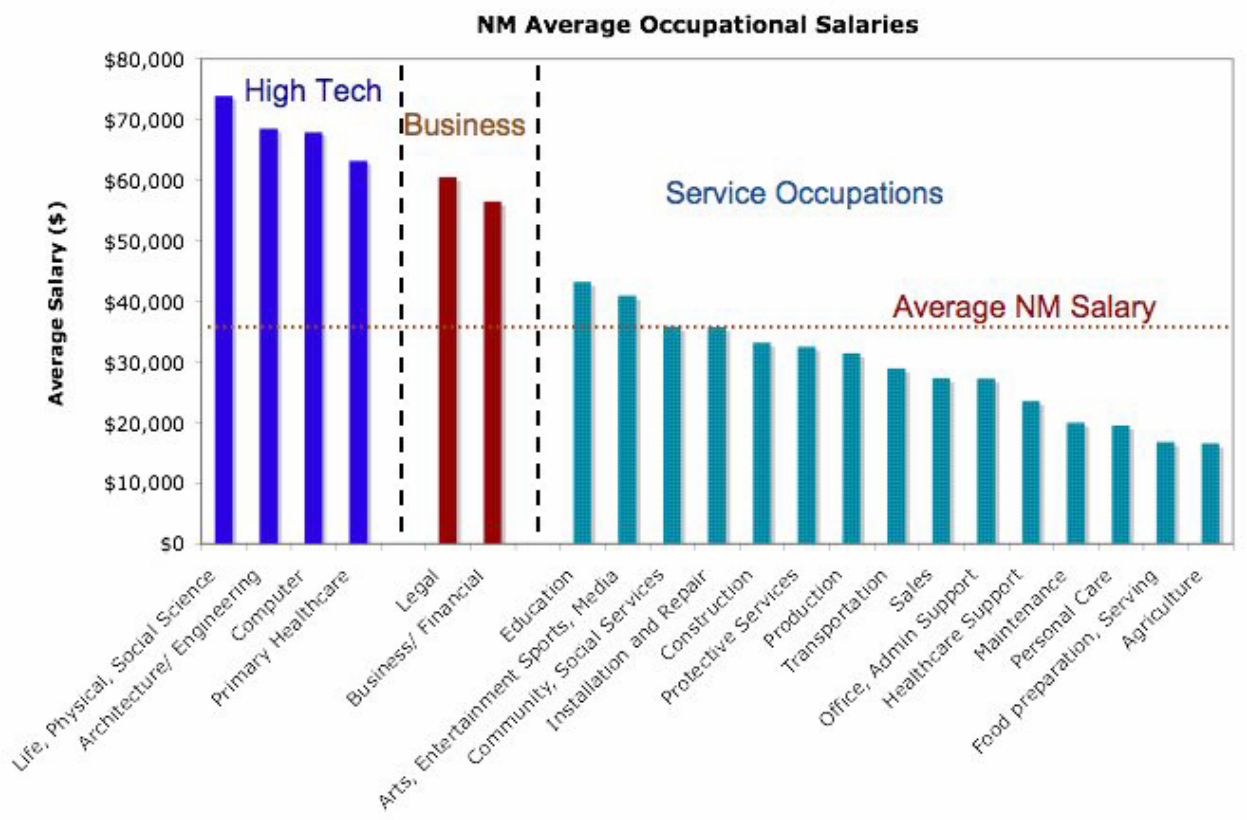


Source: U.S. Bureau of Justice Statistics 2002 data, U.S. Census Bureau 2005 data

Relationship Between Educational Attainment and High Tech Employment



Source: State New Economy Index, U.S. Census Bureau



From the charts shown above, the correlations between educational performance and personal income, health, and crime are striking. Further, it is clear that if we are to improve per capita income for New Mexicans requires an increase in the number of high-tech and business jobs in the state. The final figure shows that the salaries for high-tech jobs in New Mexico is 2.4 times that of jobs in the service sector. Thus, the most effective way to increase personal income is to grow the number of high-tech jobs in New Mexico. The primary goal of the State S&T Plan is to do exactly that.

Appendix 2b. Public Education (K-12) Goals and Strategies

New Mexico Project 2012
Executive Summary

Education is the key to the 21st century, both in terms of economic prosperity and personal achievement. Today's new economy is knowledge-based, entrepreneurial, and globally competitive to an extent that was almost unimaginable even a decade ago. Yet New Mexico students lag significantly in most measures of K-12 academic success, thus imperiling both their individual prospects and those of the State.

Nowhere is this more evident than in math and science education. Improving on this situation will be challenging, but it is essential that we do so. As Governor Bill Richardson has repeatedly emphasized, a competitive, technically capable workforce is a key part of New Mexico's economic future. And a reasonable level of math and science awareness among our population is an ever-more important part of good personal and civic decision-making.

Because of these workforce challenges, expectations for math and science education have been rising over the last three decades. In 1986 a New Mexico high school graduate was required to pass two math courses and two science courses. Today the requirement is three of each and will soon be four in math. In 1986 high school math graduation standards were more or less at the current seventh-grade level. Today many schools require Algebra II for graduation, and by 2010 all students who enter high school will have to meet that requirement.

These higher expectations make apparent some significant challenges, chief among them the simple need to produce more high school math teachers. In the 2007-2008 academic year over 1100 teachers taught high school math. Nine hundred of them were fully licensed and subject-matter endorsed. Clearly more will soon be needed. In addition, the teacher workforce is aging: in 2008, the average age was 46 with 42% being 50 or older. However, to meet these demands New Mexico's public teacher preparation institutions in 2007-2008 graduated only 26 high school math and 27 high school science teachers from their regular undergraduate and graduate programs – an insufficient number.

New Mexico's large geographic area, low population density, and rich cultural and linguistic heritages present additional challenges to the goal of providing equal educational opportunity for all of our students. The advent of readily available broadband access to information and the educational possibilities of both high-performance computing and distance learning present attractive opportunities to address this issue.

In its legislative session of 2006, the Governor and the New Mexico State Legislature funded a Math and Science Bureau (MSB) in the Public Education Department (PED). It also established a Math and Science Advisory Council (MSAC) to advise the Secretary of Education and the PED on matters related to K-12 math and science education. The MSB and MSAC were created based in part on recommendations1 of the New Mexico Partnership for Math and Science Education.

The strategic components of NM2012 are to: (1) increase student interest, participation, and achievement in math and science; (2) raise public support and awareness of the importance of science and math to New Mexico's economic health and security; and (3) to establish effective collaborations with internal and external partners.

NM Project 2012 builds on those themes. Its goal is simple yet dramatic: that in five years New Mexico K-12 students will be among the nation's leaders in math and science achievement. While recognizing that this is a very ambitious goal, we believe it is a strong motivating force for positive change.

The seven components of NM Project 2012 are:

- To improve math and science content study in the pre-service education of K-12 teachers to prepare them well to teach robust math and science curricula while at the same time increasing the supply of those teachers;

- To expand professional learning opportunities for K-12 math and science teachers so that they can stay abreast of current pedagogy as well as math and science content knowledge;

- To align the strategies used for teaching and learning math and science in New Mexico's K-12 classrooms so that they focus on the essential skills of inquiry-based learning, problem-solving ability, and writing and literacy acquisition;

- To provide quality distance-learning opportunities for New Mexico's students via the Innovative Digital Education and Learning in New Mexico (IDEAL-NM) project, the New Mexico Computing Applications Center (NMCAC), and related projects; and through television programming and broadband internet access;

- To draw on the extensive math and science expertise of New Mexico's very large community of engineers, mathematicians, and scientists in providing specialized classroom content knowledge; student tutoring, mentoring, and career advice; and in helping with professional development activities for teachers;

- To build a state-wide STEM2 education community that includes students, parents, teachers, school administrators, institutions of higher education, state and local governments, and the business community, all united to insure that New Mexico's young people are well-positioned to meet the 21st century; and

- To create an effective public awareness campaign promoting math and science education that will energize our young people, and all of New Mexico, to realize a rewarding future.

Though NM Project 2012 does not explicitly discuss post-secondary education, it is intended to be aligned with the prerequisites for entry-level college and university coursework in engineering, math, and science.

IDEAL NM

New Mexico is the first state in the nation to create a statewide eLearning system that from its inception encompasses all aspects of learning from traditional public and higher education environments to teacher professional development, continuing education and workforce education.

Background

The IDEAL-NM (Innovative Digital Education and Learning in New Mexico) initiative was announced by Governor Bill Richardson in 2006, and created by legislation in 2007 to:

- Implement a statewide eLearning delivery system for P-12, higher education, and state agencies.
- Create a state-led eLearning program in partnership with local schools, districts, and Regional Education Cooperatives. The intent of this program is to provide online courses that supplement the curricular offerings of New Mexico schools.
- Create a statewide eLearning Service Center for P-12, higher education, and state agencies to support the use of the shared eLearning delivery system via the LMS.

IDEAL-NM provides eLearning services to New Mexico P-12 schools, higher education institutions, and government agencies. It reduces geographic and capacity barriers to educational opportunity while increasing the digital literacy skills students need to participate in a global economy.

IDEAL NM provides the following services:

- Collaborate with New Mexico schools in providing online courses that expand educational opportunity for all students. The high-quality courses are taught by New Mexico teachers.
- Work with Regional Education Cooperatives in facilitating eLearning best-practices training for member schools.
- Implement a shared eLearning infrastructure using a single statewide Learning Management System, web conferencing system, and Help Desk.
- Provide professional development courses for P-20 teachers, and training courses for government agency employees (courses to be developed in 2008-09).
- Promote statewide sharing of other educational resources, including subject matter expertise, instructional content and support services.
- Coordinate with other statewide technology initiatives.

IDEAL NM has the following goals:

- Expand education opportunities, close achievement gaps, support college and career goals, and prepare students for global competition.
- Reduce the cost of technology access to P-12 schools, higher education institutions, and state agencies.
- Reduce the travel and personnel costs of state agency trainings and P-12 teacher professional development via online courses.
- Increase technology application skills of New Mexico youth and adult learners.
- Facilitate more cooperation between P-12 schools, higher education institutions and state agencies.

Project GUTS

Project GUTS -- Growing Up Thinking Scientifically -- is hosted by the Santa Fe Institute and is a summer and after-school science, technology, engineering and math (STEM) project for middle school students based in Santa Fe, New Mexico and serving northern New Mexico. Growing up thinking scientifically means learning to look at the world and ask questions, develop answers to the questions through scientific inquiry, and design solutions to their problems.

Supercomputing Challenge

The New Mexico Supercomputing Challenge is dedicated to increasing interest in science and math among 6th through 12th grade students by introducing them to computational science. During the academic school year, teams of students from across New Mexico complete computational science projects under a sponsoring teacher. The Supercomputing Challenge culminates with a presentation of the projects that are judged by several professionals in a competition for swards of trophies, savings bonds, scholarships, and computer equipment for the schools. An average of 300-400 students a year participate, with over half being minorities or women. This program has engaged students from more than 80 schools across New Mexico.

NMCAC Education Program

The Center addresses educational needs in NM across a broad spectrum. It represents an important resource to attract our kids into science, math, and engineering, to provide computer-based capabilities in teaching our kids, in providing educational research activities for our college students, in training our teachers to bring computer science into the classroom, and in providing high-tech jobs that will retain our students in New Mexico.

The Center will be an educational tool for New Mexico's K-12 students. It will support distance teaching and learning activities in the State (such as IDEAL), provide short in-house learning experiences about computational science using state-of-the-art 3-D visualization techniques, and provide training courses for K-12 teachers in computer and computational science. We must first excite our young people about science and technology. We can do that by providing play-based learning using computers and visualization. Then we must provide them with the opportunity so see and learn in a hands-on fashion. We can do this by showing them (using 3-D visualization) how computers allow us to model the world around us and to make virtual changes that allow us to understand how our decisions will change the world in the future. Our kids are already attracted to visually-oriented computer games that allow them to control the actions of characters in the game. We can use this same method to engage kids by having them "play" computer games that simulate the world and that allow them to change things in the game (such as using solar energy instead of oil or coal) that affect the sustainability of a state or country. In this type of learning game, there is no single right solution – it is not a test. Rather it is a way of learning that shows our kids how to solve complicated problems using computers and visualization as a tool. In this manner, we can show our kids the increasingly important role that simulation plays in the workplace and to attract them into careers that will use simulation to solve many of the problems that society faces.

The gateway facilities proposed in this initiative will start this by bringing kids from local schools into the Center to participate in short learning courses. We will then grow the Center through regional gateways in all areas of the State to connect to local schools. This requires the

network capability provided by Lambda Rail along the Rio Grande and Wired New Mexico to the rest of the State. The Center will be a statewide asset that will support the State's existing and proposed distance learning and teaching initiatives.

The Center will offer the opportunity for college students to learn how computing is applied to solving real-world problems that companies and communities face. They will work side-by-side and under the guidance of Center staff at the core and gateway facilities as they learn real-life computing and research skills. They will be able to do this as partial credit for courses they take at school as well as by competing for research fellowships that allow them to get paid as they develop their skills in applying computing to a wide range of problems. This kind of practical learning experience will position them very well when they go seeking permanent jobs in a high-tech world.

The Center will allow graduate students to spend a significant portion of their academic careers on-site, interacting with faculty and industrial staff from the partnering institutions. These students would receive their degrees from their home schools, augmented by a certificate from the Center. These certificates would become sought-after accreditations of "computational readiness" for Ph.D. and Masters degree students.

The Center will directly engage college students, graduate students, and postdoctoral fellows by having them participate in the on-going research projects at the Center. This will not only serve to train them in computer modeling and simulation but will also develop their understanding of critical issues facing New Mexico such as energy, water, environment, and health. Finally, it will get them connected with the member institutions and high-tech businesses in New Mexico, thus serving to position them when they seek permanent jobs.

Another important service the Center will provide is for training of K-12 teachers in how to bring computing into the classroom. This could be accomplished in several different ways: having short (2-4 week) part- or full-time courses offered for teachers during the summer where they would receive instruction from and work with Center staff; having teachers participate with Center staff as part-time interns during the year; and providing support for efforts such as the "Masters of Science Teaching" program at New Mexico Tech. The Center will also support the State's distance teaching efforts by providing computing tools and training for teachers in rural areas that they can use in their classrooms.

Appendix 2c. Higher Education Goals and Strategies

Goal 1: Build coalition of business, industry, and government installations and labs to take ownership and provide coherence in statewide advancement of STEM education and workforce development			
Strategy 1: Create P-20 Council, including industry, business, national labs, education, etc. (chaired by Gov and top 10 CEOs in the state)			
Actions	Resources Needed	Timeline	Responsible Parties
Complete plan for P-20 Council and present to governor	Plan has been completed by Flores	September 2007	Bill Flores, Kurt Steinhaus, Rick Scott, Veronica Garcia
Establish membership and calendar of meetings	Draft completed		
Create strategic goals for p-20 council that include increasing the state's capacity for STEM partnerships and education at all levels.			HED, Governor's Office, P-20 council and HED STEM bureau or group or center
Strategy 2: Create an HED STEM Bureau in collaboration with Governor's Office and P-20 Council			
Partner with existing STEM consortium group at NMSU and with PED Math/Science Bureau to consolidate and coordinate all STEM education programs in state, P-20	*Note*: this may exist as collaboration efforts between HED STEM programs and the K-12 science and math plan for New Mexico		
Provide complete web-based database of current STEM efforts in the state (build on NMSU's database – see http://stem.nmsu.edu)			STEM faculty and researchers at NMSU can help.
Develop assessment tools for analyzing effectiveness of current STEM education programs P-20 in order to replicate state-wide	Funding for meeting of evaluators of state STEM programs and support for assessment		Educational researchers (Pascal) researcher in state math/science bureau Ken Korn, MC2 evaluator, etc.
Work with National Governor's Association to get additional funding for state STEM work	*Note:* in top of proposals, only 6 funded but we were asked to submit again for next year's funding		Governor's office, NMSU STEM working group

Goal II: Build a seamless and coherent P-20 strategy that provides P-12 students increased access to STEM education			
Strategy 1: Create statewide programs based on successful STEM programs that bring additional P-12 students onto campuses, national labs and businesses to prepare them for entering STEM fields.			
Actions	Resources Needed	Timeline	Responsible Persons
Expand the current database of STEM p-12 education programs from NMSU to all state programs	Research GA, can be supervised by Harold Smith at NMSU?	Spring 2008	NMSU STEM working group Other institutional reps added; contact people at all campuses, labs, partner businesses
Assess STEM education programs based on evidence of promising practices	Support for researchers to work collaboratively across state (Have current proposal in for this to Robert Duncan, Los Alamos Institute A S?)		Work with Math/Science Bureau Scott and researcher. Ask hwsmith@nmsu.edu for copy of proposal
Strategy 2: Recruit and retain diverse faculty (women, minorities, faculty with disabilities) into Higher Education faculty and researcher positions. STEM HED staff representing increased diversity (STEM Bureau)			
Obtain funding to strengthen Higher Education STEM departments including science, math, engineering education by funding increased faculty positions. in these fields	Funding for diverse faculty to take positions in higher education and community colleges		HED, higher education council of deans
Strategy 3: Double number of teachers certified in STEM fields with advanced preparation in the science, technology, engineering, and mathematics disciplines (program with salary supplements and scholarships for (pre-service teacher education			
Actions	Resources Needed	Timeline	Responsible Persons
Design new teacher education partnerships between STEM faculty and education faculty, pre-service May want to use UTEACH (Exxon) proposal as model-students majoring in math, science, engineering & computer science can get teaching credential and BS or BA degree	Build from taskforce that created first U-TEACH proposal. Provide some faculty release time (TIME) May be able to get funding through modification of last year's proposal –	Fall 2007-task force meetings. Consider U-Teach model to all campuses in state or do as pilot first for NMSU	Waded Crusado-Salas Bob Moulton STEM faculty, dept. heads, research deans, e.g. Pat Morandi, Dan Brown, Jim O'Donnell, Cathy Kinzer, Susan Brown
Provide competitive salaries for teachers in STEM field			PED, State Legislature

Provide scholarships for teachers who will major in teaching science, math and other fields . Consider developing a new teacher certification in computer/information science and engineering. NOTE: New Mexico has no credentials for computer science teachers or engineering educators	Funds for students to focus teacher education work in STEM fields.		Deans, associate deans, and dept. heads involved in Arts & Sciences, Engineering and Education colleges.
Strategy 4: Provide opportunities for in-service teachers to increase knowledge and qualifications for teaching STEM subjects. (in-service strategies). Work collaboratively with PED k-12 math/science plan			
Actions	Resources Needed	Timeline	Responsible Persons
Create NM Research Experience for Teachers program (similar to NSF program)	Funding similar to RET in NSF and/or apply for this grant		VP-Research office
Coordinate and Expand MAT Master of Arts in Teaching math and science programs to provide advanced education for existing teachers)	Have invested funds in this already. Faculty would like release time, NMSU faculty have discussed state-wide MAT for secondary teachers with Kristen Umland, UNM	MAT in science and math currently has 75 students in partnership with Los Alamos MSA	Currently have MAT in math and MAT in science run by dept. heads and faculty in Arts and Sciences and Education
Strategy 5: Develop five5 STEM high school academies in diverse regions of the state with academic focus in strategic areas such as aerospace, nanotechnology, digital arts, robotics, energy, bioinformatics, etc.			
Actions	Resources Needed	Timeline	Responsible Persons
Partner with higher education institution and district s to create schools. Begin by identifying interested districts and HE institutions			
Use as these high schools/academies as lab schools for teacher education of future teachers in STEM fields			

Strategy 6: Collaborate with P-12 to align curricula between P-12 system and higher education and enrich both institutions			
Actions	Resources Needed	Timeline	Responsible Persons
Develop and implement pedagogies that require inquiry-based STEM learning strategies at all levels (Do science, math, and engineering to teach and learn these fields.)	Faculty teams from throughout higher ed.	Spring 07	Provosts Tech, UNM, NMSU, WNMU, ENMU
Develop and implement pedagogies that require inquiry-based STEM learning strategies at all levels (Do science, math, and engineering to teach and learn these fields, (don't just read about.)			Look at Engineering Lead the Way and at MC2 secondary grant-funded program for ideas
Increase dual credit programs for high school students in STEM area. Investigate current dual credit programs and procedures and increase amount offered in STEM	Provide course releases or supplemental funding to faculty to work on new dual credit courses		Partner with Brian Ormand and e-learning, IDEAL New Mexico group as well as others
Establish incentives for higher education faculty to teach STEM in engaging, hands-on ways to high school students (possibly in partnership with high school or middle school teachers).			Dr. Ted Stanford, Mathematical Sciences and Wanda Guzman, master math teacher are currently teaching Algebra to average students on Tuesday and Thursday at Picacho MS
Strategy 7: Focus on role of school counselors in guiding students to STEM fields (prestige, opportunities, higher expectations—bring counselors to university campuses for STEM workshops/showcases)			
Actions	Resources Needed	Timeline	Responsible
Establish or expand yearly counselor meeting to include STEM focus at universities	Minimal, could be a function for the College of Education Alliance?	Before next counselor meeting begin to add	Study NMSU counselors meetings

Goal III: Provide additional state funds for higher ed STEM efforts			
Strategy 1: Fund strategic hires of women and minority faculty in STEM fields to provide role models to increase recruitment and retention of diverse students			
Obtain funding to strengthen Higher Education STEM departments including science, math, engineering education by funding increased faculty positions. in these fields	Funding for diverse faculty to take positions in higher education and community colleges		HED, higher education council of deans
Stategy 2: Increase by 50% funding for number of GRAs and fellowships for graduate students majoring in STEM fields			
Determine current state dollar allocation for GA , RA support by institution			Graduate Dean Council and business officers
Strategy 3: Increase by 50% scholarships for undergraduate students to major in STEM fields including Science or math teaching credentials			
Action	Resources Needed	Timeline	Responsible Persons
Determine current dollar allocation for scholarships			Provosts and business officers
Strategy 4: Match R&D—joint public-private partnerships between higher ed and industry			
Work with TRC and CEOS to determine impact/ Return on Investment of research on economic development in NM (ROI)			TRC, provosts, VPR Council
Strategy 5: Provide matching funds for federal grants (NSF, NIH, DOE, ED, etc.)			
Strategy 6: Providing funding for mentored research opportunities for undergraduates			
Goal IV: Increase capital investments in identified NM areas of strength			
Strategy 1: Increase facilities development for critical areas of scientific research			
Action	Resources Needed	Timeline	Responsible Persons
Conduct External Assessment of facilities needed to meet critical areas of scientific research (NSF)	Funding needed for Assessment		NSF offers assessment services
Strategy 2: Fund Equipment upgrade and purchase in strategic STEM areas			
Assess current state of equipment; develop plan for renewal			VPS Council and business officers

Appendix 2d. Workforce Development

Current Innovative Education Initiatives for Workforce Development:

New Mexico workers who are seeking employment within the five innovative sectors of the New Mexico science and technology plan will need adequate education and training opportunities. Currently, opportunities exist in a number of community colleges in New Mexico:

Aviation and Aviation Technology at Central New Mexico Community College

The aviation industry has made great strides in New Mexico. In order to ensure that existing and emerging aviation industries in New Mexico have a highly qualified, New Mexico based workforce, Central New Mexico Community College has established an aerospace and aviation technology program. Students enrolled in this program may receive an associate of applied science degree in aerospace technology or a certificate in professional pilot and flight instruction. Pending approval by the New Mexico Department of Higher Education and the FAA, students may also receive an associate of applied science degree in aviation maintenance technology or a certificate in airframe maintenance technician or a certificate in power plant maintenance technician.

Eastern New Mexico University, Roswell Campus Aviation Training Program

In partnership with the Flight Safety Training Alliance, the Eastern New Mexico University campus in Roswell is breaking ground on a new National Flight Test Center. This center will offer instruction on safety training for pilots and will test aircraft.

North American Wind & Research & Training Center at Mesalands Community College

In the last few years, New Mexico has experienced a windfall of significant development of its wind energy potential. In 2006, the land of enchantment ranked fifth in the nation in wind generation capacity. In December 2007, Governor Richardson joined with Minnesota Governor Tim Pawlenty to establish the "Governor's Windpower Coalition" as a way to promote the increased use of wind energy in the United States.

In order to fully realize the wind potential of New Mexico and to prepare a qualified work force to support innovation in wind energy industries, Mesalands Community College in partnership with Tucumcari Economic Development Corporation, New Mexico Economic Development Department, New Mexico Energy, Minerals, and Natural Resources Department, Sandia National Laboratories, Coalition for Clean Affordable Energy, Regional Development Corporation, and New Mexico State University has developed the North American Wind Research and Training Center (NAWRTC). The mission of NAWRTC is to provide exemplary training (certificates and/or an associates degree) for wind energy technicians, wind farm managers and power electronics managers in North America. In addition, the NAWRTC highlights the potential for wind power in New Mexico and provides a location and support for research. Enrollment is underway for the fall 2008 semester. General Electric recently announced that it will consider hiring all of the wind energy technician graduates for the next three years. Representatives from Mesalands Community College have been in contact with other energy companies about the hiring of graduates of the wind energy technician program.

Santa Fe Community College's Sustainable Technologies Center.
Santa Fe Community College (SFCC) is developing a Sustainable Technologies Center (STC) to expand their education and workforce training programs in renewable energy, smart grid, green building and environmental technologies. In June of 2008, SFCC is hosting a forum entitled "Workforce Training for the Green Economy." The forum is designed to assist SFCC in identifying and planning for meeting current and future workforce training needs to support environmental, renewable energy and sustainable technology industries in northern New Mexico.

Other Innovative Initiatives:
Throughout his tenure, Governor Richardson has been a champion of energy innovation projects and has been committed to making New Mexico the "Clean Energy State." New Mexico has enacted a Renewable Portfolio Standard that requires at least 20% of electric utility power supply come from renewable sources by 2020. The State has established the Renewable Energy Transmission Authority (RETA), the first of its kind in the nation. The RETA was created to develop the transmission systems necessary to move New Mexico's renewable energy to instate and out-of-state markets. New Mexico has also established tax credits for increasing the production and use of clean energy. To drive energy innovation, we have established the clean energy projects program and the clean energy innovation Fund. The clean energy projects program invites public entities to seek competitive grants for "clean energy" projects, including renewable energy, energy efficiency, and clean-burning transportation fuels. The clean energy innovation fund seeks projects that will inspire the faster commercial adaptation of clean energy technologies in New Mexico. Following a concerted effort to make New Mexico highly business friendly, we have attracted a number of innovative renewable energy businesses to New Mexico including two of the most advanced manufacturers of solar energy technology (Advent Solar and Schott Solar).

In the fall of 2003, the New Mexico Wind Energy Center was created. This facility is the third largest wind farm in the world. As Governor Richardson stated at the grand opening of the center, "Working together, we can create a stronger renewable energy industry – and that means more jobs, and higher-quality jobs, for the people of New Mexico." The wind center consists of close to 140 turbines and produces up to 200 megawatts of power, enough electricity to power 94,000 average sized homes in New Mexico.

In April of 2008, the city of Las Cruces dedicated its first commercial photovoltaic system. The 6-kilowatt system was installed on the roof of the Southwest Environmental Center and will generate about 11,000 kilowatt hours of renewable energy each year. Also in 2008, Kit Carson Electric Cooperative, working with Los Alamos and Sandia National Laboratories and partnering with American Capital Energy, has started work on a 1 MW solar photovoltaic system in Taos.

In the summer of 2008, Sandia National Laboratories and Kirtland Air Force Base began working together on the Sandia Wind Farm Feasibility Project, a part of the Department of Energy Transformational Energy Action Management (TEAM) initiative. The Sandia Wind Farm Feasibility Project is researching the possibility of constructing a shared wind farm that could provide up to one third of the electricity used by Sandia and by Kirtland. This farm could be located on federal lands or on the Isleta Pueblo.

In June of 2008, the United States Department of Agriculture awarded $3 million to Albuquerque's Sacred Power Corporation to install hybrid solar photovoltaic systems on Navajo homes. Homes in targeted areas will be adapted for compatibility with Sacred Power's hybrid power stations.

Also in June of 2008, the Department of Energy has released about $950,000 to the Arrowhead Center at New Mexico State University. These funds will be used to conduct research on improving the economy of New Mexico by encouraging the state's production of fossil energy.

The Airforce Research Laboratory is relocating its Battlespace Environment Division to Kirtland Air Force Base from Hanscom Air Force Base. Battlespace Environment Division focuses on mapping and predicting the space environment. This move means at least 100 high tech advanced positions will be available to New Mexicans in 2011.

Appendix 3. The Planning Process

Based on a statewide technology survey of capabilities for technology-based economic development in New Mexico and an assessment of past S&T planning activities, the Plan groups S&T capabilities in New Mexico into five areas. We formed working groups in each area. The charge to the working groups is attached as an Appendix. We also formed two interdisciplinary teams in the areas of education and economic development to address crosscutting issues. The charge to the interdisciplinary teams is also attached as an Appendix. Finally, we had a core team that included representation of most of the S&T perspectives from around New Mexico. Their task was to finalize the S&T Plan.

Elements of the Plan are:

- Description of the Cluster and assessment of issues
- Strengths, Weakness, Opportunities, Threats (SWOT analysis)
- Elements of investment plan
- Process for making sustaining investments
- Projected Return on Investment
- Metrics, oversight, and accountability processes
- Request for FY09
- Integrate and coordinate State investments taking into account Federal basic R&D, mid-stage, late-stage, and commercialization efforts
- Include workforce development and education aspects

The development of the S&T Plan has involved more than 150 people across the State. Input has been received through two town meetings held in Albuquerque and Las Cruces in December 2006 as well as through a number of meetings of the working groups throughout 2007 as well as a full Advisory Group Meeting on May 15, 2008. Input has also been solicited by emails that were sent to several hundred people across New Mexico.

Finally, we reviewed the efforts at S&T Planning in several other states, among them: Maine, Massachusetts, Missouri, Oklahoma and South Dakota. Each has been analyzed for its best practices and compared to the others.

The five core areas where New Mexico has particular strengths are:

I. Aerospace
II. Bioscience
III. Energy/Environment/Water
IV. Information Technology
V. Nanotechnology

The core S&T Planning team consisted of:

State Offices: Tom Bowles (chair), Stephan Helgesen (vice-chair), Sarah Cottrell, Fred Mondragón, Bill Hume, Marlin Mackey, Lenny Martinez, Roy Soto, Kurt Steinhaus, Eric Witt

Universities: Van Romero, Vimal Chaitanya, Terry Yates/Jack McIver/Julia Fulghum

Labs: Terry Wallace, Rick Stulen

Rural NM: Jim Fries, Margaret McDaniel, Gene Simmons, Faye Vowell

R&D Organizations: Garrey Carruthers

Discipline Leaders: Scott Bryant**,** Casey de Raad, Bill Feiereisen, James Peery