Addressing The Energy Challenge: Resource Resilience

Presented to:
PACOM

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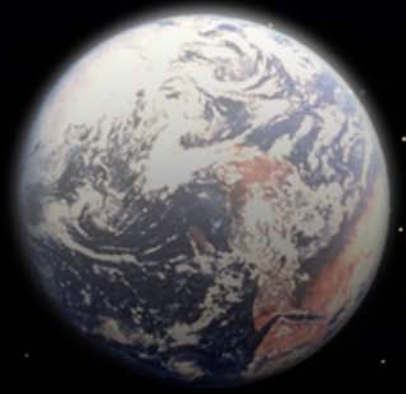
OAK RIDGE National Laboratory

Regional Profile: Southeast Asia

- **Energy has been the driver of Asia's record growth, stability and development since WW II**
- **Many diverse cultures with strong cultural heritage**
- **Fastest growing energy consumer region in the world**
  - **Five of the Top Ten Energy Users-**
    - **Japan, China, Taiwan, South Korea, India**
  - **Four of Top Ten US Export Partners-**
    - **China, Taiwan, Japan, South Korea**
  - **Four of the Top Ten US Import Partners-**
    - **Japan, China, Taiwan, South Korea**
  - **Five of the Top Ten Highest Populations-**
    - **China, India, Indonesia, Bangladesh, Russia, Japan**

Energy

- **The world's largest industry**
- **The number one challenge facing humanity**
- **A principal driver for global stability**
  - **Climate change**
  - **National security**
  - **Economic competitiveness**
  - **Quality of life**



- **Compels nation-state behavior**
- **Creates Environmental concerns**
- **Stresses Trade Relationships**
- **There will be an "Energy Trip-wire"**

Resource Resilience

- **Balance the resource equation:**

  Environment / Energy / Water / Waste

  – **Tailored to the target (country, region, etc.)**

- **Guam as a microcosm of the Resource Resilience Challenge**

  – **Native Population**

  – **Seaport Functions**

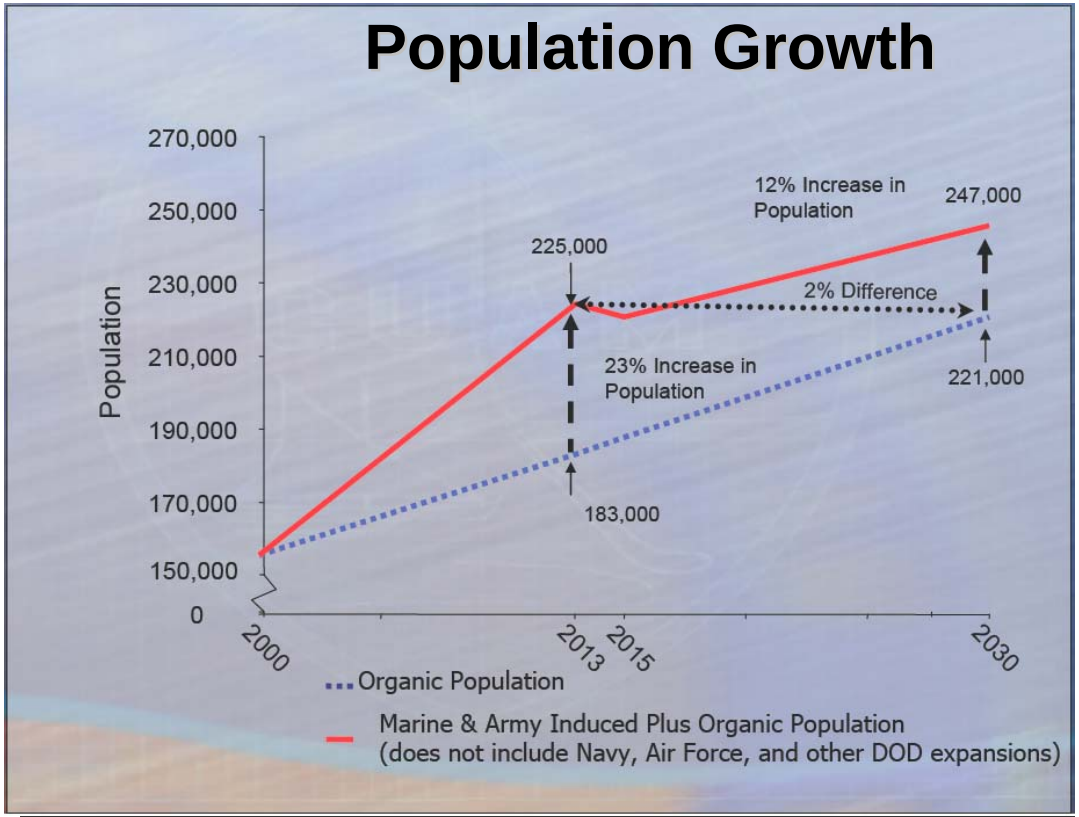
  – **Airport and Tourism**

  – **Ecological Balance**

  – **PACOM Plans (Marine, Air Force, Navy, Army)**

General Geography

- **Population: 175,877**
- **Elevation: sea level to 406 m**
- **Economy: US military spending and tourism from Asia**
- **Area 541.3 sq. km**
  - Approximately 3 times the size of Washington, D.C.



http://www.guamindustryforum.com/publications/GuamIndustryForum-II-Infrastructure.pdf

Population of D.C = 588,292

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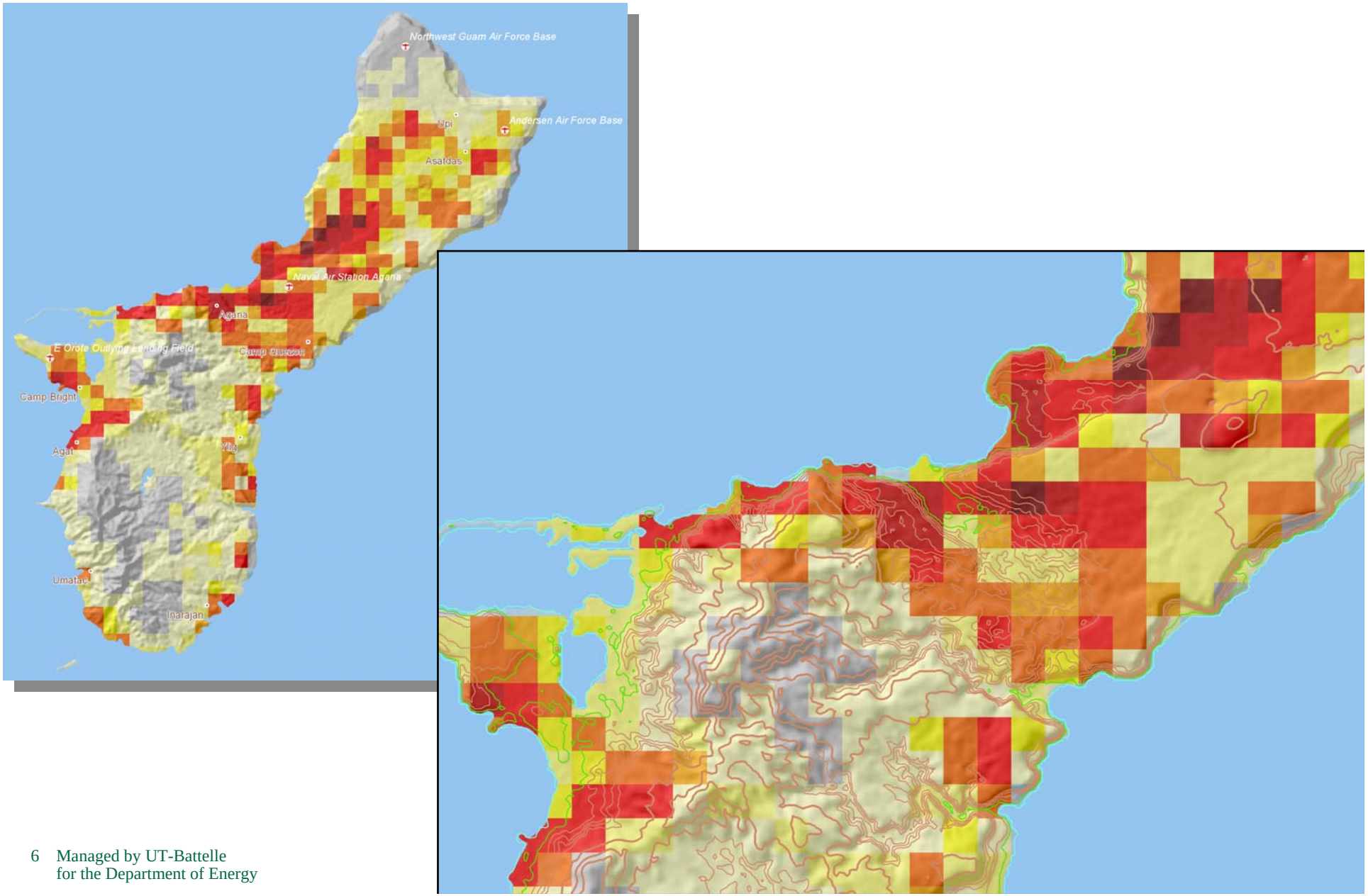
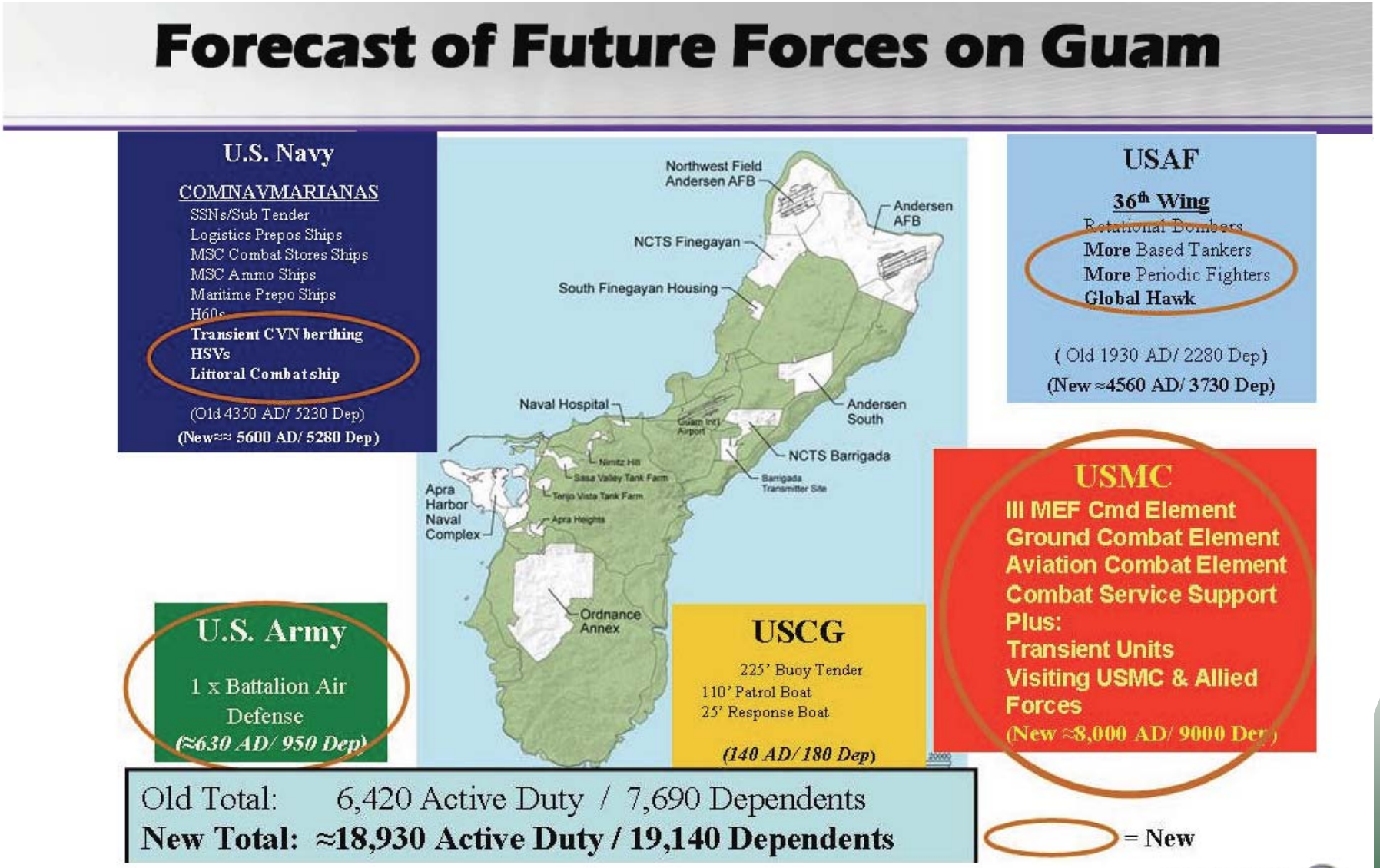
Guam: Population Distribution



Guam: Military Realignment



Source: http://www.guamindustryforum.com/publications/GuamIndustryForum-II-RealignmentProgramUpdate.pdf

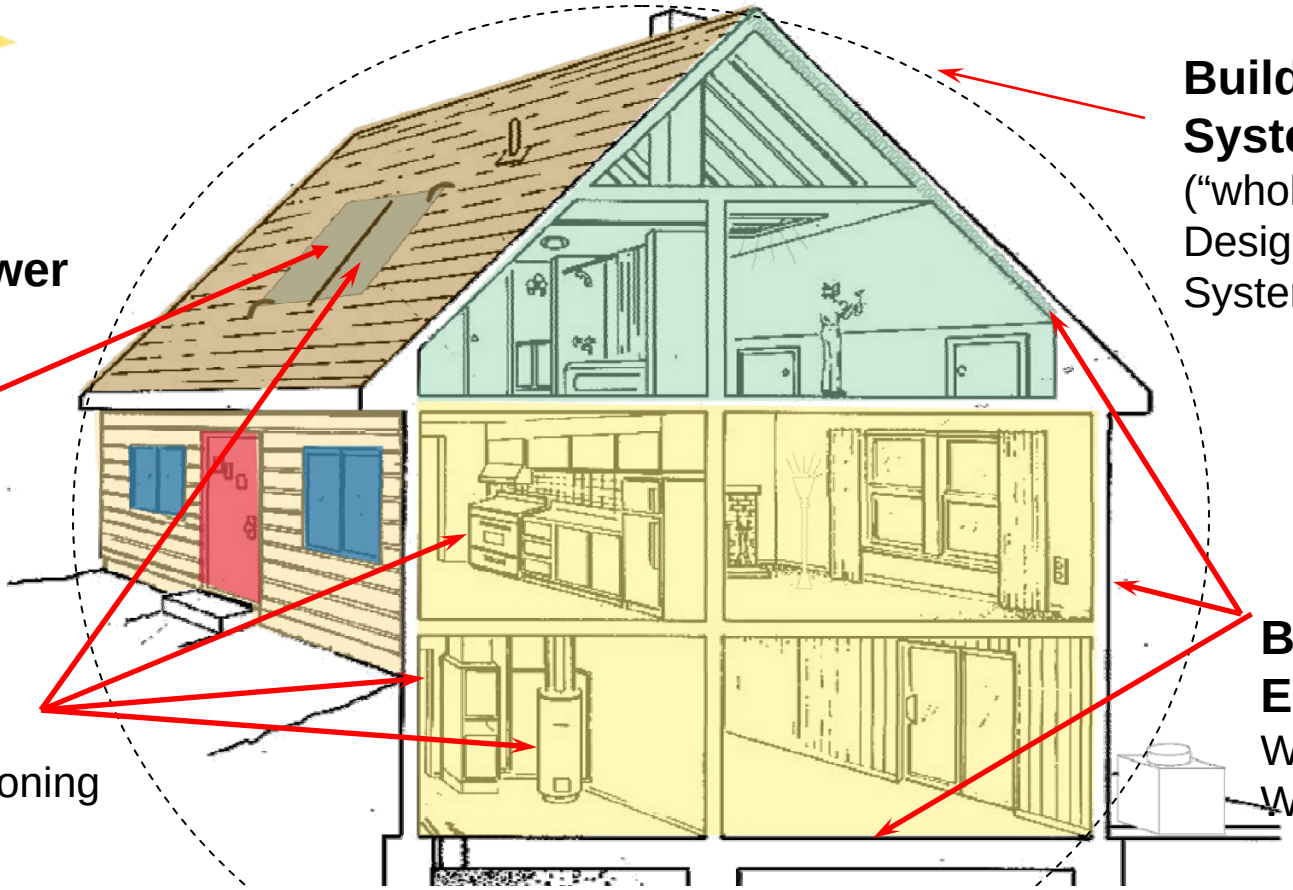
Energy Opportunity Options across the PACOM AOR

- **Think long term-ten to fifty years**
- **Technology assessment**
- **Systems thinking and interaction**
- **Capitalize on technology futures**
  - **Renewable energy**
    (hydro, solar, wind, bio)
  - **Energy Efficiency**
    (zero energy homes, electric transportation)
  - **Base Load**
    (Oil ? – Nuclear)
  - **Distribution**
    (Grid)

Guam Military Housing
Typhoon Resistant Construction

- **Concrete masonry construction**
  - **Well sealed walls, windows and doors**
  - **Homes typically have:**
    - **Low natural ventilation rate (e.g. < 0.1 ACH, leakage < 1 ft^2)**
    - **Negative shell pressure relative to outdoors (e.g. (-) 2 - 4 Pascals)**
  - **As a result:**
    - **Moisture control problems leading to mold/mildew**
    - **Poor indoor air quality**
    - **High indoor radon levels**
    - **Efficient construction but energy efficiency opportunities exist**

Opportunities for improved efficiency in buildings are enormous.



On-Site Power Systems
Building Integrated Photovoltaics
Fuel Cells

Building Equipment
Space conditioning
Lights
Appliances
BIPV, PEM-FC

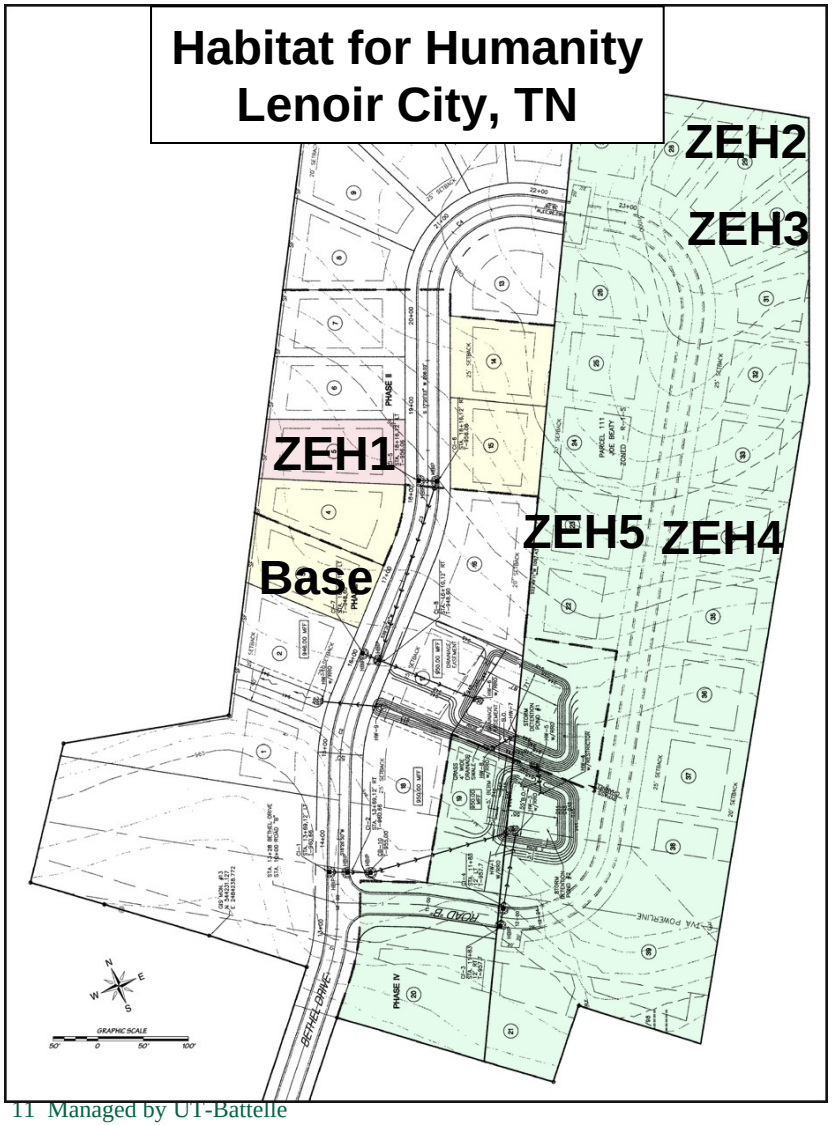
Building Systems
("whole-systems")
Design tools
System Integration

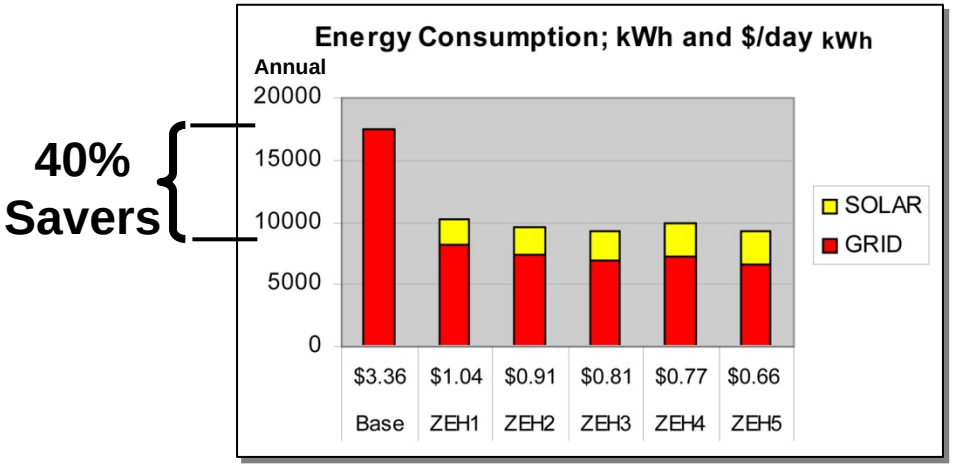
Building Envelope
Windows, Walls, Floors

Buildings consist of a complex system of interacting components facing variable input conditions

Materials Intensity

Five Years (2002-07) Five Homes
Building America 40% Savers in Mixed-Humid Climate





Buildings: Partner to develop deep-savings components to enable zero-energy, demand-responsive buildings

Whole-house energy savings: 40% use; 40% peak periods

Integration of today's technology

Heat pump water heater: 50% energy savings

Ground-source IHP: Saves 50% on H, C, WH, D

Air-source IHP: Saves 50% on H, C, WH, D in mild areas — Partner Sensitive

Appliances, suites, whole-home E-mgmt

ZEHcore wall and SIPs save energy and cost — Partner TBD

Whole-house energy savings: 70% use; 80% peak periods

Integration of emerging technologies from partners

Zero-energy homes shown (zero-energy buildings similar)

ZEH5 two story, 54% energy saver without solar, 67% with solar

Deploy proven technologies in schools and commercial buildings

- **Cool roofs**
  - **Georgia elementary school: Energy savings of $14,500 per year**
  - **Converting 2,366 Tennessee K–12 schools would save $19M per year**
- **Ground source heat pumps**
  - **All Sumner County schools are using geothermal technology**
  - **Converting 2,366 Tennessee K–12 schools would save $122M per year**
- **These and other upgrades can be readily deployed in commercial buildings**
  - **Projects routinely save 20%**
  - **Payback from savings: 10 to 15 years**
  - **Total savings in Tennessee could exceed $500M per year**

ORNL has conducted Radon Measurement and Mitigation Projects for the DoD in the Asia-Pacific Region since 1995

- **> 20,000 Radon measurements and > 1,000 Radon mitigations in residential and nonresidential buildings located in:**
  - **Hawaii**
  - **Guam**
  - **South Korea**
  - **Mainland Japan, and**
  - **Okinawa**

ORNL Federal Energy Management Program Team Have Experience in Supporting Island Needs

- **Combined Heating, Cooling, and Power Assessments:**
  - **Hawaii: Fort Shafter (03), Schofield Barracks (03), Marine base (05 & 06)**
  - **Dominican Republic: US Embassy (03)**
  - **St. Thomas: GSA Airport (03)**
  - **Puerto Rico: Fort Buchanan (03), Roosevelt Roads Naval Station (03), GSA federal buildings in San Juan and Hato Ray (02)**
- **Energy Security Planning technical assistance to Fort Buchanan, Puerto Rico (04)**
- **Energy Services Performance Contracting technical assistance:**
  - **Fort Buchanan Puerto Rico (03)**
  - **GSA Postal Service and Courthouse (04)**

Sustainability Considerations for Islands

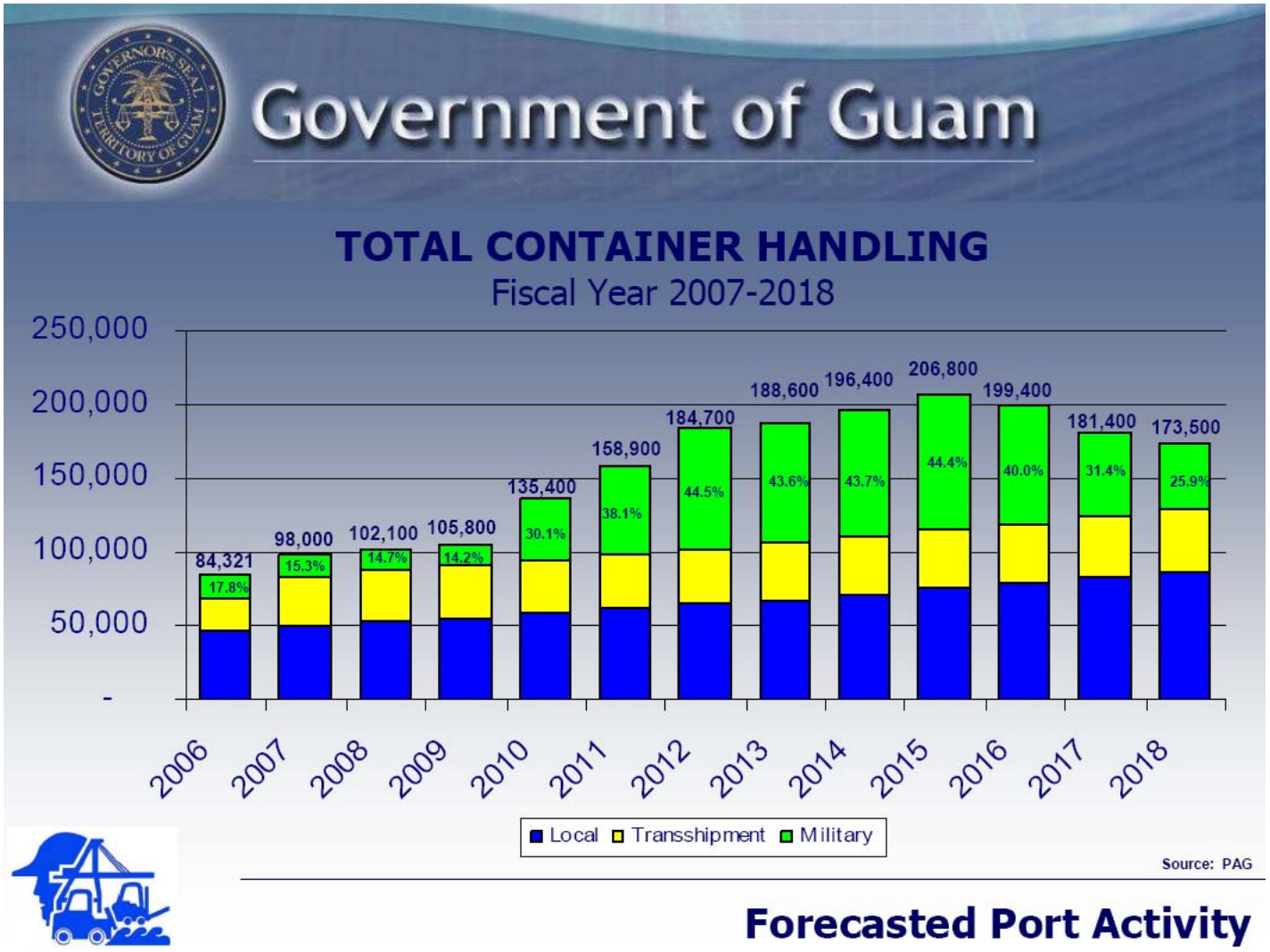
- **Islands have finite resources that present unique engineering challenges:**
  - **Specifically limited**
    - **land,**
    - **energy and potable water sources,**
    - **waste disposal options, and**
    - **on-island technical and logistical support**
    - **environmental impacts**
- **Therefore, not all emerging technologies will be suitable for island applications**

Ports: Seaport

- **Current Facilities**
  - **2 main pier areas**
  - **Container yard = 26.5 acres**
  - **2 fuel piers operated by Mobil and Shell**
  - **Served by a 2-lane paved highway**
- **Operations (FY 2007)**
  - **1,281 vessel calls**
  - **99,630 total containers handled**
    - 120,000 containers estimated capacity
    - Already at capacity for break-bulk
    - Near capacity of cement handling

Source: Port Authority of Guam
http://www.portofguam.com

Guam Ports: Seaport (cont.)



As a result of DoD build-up, the port forecasts increasing demand at the port, peaking in 2015 before beginning a decline. They also anticipate more than double demand for break-bulk goods (i.e..-construction materials) and bulk cement.

Source: 2007 Guam Industry Forum (http://www.guamindustryforum.com).

Guam Seaport Expansion

Comparison of North American Ports for Current and Forecasted Activities

2007 Rank	Port Name, State	TEUs	Containers Handled
1.	Los Angeles, CA	8,355,039	4,638,733
2.	Long Beach, CA	7,316,465	3,072,949
…	…	…	…
23	Altamira (Mex.)	407,625	264,626
Forecast →	**Apra (Guam)**	**372,240**	**206,800**
24	Wilmington, DE	284,352	142,176
…	…	…	…
33.	Wilmington, NC	191,070	104,292
34.	**Apra (Guam)**	**165,429**	**99,630**
35.	Kahului, HI	147,569	87,786

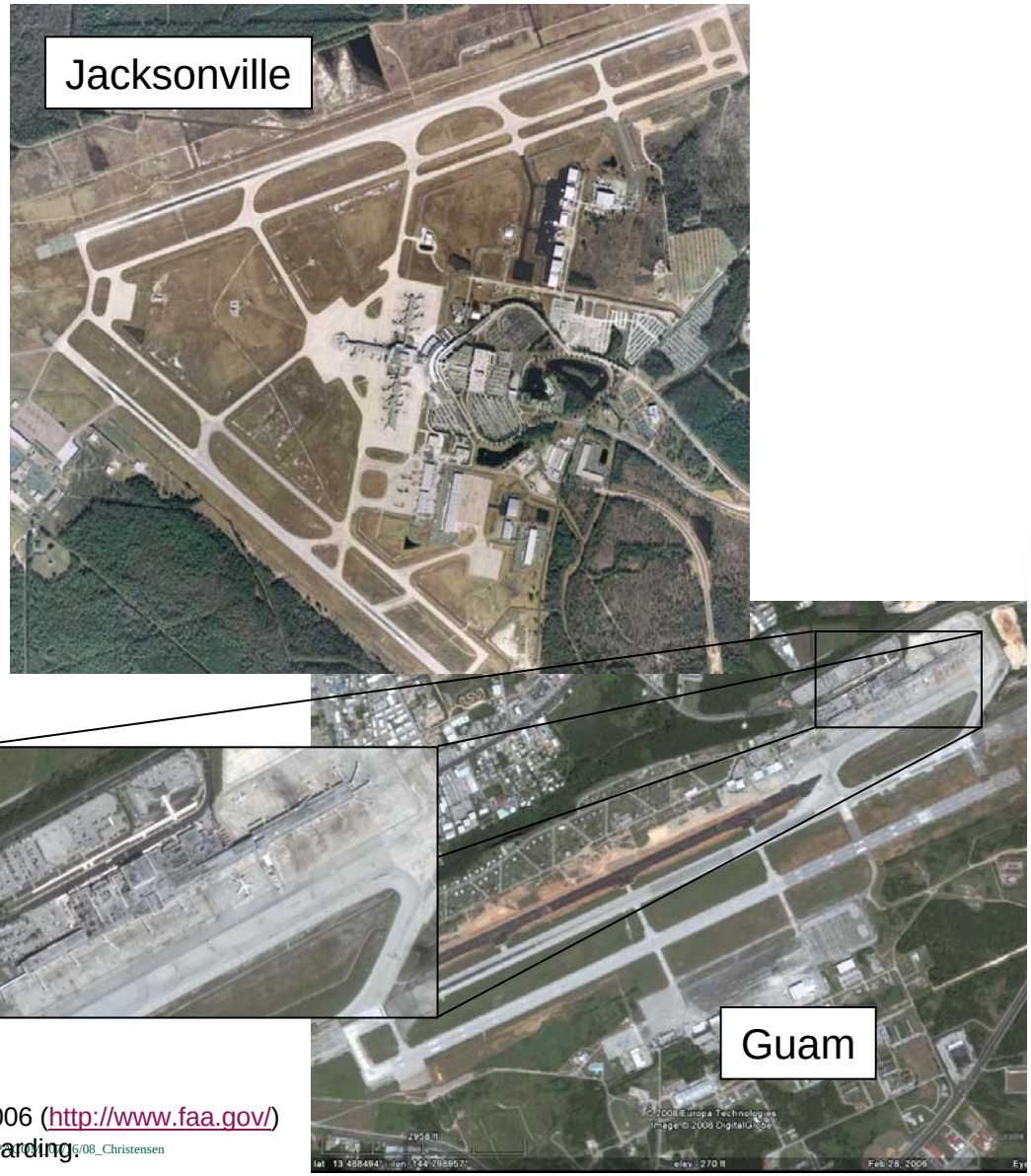
	Altamira	Guam (after expansion)
Wharf Length	**2,952 ft.**	**2,875 ft.**
Storage/Handling Area	**Approximately 110 acres**	**38.5 acres**

Source: American Association of Port Authorities (AAPA), 2007;
Forecasted containers from the Port Authority of Guam.
Forecasted TEUs = 80% makeup of 40 ft. containers, 20% from 20 ft. containers at peak volume of containers in 2015.

Guam Commercial Airport Expansion

Comparison of North American Airports for Recent and Forecasted Activities

2006 Rank	Airport, State (Code)	Enplanements
1.	Atlanta, GA (ATL)	41,352,038
2.	Chicago O'Hare, IL (ORD)	36,825,097
...	...	...
27	Reagan National, VA (DCA)	8,973,410
...	...	...
58	Jacksonville Intl., FL (JAX)	2,971,953
Forecast	**Guam Intl. (GUM)**	**2,832,708**
	Buffalo Niagara Intl., NY (BUF)	2,522,123
	...	...
79	**Guam Intl. (GUM)**	**1,416,354**
...	...	...
93	McGhee Tyson, TN (TYS)	815,130

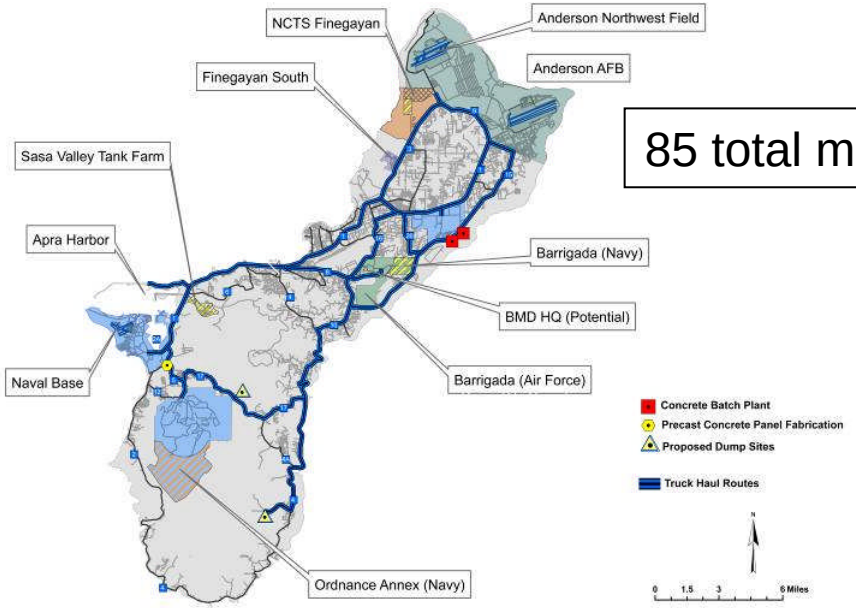


- Jacksonville International Airport (JAX)
  - 2 runways (10,000 and 7,701 feet)
  - 23 gates
  - More parking and terminal area than currently at GUM

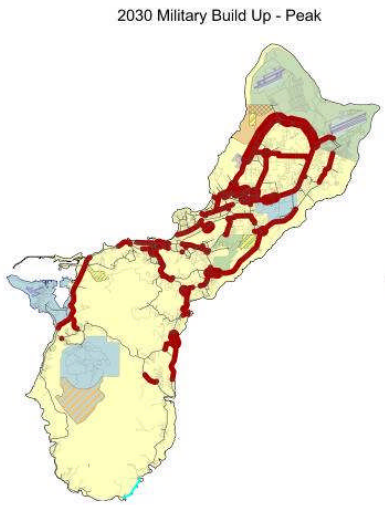
Source: FAA Passenger Boarding and All-Cargo Data, 2006 (http://www.faa.gov/)
Forecasted enplanement assumes double the current boarding.

Surface Transportation Infrastructure

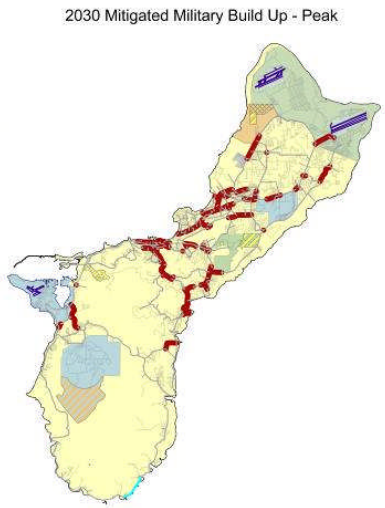
- **Roads**
  - **Upgrades needed to handle increased population and increased truck traffic**
  - **Upgrades needed prior to military build-up**



85 total miles



Congestion without Improvements



55% decrease in congestion with improvements

Source: Guam Industry Forum 2008
http://www.guamindustryforum.com/publications/GuamIndustryForum-II-Infrastructure.pdf

Transportation: Developing multifaceted solutions

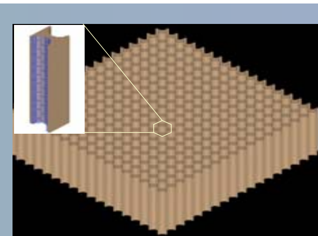
Scientific discovery

Modeling and simulation

Alternative energy sources

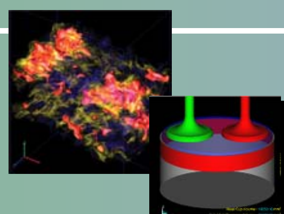
Oil shale

Non-petroleum fuels



Nanocomposite membranes

Efficient vehicle technology



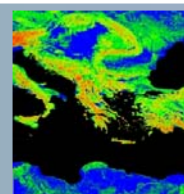
High-efficiency clean combustion

Advanced materials

Electrification

Transportation logistics, planning, and analysis

Intelligent transportation systems

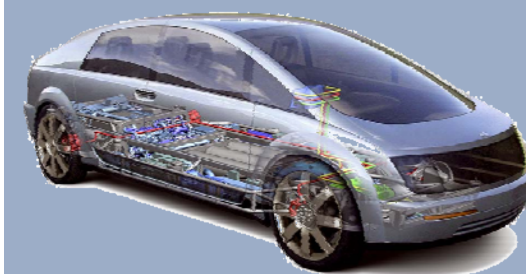


Graphical information systems

Technology innovation

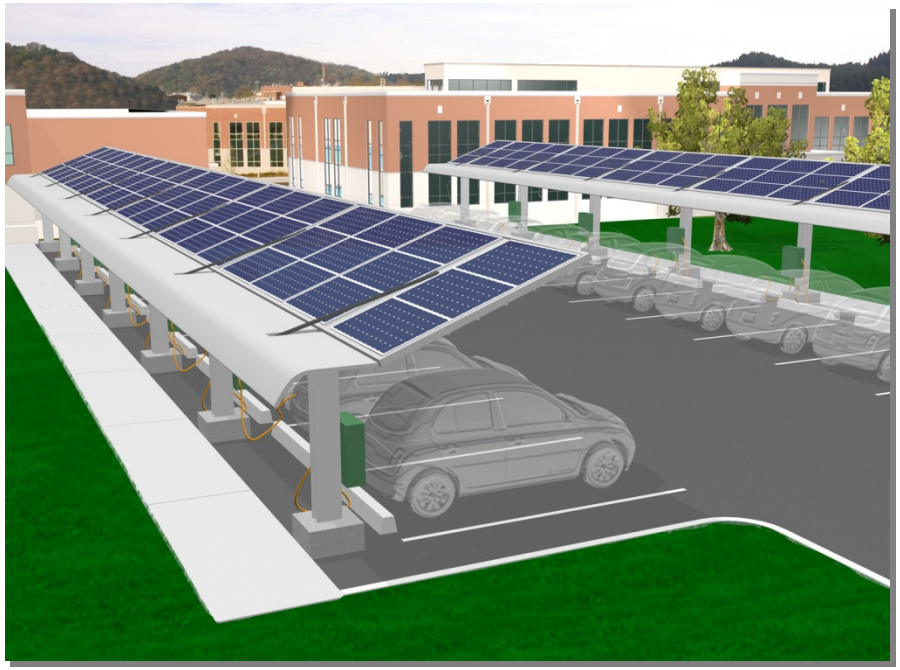
Adaptive decision tools

- 100 mpg_e automobiles
- Drive-by-wire
- Adaptive control
- Intelligent safety features



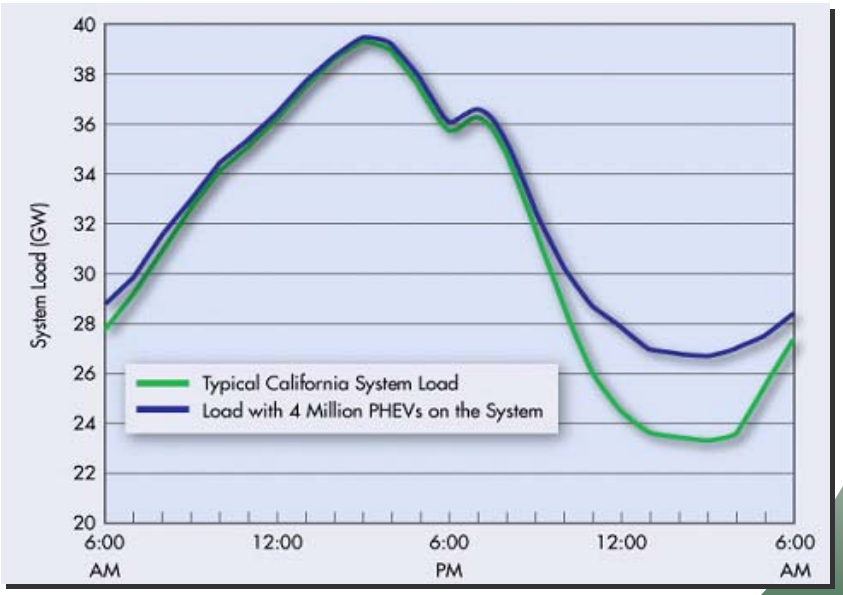
- Renewable energy
- Improved mobility
- Transportation security
- National competitiveness

ORNL employee transportation: One vision



“Plugging in” for integration and innovation

- **Direct solar charging**
- **Off-peak charging**
- **Smart metering**
- **Energy storage for the grid**
- **User incentives/convenience**

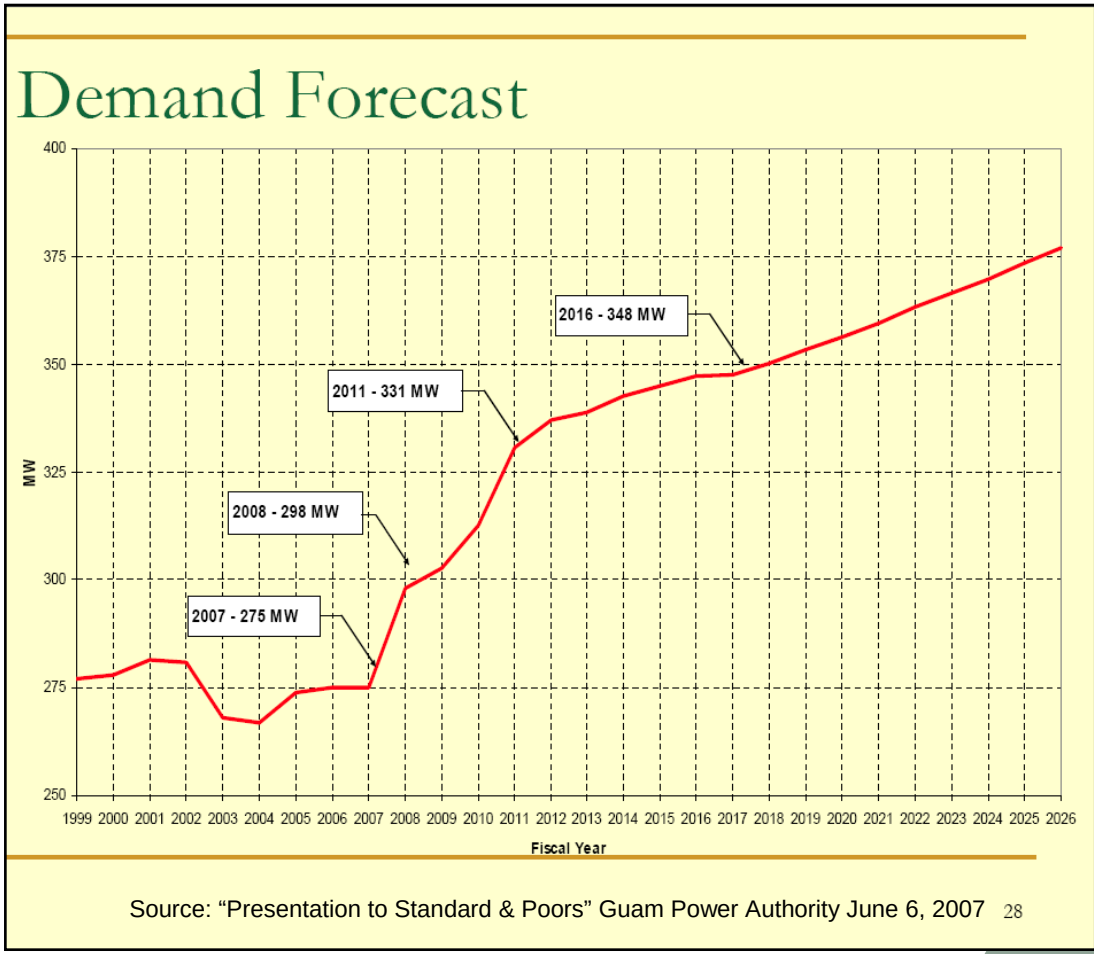


The U.S. grid has significant excess capacity (off-peak)

Energy Demand Forecast

- **Energy**
  - **552.2 MW gross generation capacity**
  - **29 substations**
  - **663 miles of transmission/distribution lines**
  - **100% Petroleum based**
  - **Currently exploring alternative energy and conservation strategies**
    - Wind farm (20 MW)
    - Seawater-cooled air conditioning for major hotels

http://www.guampowerauthority.com



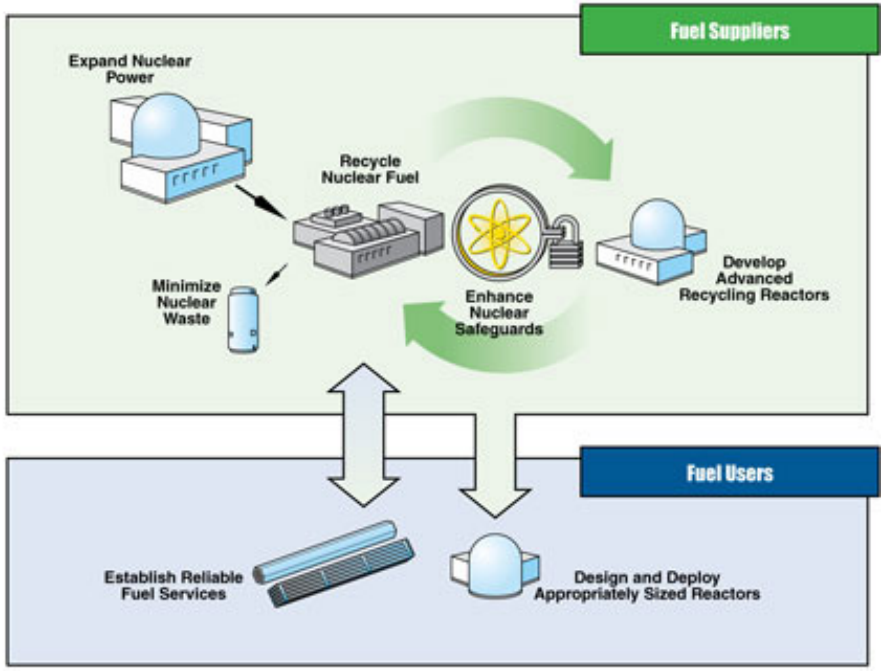
Source: "Presentation to Standard & Poors" Guam Power Authority June 6, 2007 28

Safe and secure expansion of nuclear power

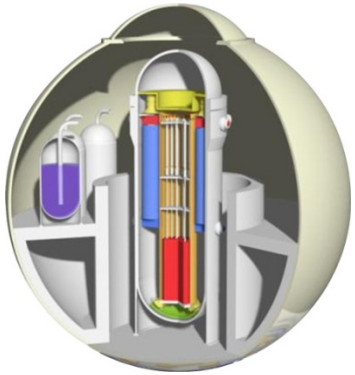
"Promoting the growth of clean, carbon-free nuclear power to meet the growing electricity demand that enhances energy security while promoting non-proliferation is a must in the U.S. and internationally."

– George W. Bush

- **Advanced proliferation-resistant reprocessing**
- **Advanced burner reactors for waste transmutation**
- **Advanced safeguard technologies**
- **Reliable fuel services**
- **Small exportable reactors**



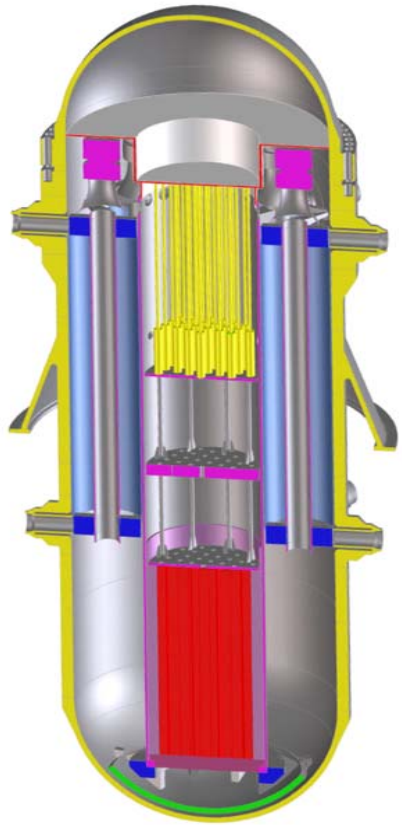
Fuel lease concept



Exportable, right-sized nuclear reactor

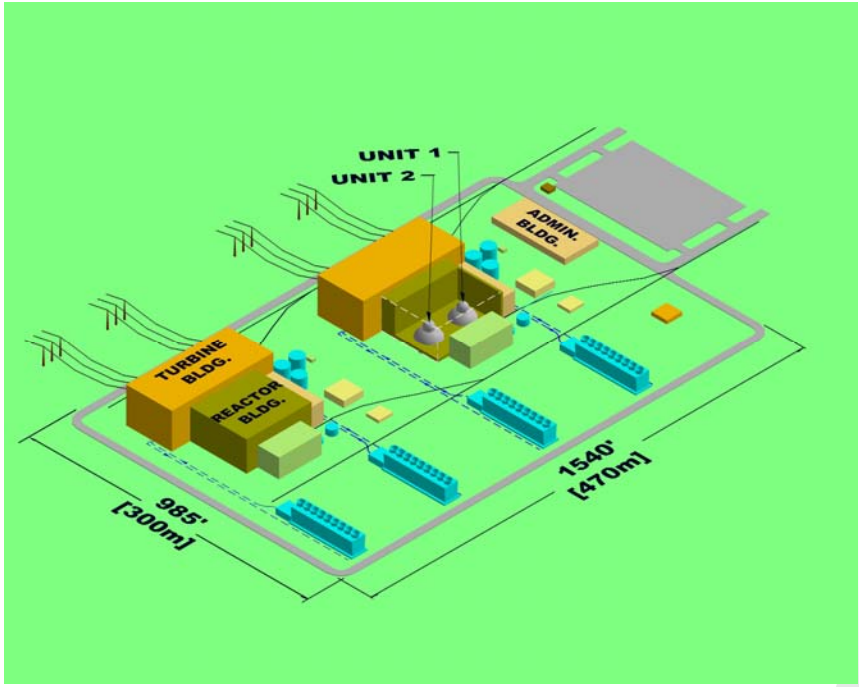
Integral Components Offer Simpler Design and Improved Performance

Steam generators	**Tubes in compression. Tensile stress corrosion cracking eliminated (responsible for over 70% reported failures)**
Primary coolant pumps	**Axial, fully immersed. No seal leaks. No shaft breaks. No maintenance.**
Internal CRDMs	**No RV head penetrations, no seal failures, no head replacements (with ~$800M cost) a la Davis Besse**
Pressurizer	**Much larger volume/power ratio gives much better pressure transients control. No sprays.**
1.7m thick downcomer	**Vessel fast flux 10^5 times lower. Cold vessel. Almost no outside dose. No embrittlement, no surveillance. "Eternal" vessel. Simpler decommissioning.**
Fuel assembly	**Almost the same as standard W PWR, but can have extended cycle up to 48 months**



IRIS – International Reactor Innovative and Secure

- **Advanced integral light water reactor**
- **1,000 MWt (~335 MWe) per module**
- **Innovative, simple design**
- **Enhanced Safety-by-Design™**
- **International development team**
- **Anticipated competitive economics**
- **Cogeneration potential (desalination, district heating, process heat)**
- **Modular installation to match demand growth**
- **NRC pre-application underway**
- **Design Certification testing program underway**
- **Interest expressed by several countries**
- **Projected deployment target: 2015 to 2017**



Multiple twin-units
(2 twin-units: 1340 MWe)

Electric grid analysis and situational awareness

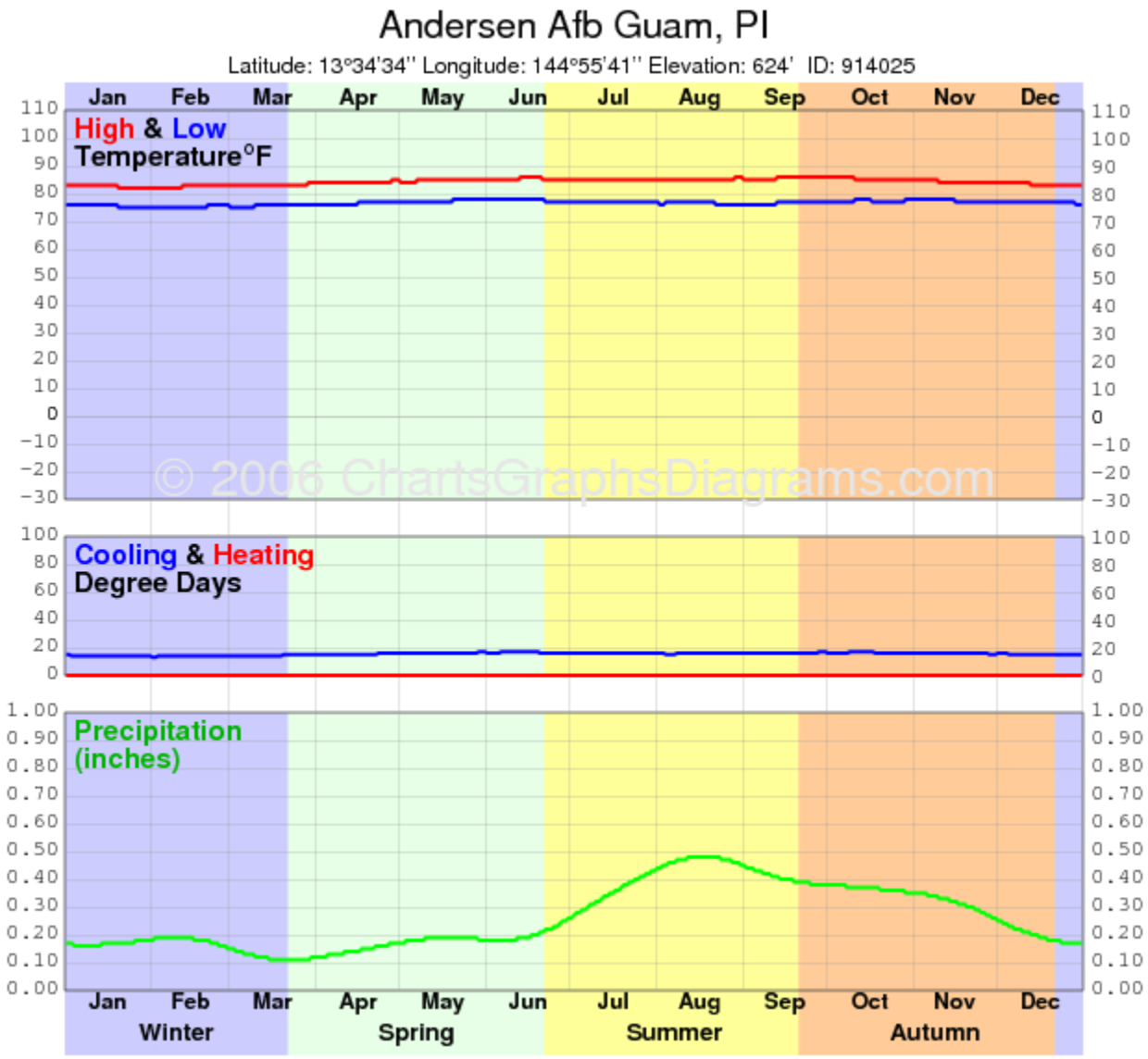
- **Major power outages over the past decade have resulted from a lack of wide-area situational understanding**
- **ORNL and TVA are developing tools to:**
  - **Monitor real-time status of the electric grid**
  - **Assess interdependences with critical energy infrastructure**
  - **Assist in coordination of federal response to natural disasters or major events**
  - **Visualization and prediction**

VERDE
Visualizing Energy Resources Dynamically on Earth


VERDE
© 2007 Europa Technologies

Climate Variables

- **Temperature**
  - **Current: Mean 26°C**
  - **Warming Rate < 2 degree Celsius per 10 years**
  - **Projected: 2010–26°C; 2015–27°C; 2030–29°C**
- **Rainfall**
  - **Current Annual Mean: 96 in (2.4 m) / yr**
  - **Current: 70% in Jul-Dec; 12% from Typhoons**
  - **Mean Change till 2030: Marginal (<0.1m); Uncertain**
  - **Change in Typhoons: Marginal; Uncertain**



Source:
U.S. Global Char
http://www2.eastwestcenter.org/climate/assessment/climate_draft2a.html

Change in Climatic Variable

- **Temperature**
  - Warming Rate
    < 2 degree Celsius
    per 10 years
  - Projected:
    2010–26oC
    2015–27oC
    2030–29oC
- **Rainfall**
  - Mean Change
    till 2030:
    Marginal (<0.1m)
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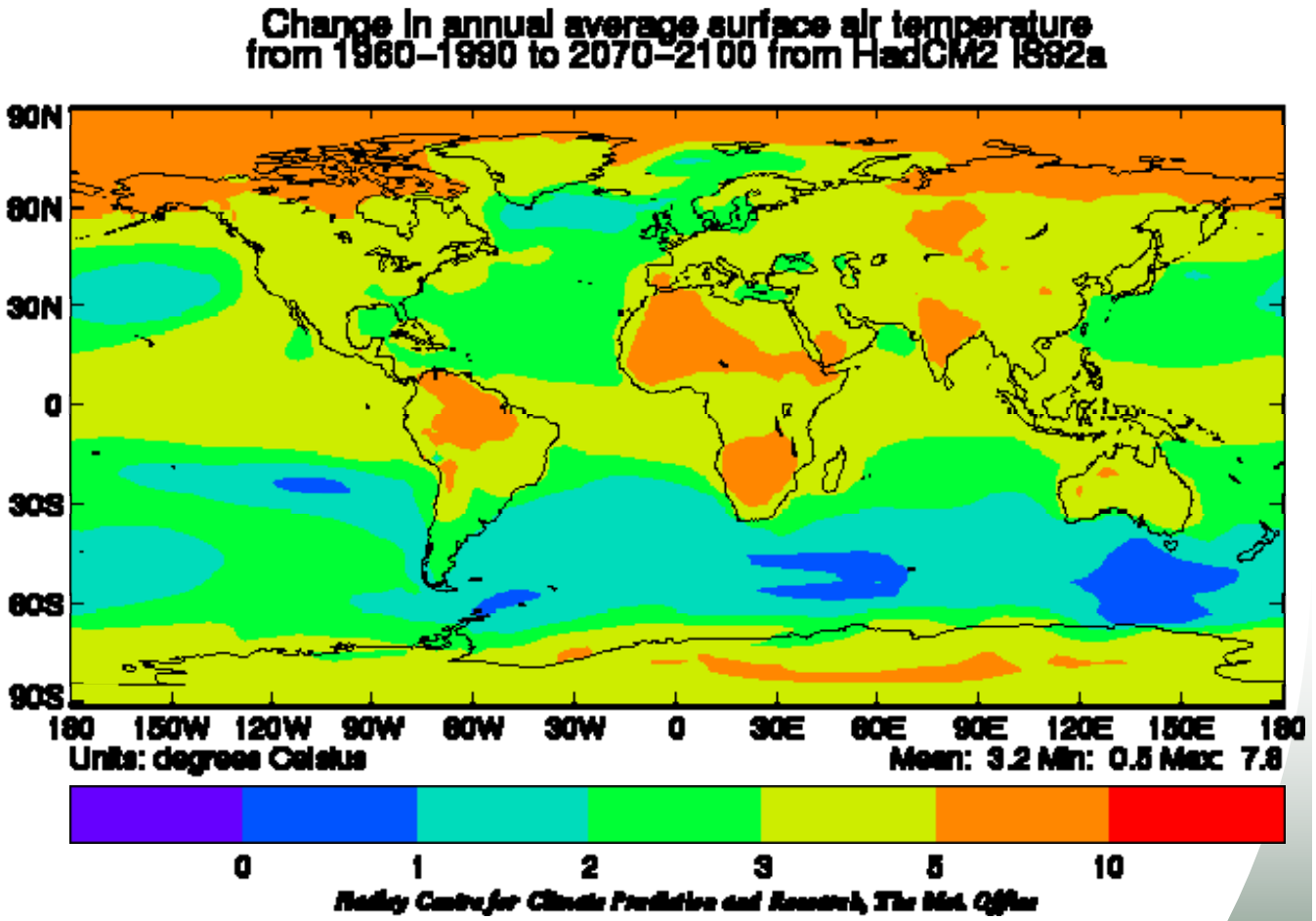
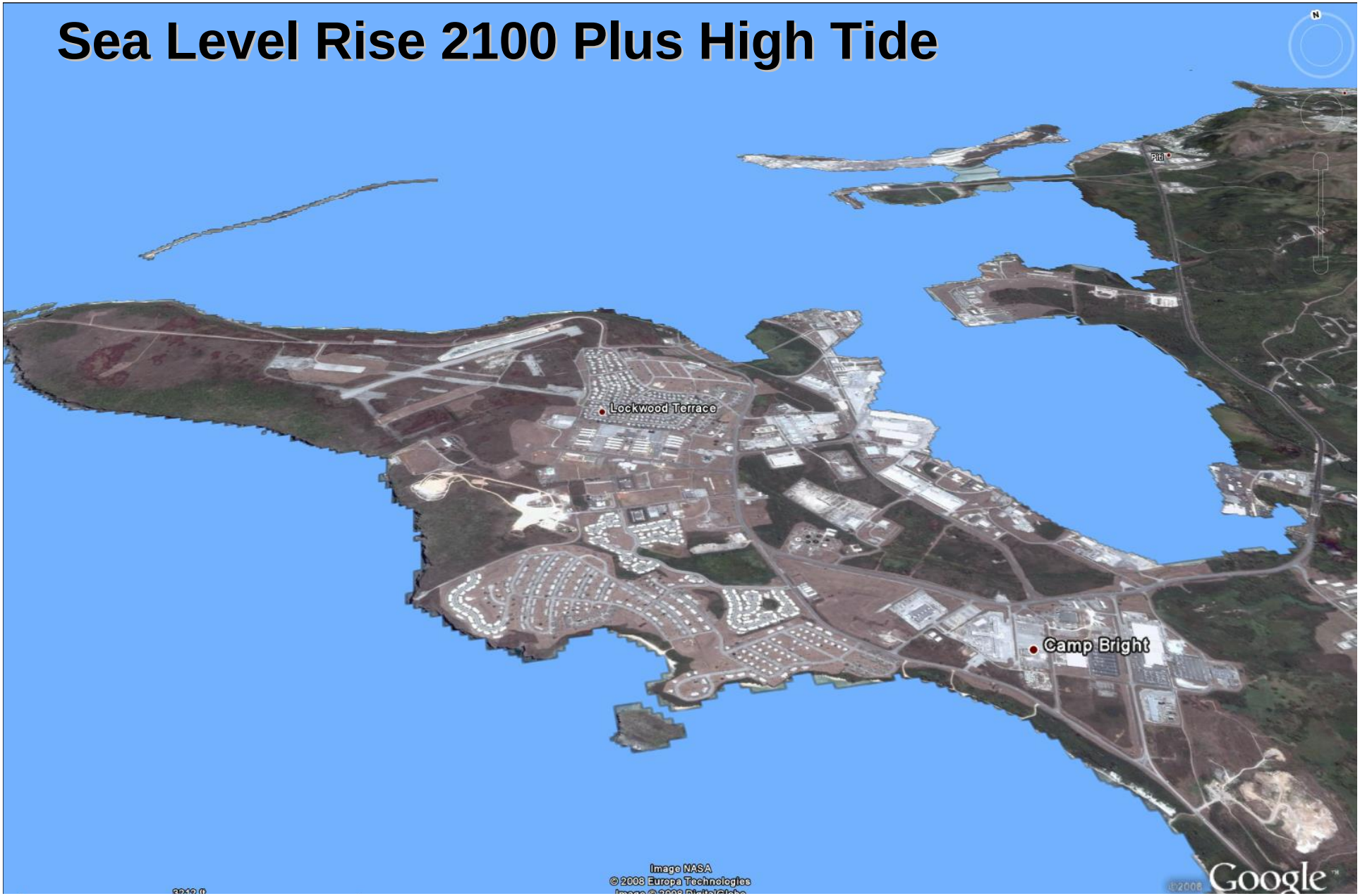
    Uncertain



Impact of Sea Level Rise in 2100



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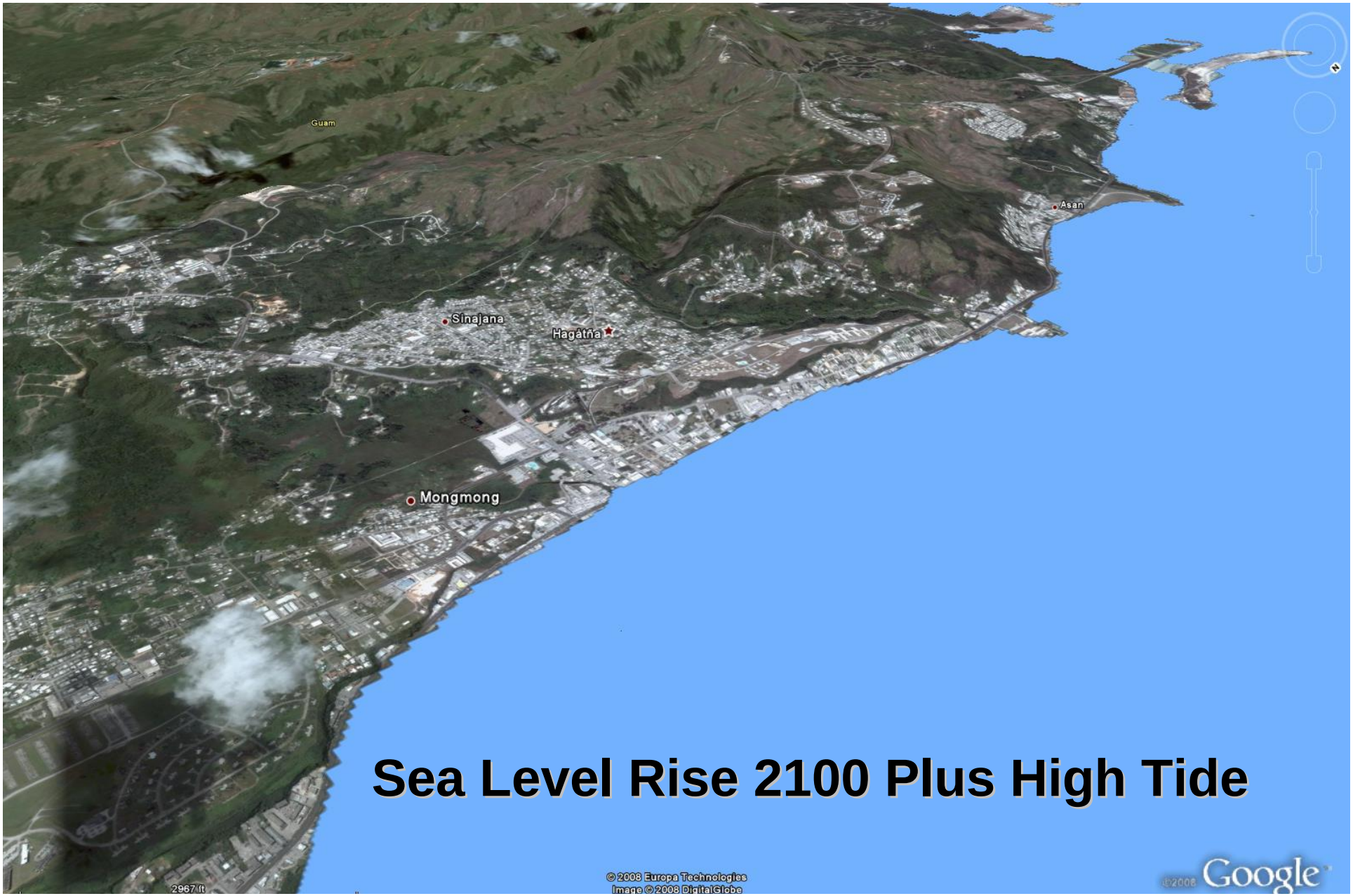

Tsunami

- **A 10 m surge can potentially have drastic impact on population and key critical infrastructure such as port operation.**

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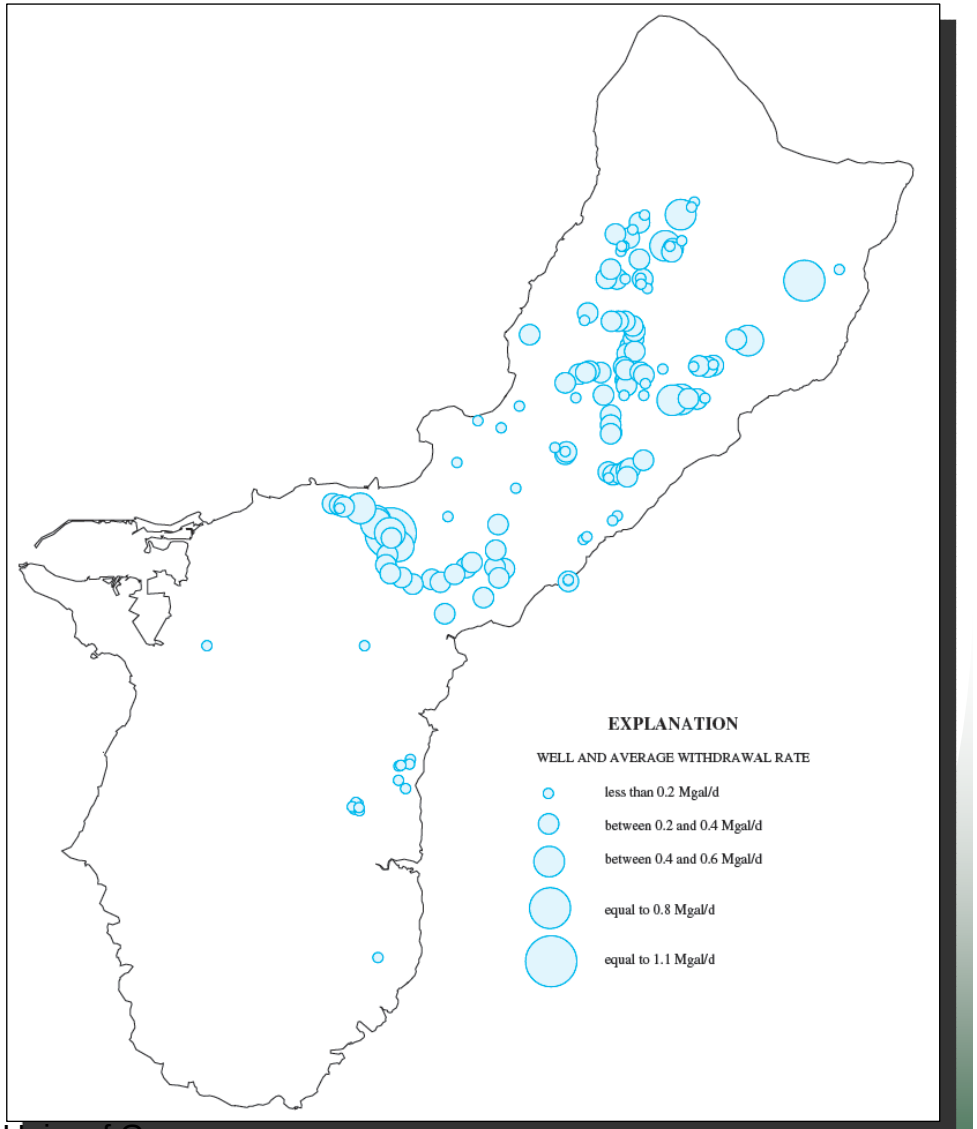
Surface Water Infrastructure

- **Water**
  - 80% drinking water from ground water
  - North: 180 wells
  - South: Surface runoff
    - Surface water runoff over weathered volcanic rock
    - Occurs locally only after intense rain (high permeability)
  - Possibility of future rainfall collection

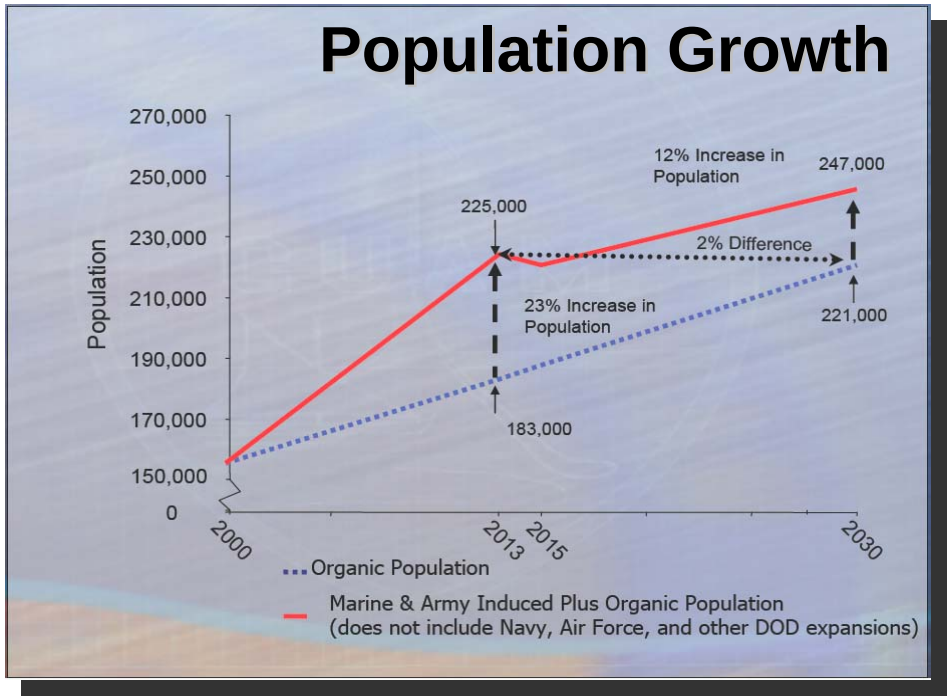


USGS Hydrologic Resources of Guam (2003)
http://pubs.usgs.gov/wri/wri034126/

Water and Environment Research Institute of Western Pacific, Univ. of Guam
http://www.weirguam.org

Projected Fresh Water Scenario

- **Residential Demand**
  - 2010: ~ 53 Mgal/d
  - 2015: ~ 65 Mgal/d
  - 2030: ~ 72 Mgal/d
- **Water Supply**
  - Wells: Current = 35 Mgal/d
  - Surface runoff: Current = 9.9 Mgal/d
    - Limited projected change under climate change
- **Potential Shortfalls: None till 2030**
  - Total sustainable supply: 79.9 Mgal/d
  - Estimated demand in 2030: 72 Mgal/d



Source: Western Pacific Institute of Guam http://www.weriguam.org/v2/projects_ground.php

Resource Resilience: Considerations for Islands

- **Sustainable solutions, in addition to being cost effective must be low maintenance and require minimal support from the mainland. With proper planning and training this is readily achievable.**
- **Some existing emerging technologies for energy generation (PV) and conservation (super insulation) are promising, but are untested in an island setting. Applied research and engineering is needed to identify the problems before wide-scale implementation.**
- **Other critical technologies essential for island sustainability still require significant research and development (e.g. desalinization, waste processing and disposal).**
- **Sustainable base-load electricity is essential.**

Conclusions

- **Energy Issues will significantly impact our global relationships**
- **Systems analyses will better guide our decisions (**
- **Islands represent “golden” opportunities as test-beds for integrated thinking**
- **Picking energy winners is premature**

Resource Resilience requires balancing the resource equation

Environment / Energy / Water / Waste