Adaptive Water-Energy Management in the Arid Americas

La Serena, Chile

June 24 – July 3, 2013

Welcome

Name	Country	Gender	Postdoc, PhD/Master student, Professional
MARINA RECALDE	Argentina	F	PhD
LIBER MARTIN	Argentina	M	PhD
JHIM TERRAZAS	Bolivia	M	MS
DANGELA MARIA FERNANDES	Brazil	F	MS
JANAINA PASQUAL	Brazil	F	MS
CRISTOBAL REVECO	Chile	M	MS
ROXANA BORQUEZ GONZALEZ	Chile	F	MS
(LA SERENA / COQUIMBO REGION PARTICIPANT)	Chile	F	MS
RUBEN DARIO MATEUS SANABRIA	Colombia	M	MS
GRICELDA HERRERA FRANCO	Ecuador	F	PhD
CLAUDIA LARDIZABAL	Honduras	F	MS
DIEGO PONCE DE LEON BARIDO	Mexico	M	PhD
ISMENE LIBERTAD AMERICA ROSALES PLASCENCIA	Mexico	F	Postdoc
SANDRA MEJIA	Nicaragua	F	MS
LUIS ALBERTO METZGER TERRAZAS	Peru	M	MS
SHIMELIS SETEGN	USA	M	PhD
RYAN LEE	USA	M	PhD
LAUREN HERWEHE	USA	F	MA
SARAH KELLY	USA	F	MA
COLIN MCKENZIE	USA	M	MS
BELIZE LANE	USA	F	PhD
MATTHEW KILANSKI	USA	M	MS
TESS RUSSO	USA	M	Postdoc
HEATHER LEE	USA	F	PhD
JENNA KROMANN	USA	F	PhD
ELVIN DELGADO	USA	M	PhD
CANDIDA DEWES	USA	F	PhD
DAVID MACPHEE	USA	M	PhD
Number of countries	11		
	% Female	50%	
	% Masters		46%

Introductions

- 15 min. total – take notes
- Meet a participant from a different country
- Ask about their background and interest in water-energy management
- Find out at least one humorous fact that does not appear in their CV
- You will introduce this person to the full group

Water-Energy Challenges

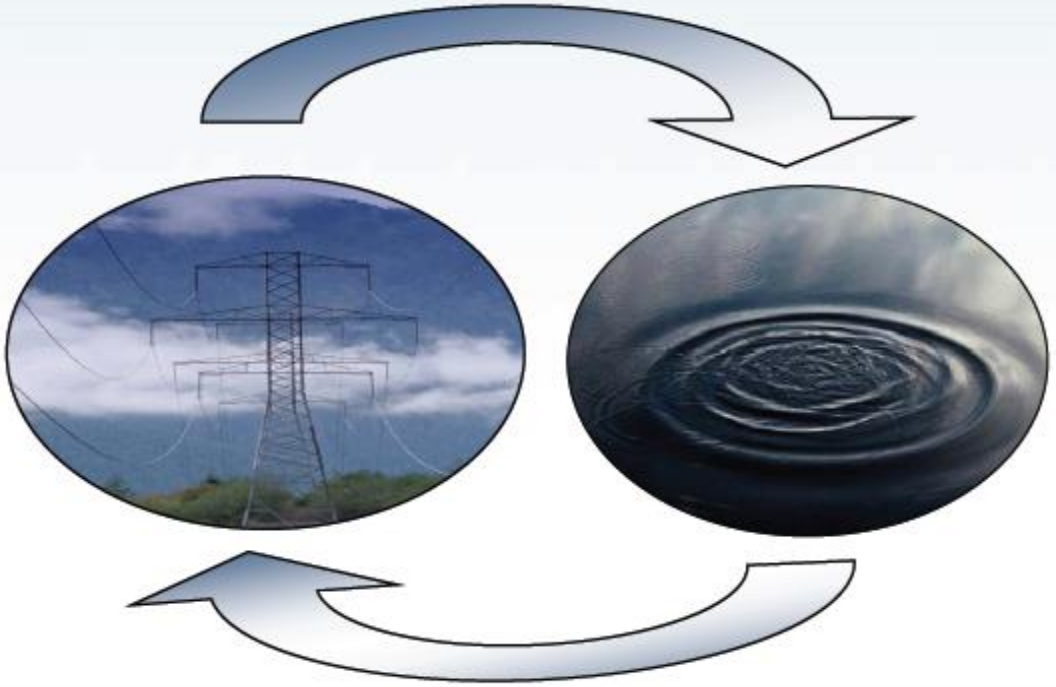
- Freshwater and energy are essential for quality of life
- Pressure on water resources in arid regions is exacerbated by climate change
- Growing water demands of energy sector
- Urbanization and irrigation demand intensify energy dependence
- Environmental impacts of water, energy use
- How to exploit water-energy nexus for adaptation to global change?

Energy and Water are ... Inextricably linked

Energy for Water and ***Water for Energy***

Energy and power production requires water:

- Thermoelectric cooling
- Hydropower
- Energy minerals extraction / mining
- Fuel Production (fossil fuels, H_2, biofuels/ethanol)
- Emission controls



Water production, processing, distribution, and end-use requires energy:

- Pumping
- Conveyance and Transport
- Treatment
- Use conditioning
- Surface and Ground water

ENERGY and WATER

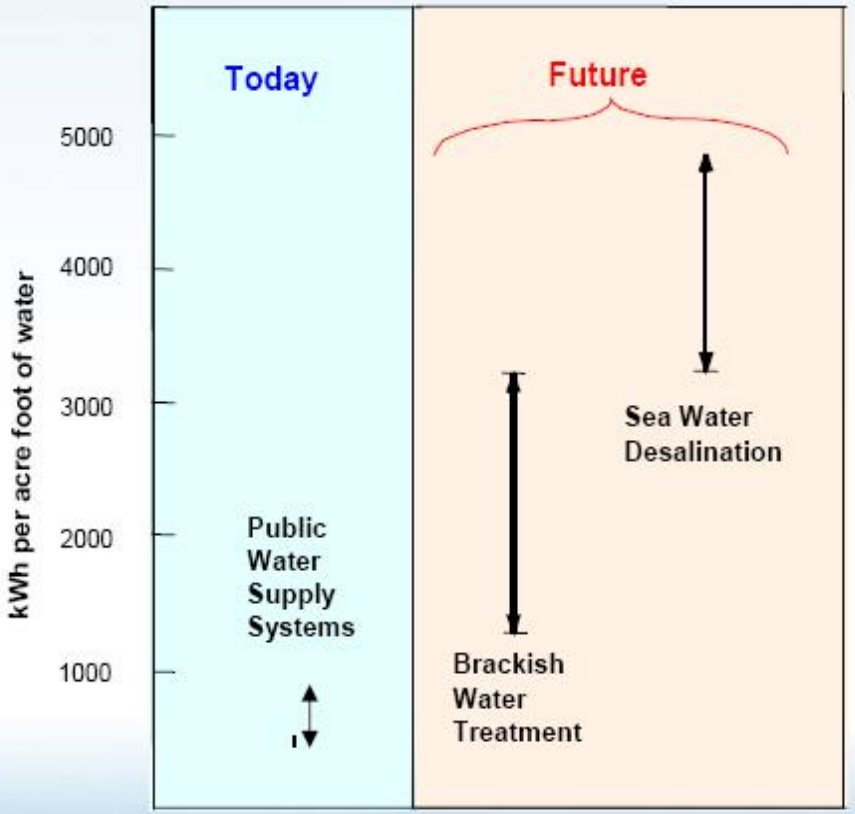
US Energy Sustainability

ENERGY and WATER

Future water supplies and treatment will be more energy intensive

- Readily accessible fresh water supplies are limited and have been fully allocated in some areas
  - Increased energy for pumping at deeper depths and longer conveyance
- New technologies to access and/or treat non-traditional water resources will require more energy per gallon of water
  - Impaired water, produced water, brackish water, and sea water

Power requirements for current and future water supply



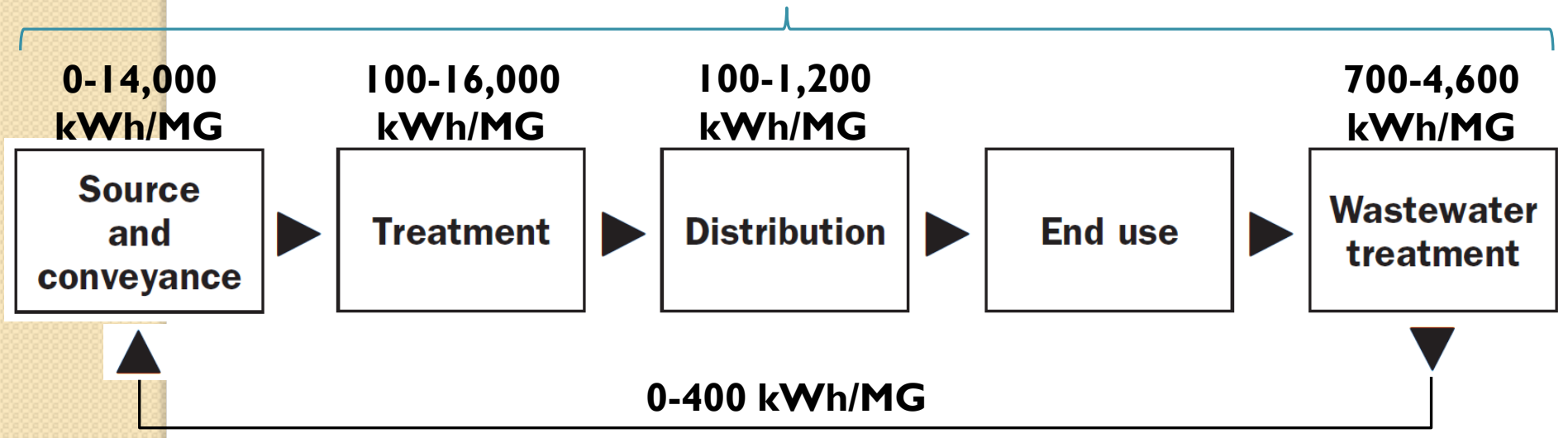
Source: EPRI (2000), Water Desalination Task Force (2003)

WATER-RELATED ENERGY CONSUMPTION IN *treatment & supply*

In the US, moving and treating water/wastewater represents a significant energy consumption

about **75 billion kWh/year** or **4% of the nation's electricity** use

Range: 1,050-36,200 kWh/MG
Average: 1,250-6,500 kWh/MG

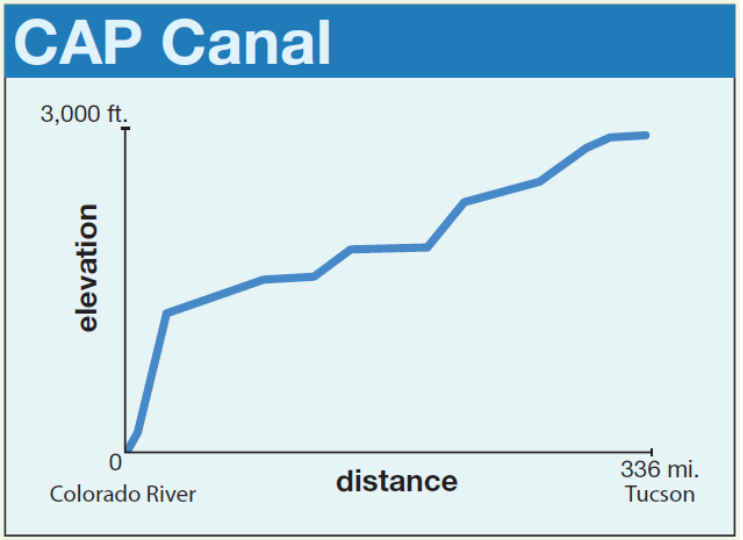


Source: *Energy Down the Drain, 2004*
Water & Sustainability (Volume 4), 2002

In arid Southwestern US, the water-related energy consumption increases due to water scarcity and the necessity of pumping over long distances and significant elevations

The city of **Tucson** (Arizona) consumes **3200 kWh/acre-foot** to pump water from the Colorado River over 336 miles and 3,000 feet elevation

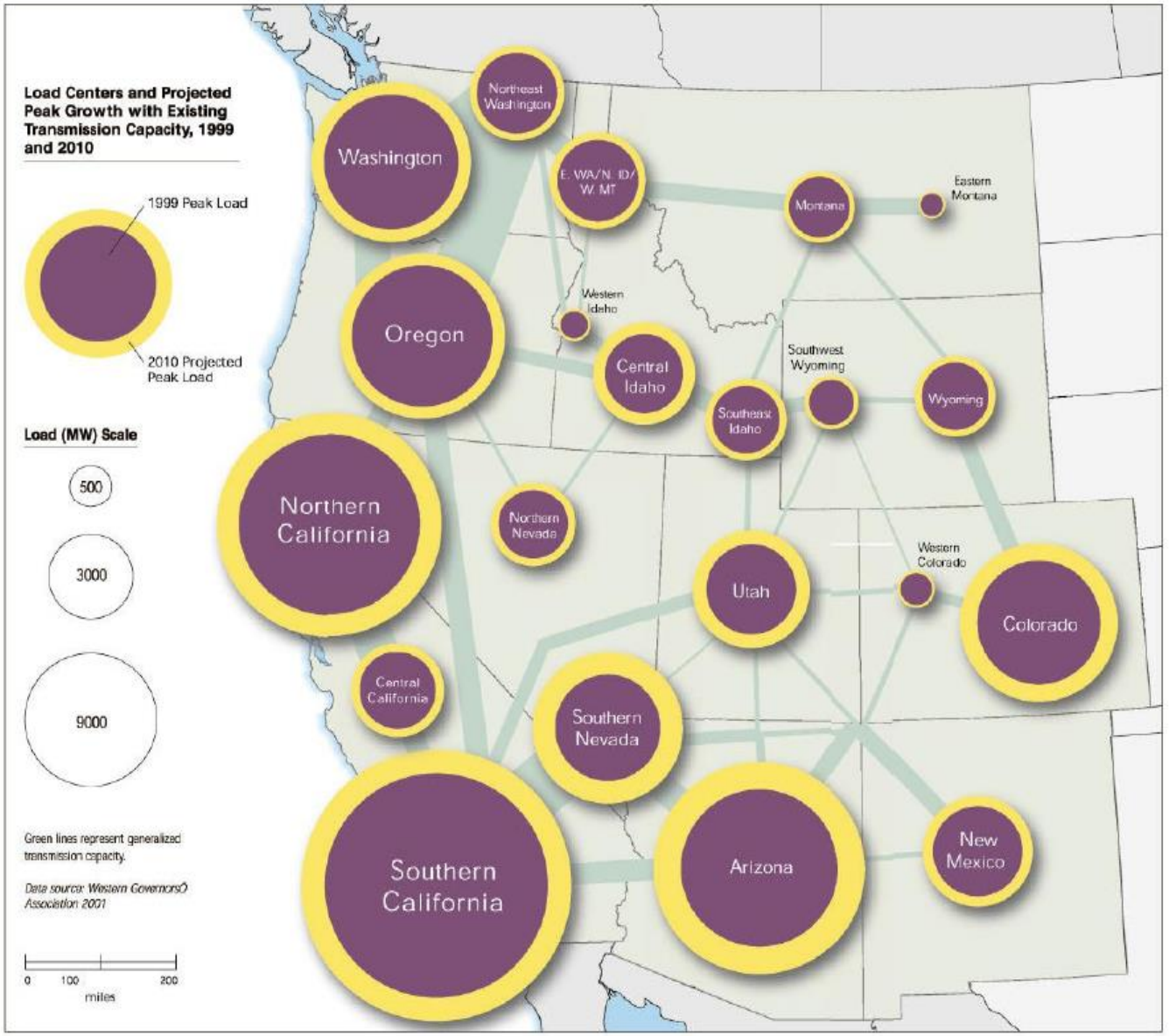
State of **California**, water agencies account for **7% of the energy consumption**.



3200 kWh to pump one acre-foot of CAP water from the Colorado River to Tucson.

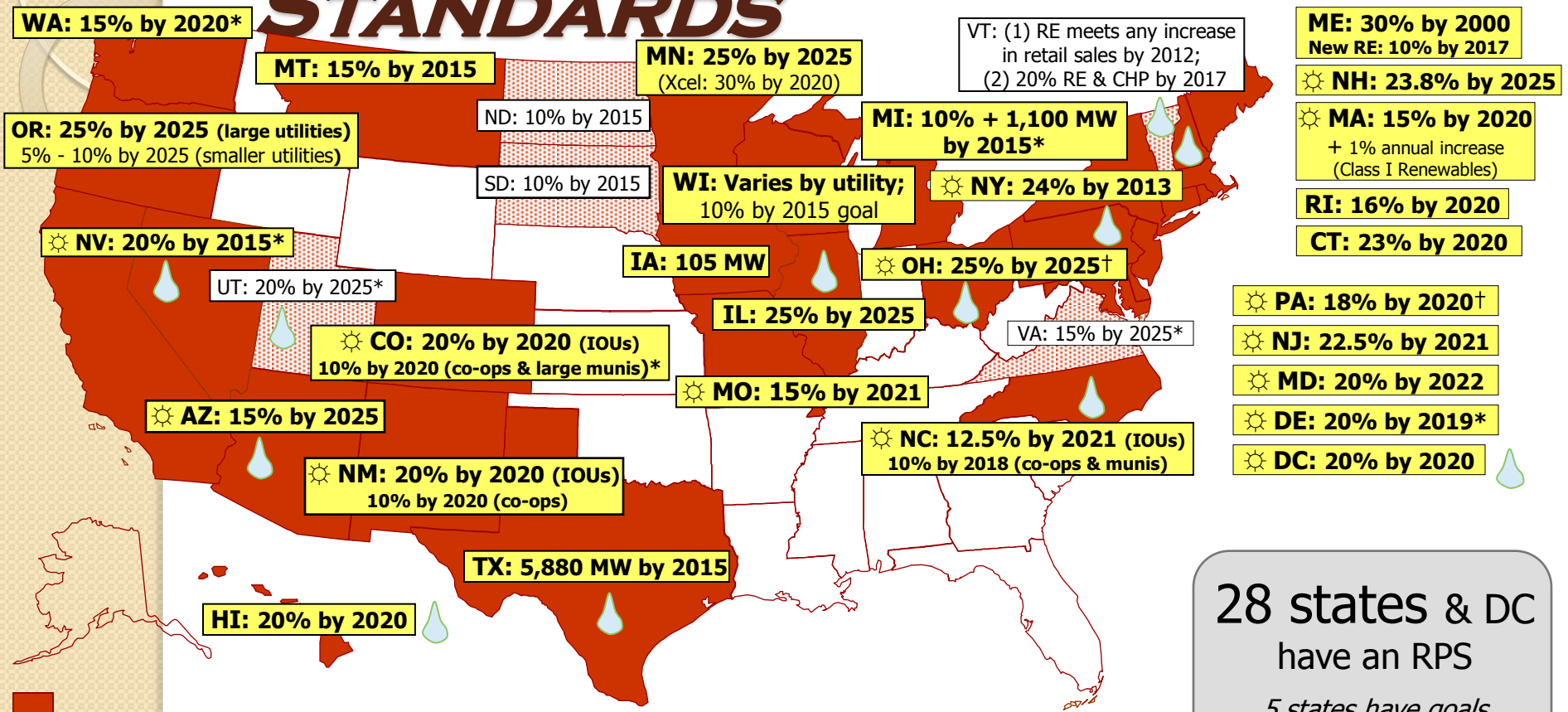
Source: Scott et al., 2007, Southwest Hydrology, pp26-31.
Energy Down the Drain, 2004

Load Growth



www.energyatlas.org

Renewable Portfolio Standards



28 states & DC have an RPS

5 states have goals

State renewable portfolio standard

State renewable portfolio goal

Solar water heating eligible

Minimum solar or customer-sited requirement

* Extra credit for solar or customer-sited renewables

† Includes separate tier of non-renewable alternative resources

www.dsireusa.org / April 2009

Background

- Need for conceptual understanding on water, energy, adaptation to global change
- Interdisciplinary training and skills development
- Financial support from NSF-PASI (Pan-American Advanced Studies Institutes of U.S. National Science Foundation)
- Training institutes approach

Partners

- AQUASEC Center of Excellence for Water Security
  - University of Arizona, USA
  - Pontificia Universidad Católica, Chile
- Centro del Agua para Zonas Áridas y Semiáridas de América Latina y El Caribe (CAZALAC), Chile
- Inter-American Institute for Global Change Research (IAI)
- Itaipu Binacional, Brazil
- UNESCO Internat'l Hydrology Program

Training Objectives

- Strengthen water and energy security
- Provide tools to evaluate water-energy nexus
- Integrate hydrological, climatic, social and economic analyses
- Improve management options for energy and water sectors
- Promote the use of decision-making tools
- Develop a regional knowledge network

Pre-training evaluation

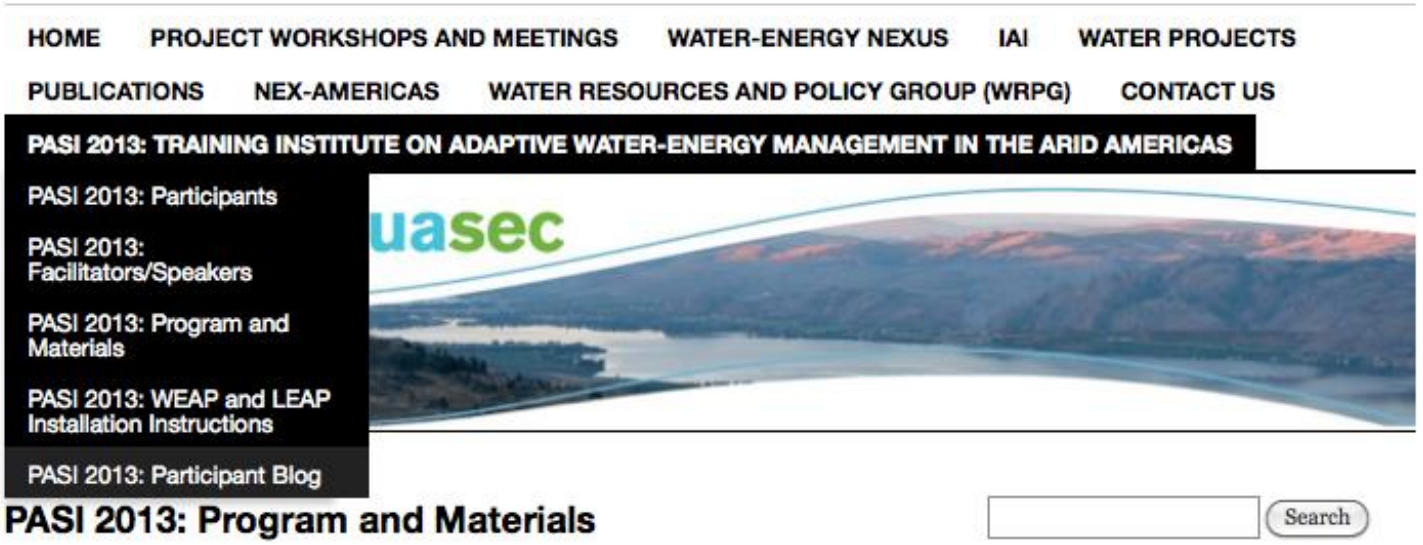
1. What are your objectives or expectations for the PASI 2013: Adaptive Energy-Water Management in the Arid Americas? Why?
2. Are there specific topics or content that you would like to see emphasized or amended to the PASI 2013 program? Why?
3. What topics or sessions are you most excited about? Why?
4. How do you anticipate using what you have learned at PASI 2013 in your work? How will you apply what you have learned?

PASI Water-Energy Website

- http://aquasec.org/pasi2013_mainpage/

will replace wiki site used earlier

- instructions on submitting blog responses



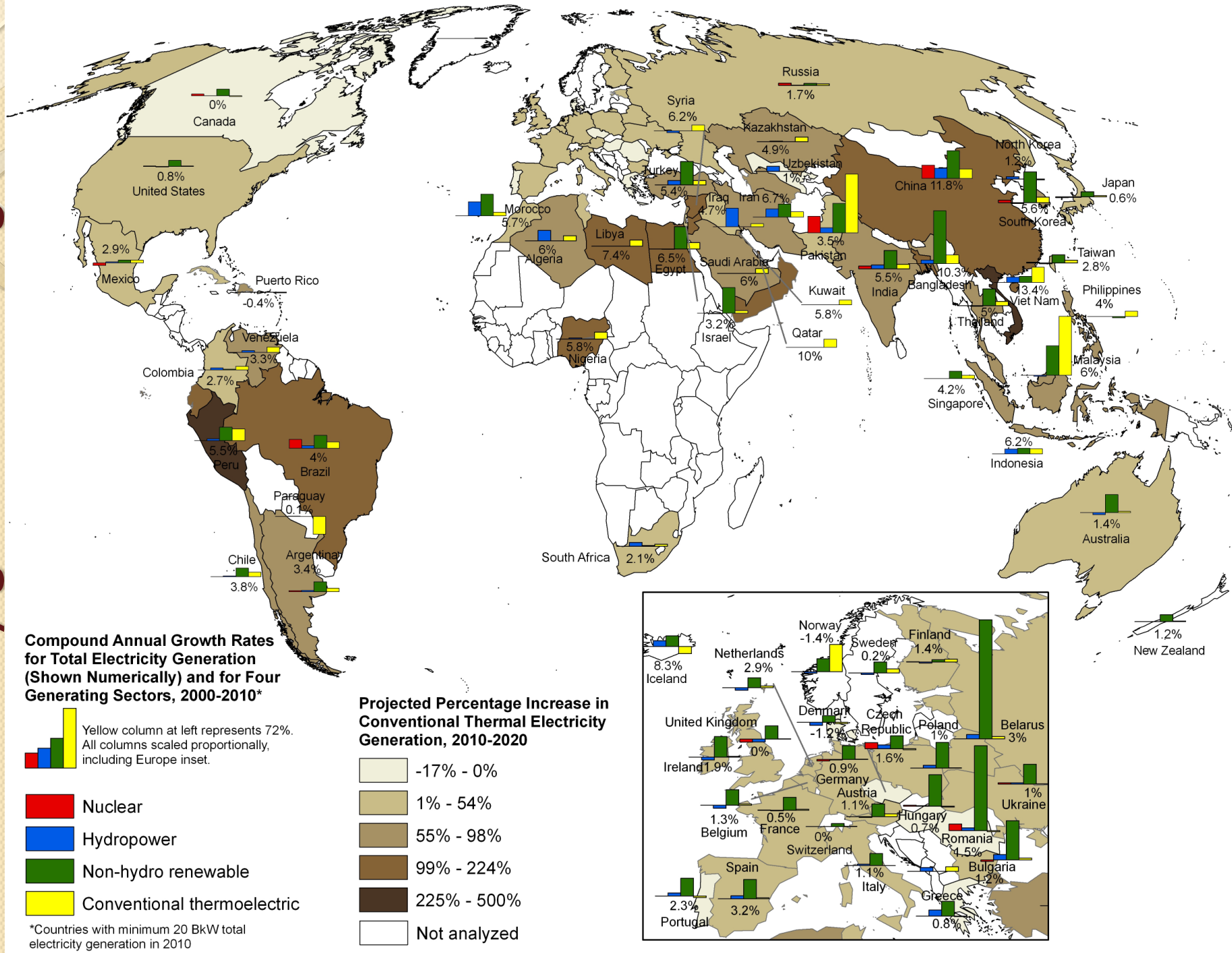
Conceptual overview - resource security

- Water and energy – strategic resources
- Anthropocene drivers
  - Climate change, impacts
  - Resource & market globalization, development
  - Environmental 'externalities'
- Interdisciplinary approaches
  - Coupled-systems, bidirectional impacts
  - Science-policy, outcomes

Global energy development and water scarcity

- Consider water availability
  - physical limits, allocations
  - water-for-energy – global spatial & temporal trends
- Greatest water-quantity impacts
  - electrical power generation
  - biofuel – irrigation and lifecycle assessments
- Data
  - US Energy Information Administration
  - UN FAO AQUASTAT

Electricity generation and growth



Compound Annual Growth Rates for Total Electricity Generation (Shown Numerically) and for Four Generating Sectors, 2000-2010*

Yellow column at left represents 72%. All columns scaled proportionally, including Europe inset.

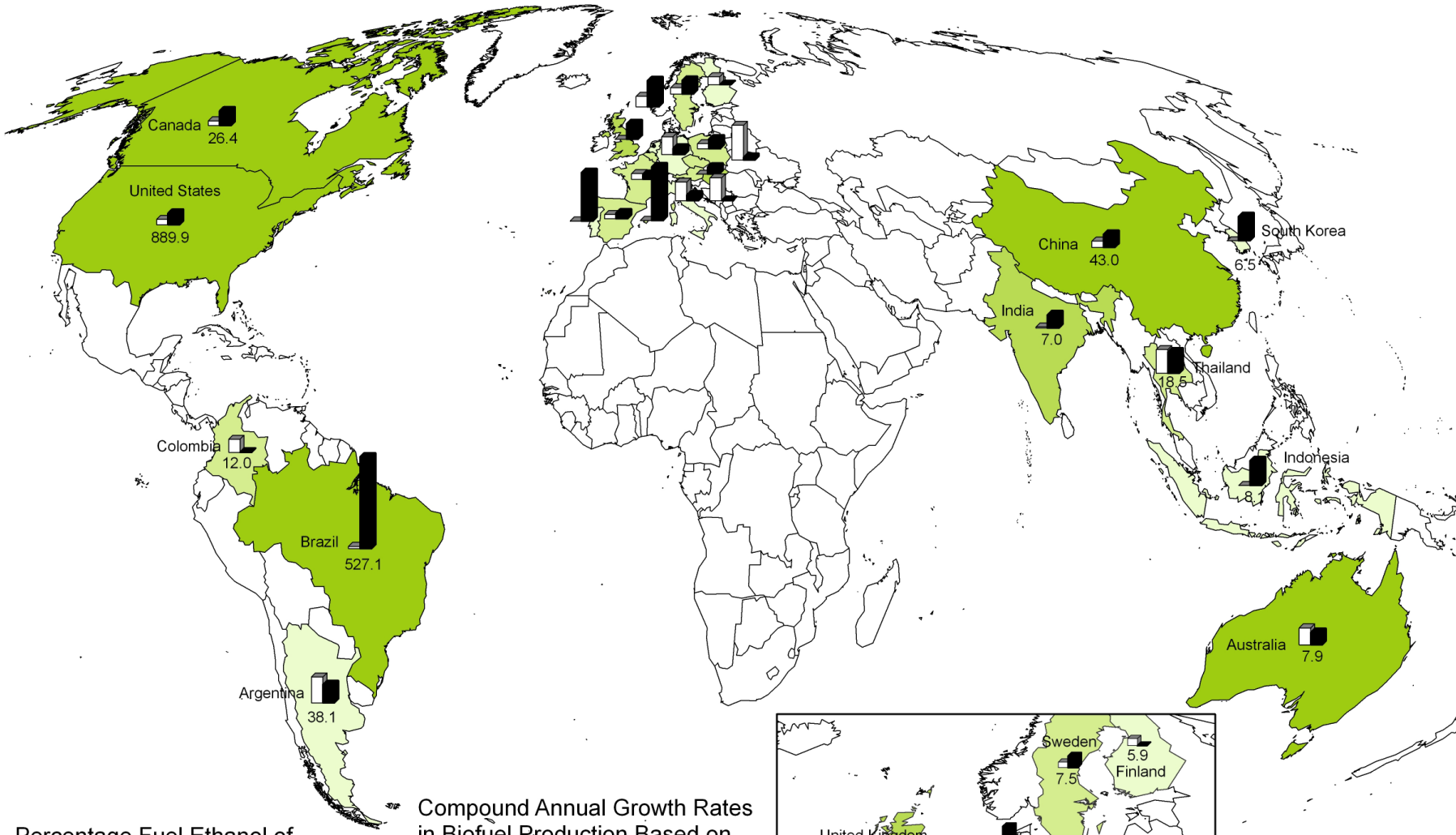
- Nuclear
- Hydropower
- Non-hydro renewable
- Conventional thermoelectric

*Countries with minimum 20 BkW total electricity generation in 2010

Projected Percentage Increase in Conventional Thermal Electricity Generation, 2010-2020

- -17% - 0%
- 1% - 54%
- 55% - 98%
- 99% - 224%
- 225% - 500%
- Not analyzed

Biofuels production and growth



Percentage Fuel Ethanol of Total Biofuel Production, 2010*

Numeric values in the map are total biofuel production (thousand BPD) for year 2010.

- 1% - 26%
- 27% - 51%
- 52% - 75%
- 76% - 100%

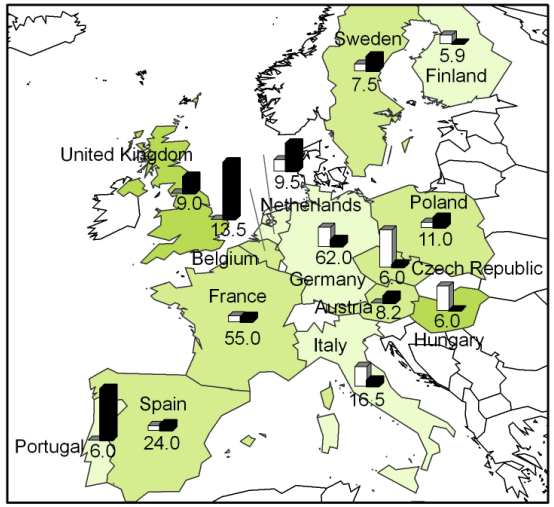
*For countries with total biofuel production at least 5,000 BPD.

Compound Annual Growth Rates in Biofuel Production Based on 2000-2010 Annual Totals**

All bars including inset drawn to same scale. Black bar below denotes 200% growth rate.

- 200%
- Fuel Ethanol
- Biodiesel

**If production data were not reported for the full period, growth rates were calculated if at least five years of data were available.



Source: U.S. Energy Information Administration

Flashpoints

- Energy-related physical water scarcity
  - Middle East
  - Small-island states
- Sectoral limits (reallocate increasingly scarce, rights-appropriated, ecological-flow water)
  - Brazil
  - India
  - China
  - USA
  - others

Basic indicators & trends

Country	CO2 emissions increase [%/yr], 1999-2009	Total freshwater withdrawals increase [%/yr], 2002-2011	Agricultural freshwater withdrawals increase [%/yr], 2002-2011	Industrial freshwater withdrawals increase [%/yr], 2002-2011	Public sector institutions (rights, governance, transparency, corruption) [indicator], 2005 to 2011 change	Structural policy (trade, finance, business regulation) [indicator], 2005 to 2011 change
Australia	2.1%	0.0%	0.0%	0.0%	*n/a*	*n/a*
Brazil	1.4%	-0.2%	-1.6%	-0.5%	*n/a*	*n/a*
Canada	0.0%	0.0%	0.0%	0.0%	*n/a*	*n/a*
China	8.8%	0.6%	-1.4%	3.7%	*n/a*	*n/a*
Egypt	5.6%	0.0%	0.0%	0.0%	*n/a*	*n/a*
India	5.6%	2.5%	2.3%	6.1%	decline	no change
Mexico	1.6%	1.1%	1.0%	0.8%	*n/a*	*n/a*
Pakistan	4.9%	0.7%	0.6%	-9.6%	decline	decline
S. Korea	2.5%	0.0%	0.0%	0.0%	*n/a*	*n/a*
Saudi Arabia	6.7%	3.7%	3.5%	15.6%	*n/a*	*n/a*
South Africa	3.0%	0.0%	0.0%	0.0%	*n/a*	*n/a*
Thailand	3.3%	0.0%	0.0%	0.0%	*n/a*	*n/a*
Turkey	3.5%	-0.5%	-0.7%	0.5%	*n/a*	*n/a*
UK	-1.2%	-2.0%	-0.2%	-5.6%	*n/a*	*n/a*
USA	-0.4%	0.1%	-0.2%	0.4%	*n/a*	*n/a*
Venezuela	0.7%	0.0%	0.0%	0.0%	*n/a*	*n/a*
[Value:]	> 1% /yr	> 1% /yr	> 1% /yr	> 1% /yr	decline	decline
[Value:]	> 3% /yr	> 3% /yr	> 3% /yr	> 3% /yr		

Energy for water indicators & trends

Country	Current thermo & nuclear water withdrawal / Industrial water withdrawal [%, fraction], 2010	Future thermo & nuclear water withdrawal / Industrial water withdrawal [%, fraction], 2020	Current irrigation withdrawal for ethanol / Agricultural water withdrawals [%, fraction], 2010	Future irrigation withdrawal for ethanol / Agricultural water withdrawals [%, fraction], 2020	Current thermo & nuclear water consumption + lifecycle water (ethanol & biodiesel), low bound / Total internal renewable water [%, fraction], 2010	Current thermo & nuclear water consumption + lifecycle water (ethanol & biodiesel), high bound / Total internal renewable water [%, fraction], 2010	Future thermo & nuclear water consumption + lifecycle water (ethanol & biodiesel), low bound / Total internal renewable water [%, fraction], 2020
Australia	32.6%	37.3%			0.1%	0.1%	0.1%
Brazil	2.8%	6.2%	7.7%	20.4%	0.4%	1.7%	1.1%
Canada	2.7%	2.8%	8.9%	57.8%	0.1%	0.4%	0.3%
China	10.0%	28.4%	1.6%	18.9%	0.4%	0.8%	2.2%
Egypt	11.8%	24.2%			15.7%	15.7%	32.3%
India	17.1%	29.1%	0.2%	0.3%	0.1%	0.2%	0.2%
Mexico	10.7%	14.8%			0.1%	0.1%	0.2%
Pakistan	15.7%	22.4%			0.2%	0.2%	0.4%
S. Korea	57.4%	101.4%			1.7%	1.7%	3.0%
Saudi Arabia	113.2%	202.5%			20.1%	20.1%	35.9%
South Africa	120.4%	148.9%	0.1%	*n/a*	1.2%	1.2%	n/a
Thailand	18.6%	30.6%	4.7%	*n/a*	0.3%	0.8%	208.6%
Turkey	12.9%	21.3%			0.1%	0.1%	0.2%
UK	28.9%	28.2%			0.5%	0.5%	0.5%
USA	6.3%	6.8%	11.0%	90.6%	3.1%	13.4%	23.1%
Venezuela	21.6%	40.1%			0.0%	0.0%	0.0%
[Value:]	> 10%	> 10%	> 10%	> 10%	> 10%	> 10%	> 10%
[Value:]	> 30%	> 30%	> 30%	> 30%	> 30%	> 30%	> 30%

Remarks

- Emerging, energy-related water scarcity hotspots include the world's largest and most diversified economies (BRICS, Australia, Canada, Mexico, UK, US, among others)
- Physical water scarcity poses limits to energy development in the Middle East and small-island states.
- Policy futures
  - assess coupled energy-water policy alternatives
  - water-conserving energy portfolio options, innovation
  - intersectoral water transfers
  - virtual water for energy
  - hydropower tradeoffs
  - use of impaired quality waters for energy

Ongoing and future work

- Meld global meta-analysis with regional and country case-study analyses
- Link explicitly to energy, environment, economic drivers of global-change scenarios (IPCC, others)
- Review policy context (flashpoint countries)
  - Adaptation planning
  - Investments
  - Energy sector developments
- Innovation and adoption
- Better understand drivers of political change, governance, and rule-making

Some recent water-energy-climate pubs (http://aquasec.org/wrpg/publications/)

Scott, C.A., F.J. Meza, R.G. Varady, H. Tiessen, J. McEvoy, G.M. Garfin, M. Wilder, L.M. Farfán, N. Pineda Pablos, E. Montaña. 2013. Water security and adaptive management in the arid Americas. *Annals Association American Geographers* 103(2): 280-289

Kumar, M.D., C.A. Scott, O.P. Singh. 2013. Can India raise agricultural productivity while reducing groundwater and energy use? *Int'l J. Water Resources Development*, doi:10.1080/07900627.2012.743957

Prichard, A.H., C.A. Scott. 2013. Interbasin water transfers at the US-Mexico border city of Nogales, Sonora: Implications for aquifers and water security. *Int'l J. Water Resources Development* doi:10.1080/07900627.2012.755597

Scott, C.A., C.J. Bailey, R.P. Marra, G.J. Woods, K.J. Ormerod, K. Lansey. 2012. Scenario planning to address critical uncertainties for robust and resilient water-wastewater infrastructures… *Water* 4: 848-868

Varady, R.G., C.A. Scott, M. Wilder, B. Morehouse, N. Pineda, G.M. Garfin. 2012. Transboundary adaptive management to reduce climate-change vulnerability… *Environmental Science & Policy*. doi 10.1016/j.envsci.2012.07.006

Scott, C.A., R.G. Varady, F. Meza, E. Montaña, G.B. Raga, B. Luckman, C. Martius. 2012. Science-policy dialogues for water security… *Environment* 54(3): 30-42

Halper, E., C.A. Scott, S. Yool. 2012. Correlating vegetation, water use and surface temperature in a semi-arid city… *Geographical Analysis* 44(3): 235-257

Scott, C.A., S. Megdal, L.A. Oroz, J. Callegary, P. Vandervoet. 2012. Effects of climate change and population growth on the transboundary Santa Cruz aquifer. *Climate Research* 51: 159-170

Scott, C.A. 2011. The water-energy-climate nexus: resources and policy outlook for aquifers in Mexico. *Water Resources Research* 47, W00L04, doi:10.1029/2011WR010805.

Scott, C.A., S.A. Pierce, M.J. Pasqualetti, A.L. Jones, B.E. Montz, J.H. Hoover. 2011. Policy and institutional dimensions of the water-energy nexus. *Energy Policy* 39: 6622–6630

Eden, S., C.A. Scott, M.L. Lamberton, S.B. Megdal. 2011. Energy-water interdependencies and the Central Arizona Project. In D. Kenney and R. Wilkinson (eds.) The Water-Energy Nexus in the American West, Edward Elgar, Cheltenham, UK, pp. 109-122.

Kumar, M.D., C.A. Scott, O.P. Singh. 2011. Inducing the shift from flat-rate or free agricultural power to metered supply… *Journal of Hydrology* 409: 382-394, doi:10.1016/j.jhydrol.2011.08.033.

Scott, C.A., M.J. Pasqualetti. 2010. Energy and water resources scarcity: Critical infrastructure for growth and economic development in Arizona and Sonora. *Natural Resources Journal* 50(3): 645-682.

QUESTIONS?

Christopher Scott

School of Geography & Development,
and
Udall Center for Studies in Public Policy
University of Arizona
cascott@email.arizona.edu
http://aquasec.org/wrpg/nexus

Thanks