



# The Role of Geothermal in Enhancing Energy Diversity and Security in the Western US

**Roger Hill**  
**Technical Director of GeoPowering the West**

USDOE Energy Efficiency and Renewable Energy  
Geothermal Technologies Program

# **The Role of Geothermal in Enhancing Energy Diversity and Security in the Western US**

**A Mean-Variance Portfolio Optimization of the Region's Generating Mix to 2013**

**Prepared for Sandia National Labs**

**Roger Hill  
Contract Officer**

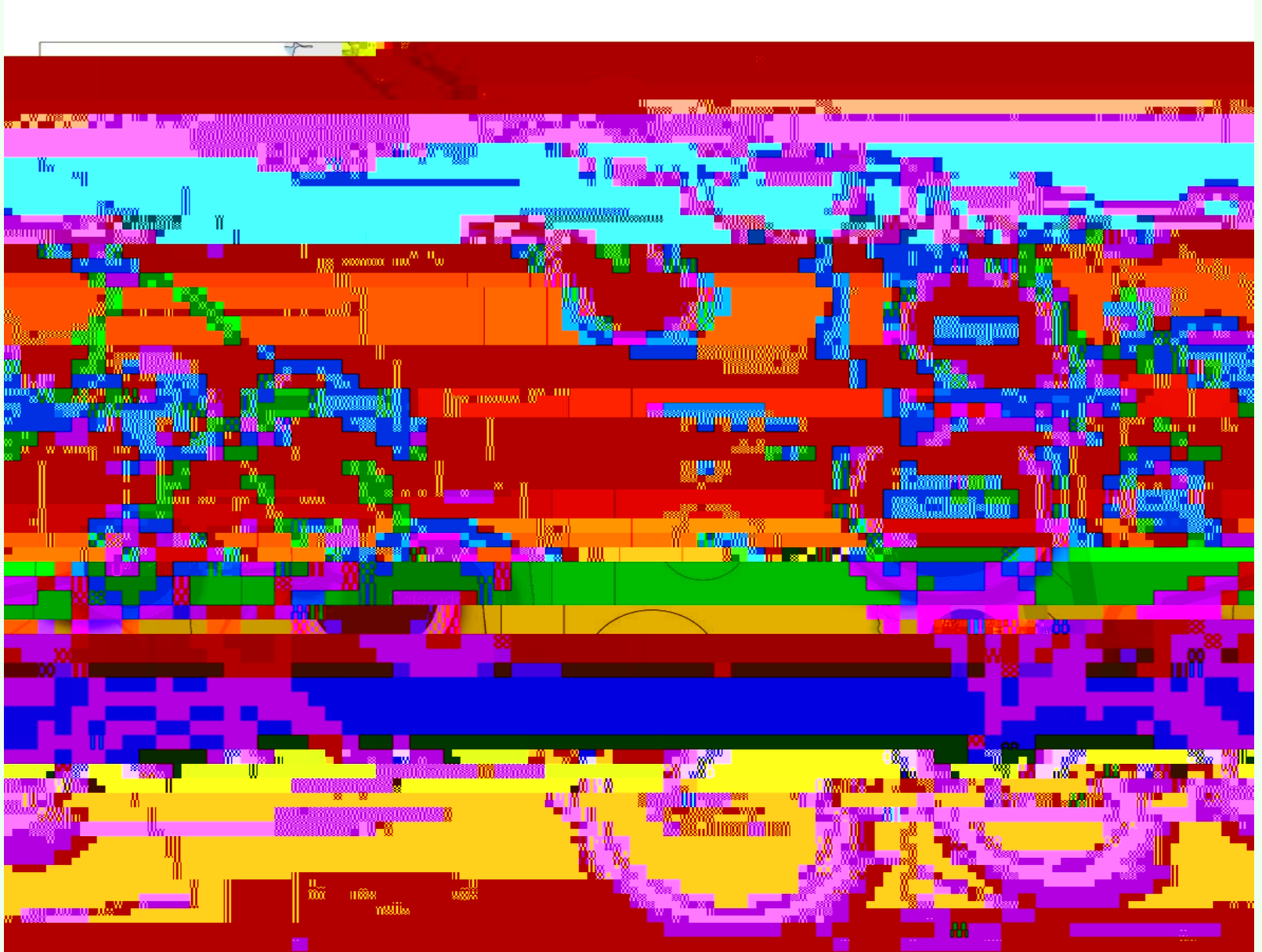
**By**

**Shimon Awerbuch, Ph.D.**

**Tyndall Centre Visiting Fellow - SPRU-Un/Attacherttacherttachert2 -123**

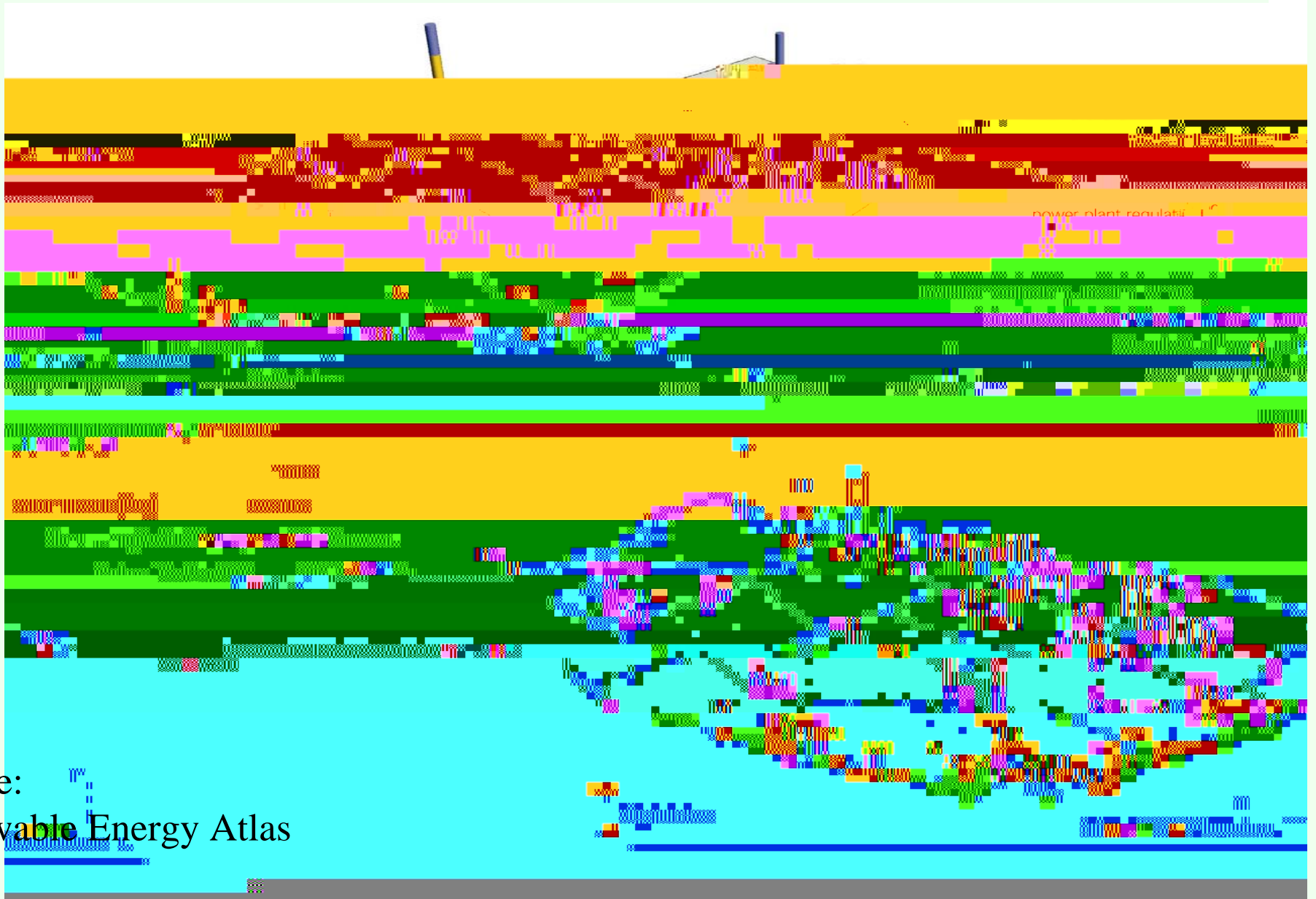


# Western US: Load Growth



Source:  
Renewable  
Energy Atlas

# Regional Power Plant Emissions



Source:  
Renewable Energy Atlas

**Optimization Defines Four Bands for  
New Geothermal Based es Tc -0inB 55Bi for**

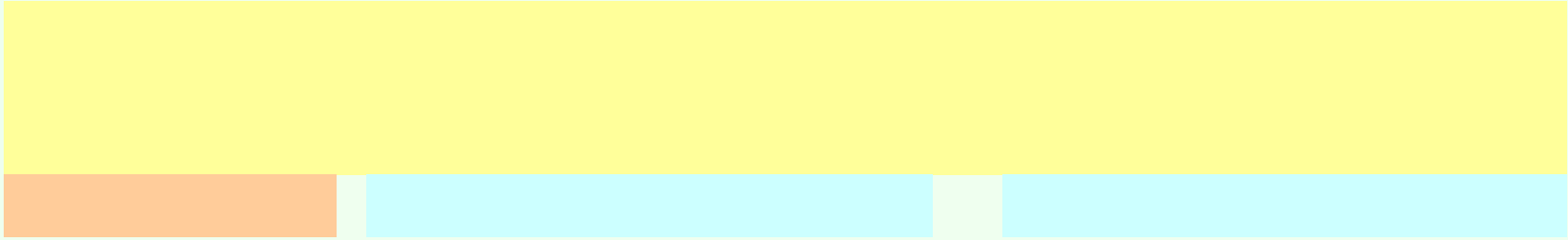








# Generating Cost Inputs: Nominal \$/kWh



# Understanding Risk

- **Portfolio optimization locates generating mixes with minimum expected cost and risk**
- **For each technology, risk is the year-to-year variability (standard deviation) of the three generating cost inputs: fuel, O&M and capital (construction period risk)**
  - Fossil fuel standard deviations are estimated from historic US data
    - e.g. standard deviation for natural gas over the last 10 years is 0.30
  - Standard deviations for capital and O&M are estimated using proxy procedures (see Awerbuch and Berger, IEA, 2003)
- **The construction period risk for embedded technologies is 0.0**
- **'New' technologies are therefore riskier than embedded ones**
  - e.g. new coal is riskier than 'old' coal









# **A Mean-Variance Portfolio Optimization of the Western Region's Generating Mix to 2013**

- **Portfolio optimization locates generating mixes with lowest-expected cost at every level of risk**
  - Risk is the year-to-year variability of technology generating costs
- EIA (NEMS) projected generating mixes serve as a benchmark or starting point;
  - Detailed decommissioning date assumptions using *World Electricity Power Plant Database* age of existing plants
- The optimal results generally indicate that compared to EIA target mixes, there exist generating mixes with larger geothermal shares at no greater expected cost or risk
  - There exist mixes with larger geothermal shares that exhibit *lower* expected cost and risk

