Concepts

- Markets are Diverse - Vertical Domain
- Functional Areas are Similar - Cross cutting
- Needs are Universal - developed and developing
- Dependencies between Weather and Operations
- Sequential Decision Making and Error Propagation
- Case Studies in the Energy Industry
- Case Studies in the Tourism Industry
- Case Study in Emergency Management
- Case Study for Developing Nations
Your IT Business Partner to the Future

Provider-User Concept

Providers Push

Data and Information

Knowledge and action

Users Pull

Added Value

Partnership

-Interpret user Needs
- Sensitize
Market research

THORPEX
National Met Ocean Services

Research

Government

Resource Management

Business

Technology goals

Development Goals

Your IT Business Partner to the Future
## Dual-Use Market Structure

<table>
<thead>
<tr>
<th>Research Community</th>
<th>Government Policy</th>
<th>Business (Domain or Verticals)</th>
<th>Natural Resource management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Energy</td>
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<td>• Water</td>
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<td>• Tourism &amp; Leisure</td>
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<td>• Construction</td>
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<td>• Financial Services</td>
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<td>• Defense</td>
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<td>• Agriculture</td>
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</tbody>
</table>
Critical Cross Cutting Functions for the Ensemble Forecast

- Supply/Demand Forecasting across All sectors (tactical)
- Revenue/Earnings/Shareholder value Forecasting (strategic)
- Incident (Emergency) Management (tactical)
- Policy Formulation and Governance (Strategic)

Provides

- **Advance Situational Awareness**
- **for Decision Support** (situation influence modeling, consequence assessment and Tactical Decision aids)
- **for Optimal operational response** (dispatch)
- Leading to Proactive Management Strategies and Policies
In Energy Industry Operations
- Energy load forecasting across grids
- Fuel mix determination
- Thermostat control
- Wind farm siting

In the Health Industry
- Health forecasts
- Spread of toxins and pollutants both airborne and waterborne
- Famine, flood, and drought climate forecasts
- Health facility scheduling
**In the Transportation Industry**
- Ship route optimization and planning
- Aviation routing and planning
- Intermodal transportation optimization
- Trucking industry logistics

**In the Tourism and Leisure Industry**
- Infrastructure planning for new construction
- Training courses for staff development programs
- Seasonal planning for resort load capacity
- Hazard and risk management preparation
- Leisure line route planning and recreational boating

---

**In the Finance Industry**
- Risk rating for compliance
- Weather derivatives for trading, futures and hedging
- Environmental evaluation for asset managers
Case Studies: The Power Industry
Energy Operations Aided by Reductions in Environmental Forecast Uncertainty

• Forecast Uncertainty

• Forecast Lead Time

Critical forecast periods
Sub day, 2-4 day, 90 day

- Load balancing
- Electricity pricing/trading
- Outage/surge mngt.
- “Intelligent” infrastructure
- “Neck metering”
- Dispatch management
- Hazard response
- Platform operations

- Tariff calling
- Utility grid management
- Wind generation dispatch
- Hydo supply management
- Ship/tanker routing
- Refining operations mngt.
- Pipeline laying logistics

- Customer billing service
- Pump load forecasting
- Fuel supply forecasting
- Energy switching strategy
- Distributed generat. mngt.
- Maintenance scheduling
- Sequestration timing
- Inventory management
- Pipeline throughput mngt.

- Infrastructure design
- Regional infrastructure plan
- New storage capacity plans
- Mitigation strategy design
- Plant/infrastructure siting
- Energy grid adaptation plans
- Energy policy setting

Forecast Uncertainty
New England Grid Operator (ISO NE) – weather impacts on short term load forecasting

Major Urban Utility (Con Ed) – weather impacts on distribution system loads

Major state owned end user (SUNY) – use of weather forecasting to control day ahead electric prices and manage natural gas and electricity costs at state facilities
Overall Goal

- Examine the value of improvement in weather/climate forecast accuracy to major stakeholders in the Electric Power Value Chain (Sellers, Distributors, Buyers)
- Determine the precise requirements of the stakeholders for the improvements of decisions—“what do you do?”
- Establish the Impact of forecast accuracy on the operation and planning decisions of the Industry
- Examine and Improve the Decision Support Tools of the User community to “institutionalize” information
- Develop the Stakeholder Advocacy through Awareness raising and Capability Building
Diagnostic Approach to Assessing Vulnerability and Risk

Project Objectives
Identify optimal NOAA product definitions supporting Energy industry planning requirements

Task 1. Base Case
Situation Assessment
• Project Initiation
• Define Current Practice
• Define Planning Needs
• Evaluate current data Strengths and weaknesses

Task 2. Gap Analysis
• Apply “Perfect Case”
• Identify Gaps
• Evaluate NOAA Prototypes

Task 3. Cost-Benefit
• Identify costs and benefits
• Review and select methodology
• Apply Methodology
• Recommend Ideal/Most Optimal Product

Planning Requirements
• Load forecast
• Short-term pricing
• Load flow management
• Power purchases

Planning Area
Level of Analysis:
Inter-/Intra Regional Distribution
End-customer

Weather Information
Supply Curve

Cost

Marginal Benefits/Decisions

Not Attractive Products

Attractive Products
Key Utility functions/decisions at Risk from inaccurate weather/climate data

- Load Balancing-single utility and grid
  - Generation commitment-
  - fuel mix choice and seamless integration (fossil fuel, hydro, wind)
  - Dispatch scheduling
- Power Marketing
  - Cash trading
  - Power pricing
  - Fuel pricing and procurement
- Tariff Scheduling
- Lineman and repair crew dispatch
- Pump Load Forecasting
- Natural Gas Storage Management
- Revenue Projections
- Infrastructure siting- fossil and renewables
- Management strategic planning
- Substation Scheduling/maintenance
- Emergency Management-Trimming and storm team dispatch
Weather Information “Flow” on the Decision Process and Value Chain: Risk Reduction Areas

**DATA** → **INFORMATION** → **KNOWLEDGE** → **ACTION** → **OUTCOMES** → **IMPACTS**

- **Weather Data/model products**
- **Weather Data Formatting**
- **Weather Data Pre-Processing**
- **Weather Information Integration**
- **Weather Decision Support**
- **Weather Information Evaluation**

**Load Forecasting**
- **Short**
- **Mid**
- **Long term**

**Operational Decisions**
- scheduling and load balancing
- asset management and replacement
- enterprise wide contingency and financial planning
- demand reduction and price responsive loads
- Revenue forecasting
- congestion management

**Management goals**
- Improved profit
- Increased Efficiency
- Improved reliability
- Increased safety
- Decreased Liability
- Decreased Risk
- Decreased Exposure

**NMS Other Weather/Climate forecasts**
- **Present Value-Added Service Providers**

**Data Analysis and IT Services:**
- Quantify, source, cost and reduce weather data error

**Load Model Error Analysis:**
- Improve Software and Support

**Decision Analysis, Dependencies and Support Tools**

**Economic/Performance Valuation of Weather Error Impacts**
Your IT Business Partner to the Future

Electricity Demand Model Error - Neural Net Diagnostics

Weather Forecast Model - AVN, MRF, etc or ensemble

Load Forecast Error

Power Demand Forecast Model - AANSLFF, RER Metrix, etc. or ensemble

Skill of the Environmental Forecast Impacts the Skill of the Power demand forecast
Diagnostics Approach

Fiscal loss (blown forecast)
Imbalance of supply-demand
Low skill of demand model
Weather error
Uncaptured event – seabreeze, fronts
Improve Model or observations

Install
Beta Test
validate
(Alpha test)
Urban Utility Case Study Findings 1: Significant load error due to high impact weather

Most utilities calculate weather error in MW as well as percentage of variance of the load. Analysis indicates that on some days, variance in the load forecast in MW may be solely due to weather error. This appears to be from events or unmodeled mesoscale features such as back door fronts, sea breeze and afternoon thunderstorms. SAIC estimates of cost of such events can be greater than $10M.
Principle Causes of Uncertainty on Energy Operations and Planning

- Uncaptured **WIND** Events
  - Delta Breeze- Cal ISO
  - Lake effects- Salt Lake City- Pacificorp, Great Lakes- SUNY Buffalo
  - Seabreeze- NE ISO, Entergy
  - Frontal passage- 2-4 day

- Uncaptured **PRECIPITATION** Events
  - Rain vs. snow/ice
  - Regional day ahead error in precipitation- Pacificorp
  - Afternoon thunderstorms
  - Marine Layer, fog- SDG&E
  - Drought and flood, flash flood
  - Humidity

- Uncaptured **CLIMATE** Events
  - Climate outlooks—weather events frequency
  - El Nino and seasonal events
  - Decadal oscillations- NAO

- **Accuracy/RESOLUTION**- Spatial, temporal
  - Sub grid level
  - Targeted watershed level, Nodal, congestion and population
  - Topographic Effects- microzones
  - Hourly changes during events
  - Dew Point

- **Load Model Error**
  - 50% load error at certain event periods
  - Can't incorporate probabilities/ ensembles

- **Sub-optimal Use**
  - Dew Point, cloud cover, wind speed
  - Need for decision aids
“The project estimated that the benefits of improving day ahead weather forecast accuracy by one degree F or by reducing forecasting error by 50% for days 2-7 is:

- --$20-25 million per year for a regional transmission authority
- --$1-2 million/year for a major distribution utility.

Optimal use of weather information could yield savings of $8–18 million/year for a major university system (electric and natural gas).

If these savings were generalized to other regional transmission organizations, large statewide colleges and universities and regional transmission authorities the total savings would be for the Northeast Region:

- -- $100-140 million/year for ISO’s
- --$30-60 million for regional electric distribution companies.
- -- $38-67 million for Statewide university campuses

HOWEVER capturing the “HIGH Impact events” will yield significantly higher savings (10’s millions/day).- seabreeze, backdoor fronts, afternoon showers
Case Studies 2 and 3

Evaluation of the Use of 30 Year Climate Forecasts To Improve Regional Long-Range Energy Infrastructure Planning for San Diego County

The Economic Benefit of Incorporating Weather and Climate Forecasts Into Western Energy Production Management.

Deliverable 2: Case Study Design and Scenario Report

Scripps Institution of Oceanography (SIO)
LA Jolla, CA

December 31, 2003
• Load balancing Problems
  • Coastal winds
  • Coastal fog
  • Microclimates
  • El Nino
Delta breeze and weather/load forecast errors contribute to major errors in prediction of Delta Breeze effects.

- Delta breeze is defined as the conditions when the wind speed is > 12 knots and the direction is between 190 degrees and 280 degrees.
- Delta Breeze can change load by 500MW
- Direct Costs: 250k per breeze day; 40 events per year
Case Study: Cal ISO Weather Forecast Error and Potential Cost $7M

- Gap of 4,724 MW
- Actual Load 39,577 MW
- DA Forecast 35,012 MW
- SC Bid Load 34,853 MW, 88%
FIGURE: Relative cost curve for under/over forecasting from CAL ISO, note the asymmetry between over forecasts and under-forecast.
Objective – To determine whether an ensemble based probabilistic forecast would outperform the forecast products currently used by the Cal ISO

Approach –

- Construct several (5) one-day-ahead multi-model ensemble forecast products
- Test in the Cal ISO Load Forecast Operation to determine the “performance” of the improved probabilistic product.
- Reanalysis of the past load and weather error (summers of 2002, 2003)
- Retrospective analysis of the financial impact of load imbalance. Two sets of performance metrics - technical performance or skill of the weather forecast model. The second is for the financial performance of the ensemble as it is transformed into a business forecast through the load forecasting process.
Relative costs of PF1 package forecasts versus the Cal ISO surrogate forecasts for days in May and June 2002, a positive value represents a savings of using PF1.

May and June 2002

1. More information is contained in the existing weather data stream that can be gleaned from an ensemble based approach.

2. This new information can save up to 50% of the weather error related costs by getting the forecast right during peak periods.

3. It works in relation to the cost curve and allows a forecaster to hedge risk based on fact not on “gut feeling”.

4. This new added information gives utility organizations an additional way to mitigate weather –related risks inherent in the load forecasting process.

5. The significant economic savings reported for 2003 is found to be even larger in the corresponding drop-one-out analysis for 2002; PF1 is shown to save about $15 million over current method, with a loss of about $5 million over perfect weather information

From Altalo, M. and L.Smith, Environmental Finance, October 2004
Emergency Management

State of Maryland Emergency Management Agencies (MEMA) and The Public Utilities Commission (PUC)
The “worst nightmare” according to Dr. Richard Schaeffer, head of the PUC is that the Governor’s office calls and asks “what is going on and when will services be restored?” and they don’t know

- Thus the need for “Situational Awareness”
- more than just environmental awareness-It is the status of the operations of power, water, communications, police, pipeline, toxic spill etc.
- Need probabilities of strikes for action
Severe Weather/Climate/Ocean Forecast + Impact Assessment on Operations + Emergency Power Dispatch Management

Storm Tracking with simulation tool - predict hurricane landfall

Emergency preparedness with “CATS” (consequence assessment tool set)
Locate critical energy assets, estimate damage and position for relief

Expert “Grid” Management
Situational Awareness and Power Restoration Management Tool

Data-Information Knowledge Action and Outcomes

Your IT Business Partner to the Future
“Chem-Bio Weather” Forecasts and Dispersion Models Predict Hazards and Allows Mitigation
Recreation and Tourism Industry Needs for Probabilistic Weather/Climate Information
1. **Hospitality**
   - Food service
   - Accommodation
2. **Distribution**
   - Travel Agents
   - Tour operators
3. **Transport and Infrastructure**
   - Aviation
   - Marine
4. **Visitor Attractions**
   - Man-made (theme parks, marinas, golf courses)
   - Natural (e.g. natural parks, coast, lakes)
5. **Host city/infrastructure**
   - Olympics
Recreation/ Tourism Operations Aided by Reductions in Environmental Forecast Uncertainty

- Building energy mngmt.
- Disaster risk mngt.
- Daily staff briefings
- Daily guest information
- “Intelligent” infrastructure
- Cruiseship positioning
- Snowmaking

- Sales/earnings forecasting
- Stock pricing
- Food service/supply procurement
- Group properties budgeting
- Unit price setting
- Rev par estimation
- Seasonal “occupancy” forecasts
- Delivery rate setting
- Compliance reporting

Forecast Lead Time

- Forecast Uncertainty
- Months
- Seasons
- Years

6 – 10 Days

8 – 14 Days

- Fuel supply procurement
- Backup generation plans
- Marketing (brochure, radio, ) development
- Annual insurance review
- Inventory management
- Cruiseline destination planning
- Convention “bidding”
- Premium/deductible setting

- Infrastructure design
- Landscape design
- Access planning
- Regional infrastructure plan
- New hotel capacity plans
- Mitigation strategy design
- Infrastructure siting
- Building code setting
- Development Master planning and revisit
- Regional Policy plans
- Federal Policy Development
RECREATION & TOURISM INDUSTRY
PERFORMANCE METRICS: The Business Models

Revenue per available room (RevPar)  Accommodation sector
Occupancy rates  Accommodation sector
Occupancy percentage  Accommodation sector
Average Daily Rates (ADR)  Accommodation sector
Comparative Operating Rates (COR)  Accommodation sector
Gross Operating Profit (% before fees) Across the industry
Economic Impact Assessment Across the industry
  Financial rate of Return (FRR) Across the industry
  Economic Rate of Return (ERR) Across the industry
International arrivals[1] Travel sector
Journeys made Travel sector
Environmental Information in the Operational Business Models

- Average daily temperature
- Average Annual temperature
- January rainfall in inches
- July rainfall in inches
- Snowfall in Inches
- Number of Heating degree-days (Last 30 years)
- Number of Cooling degree-days (Last 30 years)
- Wind speed in Miles per Hour (Annual average)
- Annual number of days sunny or partly sunny
- Elevation (Mean feet above sea level)
- Wave height
- Current speed and direction
Utilities - Energy Pricing & 4hr forecasts of temp./sea breeze - Scottish Power

Oil and Gas - Regional Energy infrastructure master planning and climate/ocean conditions - BP

Construction - Building codes & standards with 20 year heat/precipitation/sea level forecasts - Building Research Establishment

Leisure - Revenue projections and seasonal temperature/ppt forecasts - The Starwood Group, Europe/Africa

Finance – Financial Risk Rating Index and air/water quality and climate forecasts - SERM Rating Agency

Health and EM - Coastal metropolitan health alert planning and met/AQ forecasting
Starwood Hotel Trial
Marbella, Spain

CEO
Strategic Planning

Marketing/Sales
Operations
Finance-Revenue Manager
Procurement
Development

Shareholders

Business Forecasting-1,6,12mo,5y
Revenue Projection-RevPAR
Yield Management Models
Demand & Capacity Forecasting
Implement Rev Mngt Strategy
Market analysis

Environmental Conditions
Observing System Products
* temp amd ppt forecasts at 1mo, 60 mo, 12 mo and 5 year time periods

• Can seasonal environmental information improve the accuracy of Revenue Forecasting in the Iberian Peninsula?
“Industry Trials” for African Business Needs

- **Tourism and Leisure** - Revenue Forecasting and Unit Pricing
- **Power Utilities** - Energy Grid/Dispatch Management and temperature and ppt forecasting
- **Oil and Gas** - Platform scheduling and wave height forecasts
- **Health and EM** - Disease Prediction and Seasonal to interannual ppt forecasts
- **Finance** - Insurance and Underwriting
- **Transport** - Port security, congestion management
- **Construction** - Sustainable Housing and materials
## Candidate Industry Trials

<table>
<thead>
<tr>
<th>Business</th>
<th>Country</th>
<th>Institution</th>
<th>Information Requirements</th>
<th>Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tourism &amp; Leisure</strong></td>
<td>NEPAD Pilot, Tunisia</td>
<td>OTT, Starwood</td>
<td>1-2 week forecast, Seasonal Prediction</td>
<td>More atmospheric and ocean observations-remote sensing</td>
</tr>
<tr>
<td><strong>Power &amp; Utilities</strong></td>
<td>Mozambique, Zambia, Zimbabwe (Hydro power)</td>
<td>Zambezi water Authority</td>
<td>Now casting, Event Monitoring, 2-4 day forecasting</td>
<td>More radar coverage, Coastal Buoys &amp; weather stations, Downscaling and models nesting, Bathymetry, Thorpex</td>
</tr>
<tr>
<td><strong>Oil &amp; Gas</strong></td>
<td>Nigeria, Algeria</td>
<td>Shell, Sonatrach</td>
<td>Wave, Winds, Storm tracking, Sub-surface currents,</td>
<td>Dispersion Models, more ocean observations, moorings and drifters</td>
</tr>
<tr>
<td><strong>Health &amp; EM</strong></td>
<td>Burkina-Faso, South Africa</td>
<td>MDSC, MARA, Medical Centres</td>
<td>Seasonal predictions (Temp, Pres), 1-2 weak forecasts,</td>
<td>Ocean, Global atmospheric observations.</td>
</tr>
<tr>
<td><strong>Finance</strong></td>
<td>South Africa</td>
<td>UNEP-FI, GENSEC</td>
<td>Historical Climate Info, Seasonal predictions, 1day -2week forecast</td>
<td>Global atmospheric observations, Remote atmospheric observations</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>Abidjan, Accra, Cotonou</td>
<td>Port Authorities, Container shipping companies</td>
<td>Waves, Currents, Winds, Storms</td>
<td>More Over and In ocean sensors, Improved surface models</td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td>SA</td>
<td>Bouygues, Bovis Lend Lease</td>
<td>Short term forecasting, Seasonal predictions, Inter-annual (Temp, Pres)</td>
<td>More Over and In ocean sensors, Improved surface models</td>
</tr>
<tr>
<td><strong>Mining</strong></td>
<td>SA, RDC</td>
<td>Anglo American Seabed mining companies</td>
<td>Pres, Event monitoring, Now-cast, Waves, surface and sub-surface currents</td>
<td>Spatial resolution models, moorings</td>
</tr>
<tr>
<td><strong>Telecoms</strong></td>
<td>JHB</td>
<td>Rascom</td>
<td>Lightning, winds, storms</td>
<td>Lightning networks,</td>
</tr>
</tbody>
</table>
Ethiopian Electric and Power Corporation – 97% hydro from Koka Dam

- Mitigate flash flood hazards and identify periods of water scarcity - risk analysis
- Incorporate surface variables (ppt, t) into hydrological forecast
- Skill score of climate forecasts
- Dam capacity impacted by erosion in basin
- Flash floods and water releasing schemes from dams by Ministry of Water Resources
- During drought power rationing leads to revenue loss - Linkage effect of power production and customer revenue loss -$8M, enough to destabilize the economy

Recommendations

- EEPCo must include seasonal forecasts into its long term plan
  - Produce power demand scenarios based on seasonal rainfall outlooks
- Development of future models hydro parameters be included in addition to meteorological variables
- Combine variability of rainfall and complex topography and behavior of rainfall on subgrid level
Relative costs for developing and developed Nations

- 8M to Ethiopia is enough to destabilize the economy
- 8M to California causes minor institutional discomfort

PRIORITY MUST BE DEVELOPING NATIONS---WHO WILL PAY FOR THEIR COSTS