# This presentation premiered at WaterSmart Innovations

watersmartinnovations.com



### Micro-simulation approach for modeling customer behavior for demand forecasting and demand management

**Intelligent Software Development (ISD)** 



## **Common problems**

- How can we more accurately forecast demand in a complex and changing consumer environment?
  - Bounce-back in demand following drought and water restrictions
  - Building business cases: capital planning, corporate plans, regulators & pricing
- How can we determine why household water consumption is decreasing?
  - What is contributing to the decrease?
  - When will the decrease slow down or stop?
- How can we design more effective demand management programs?
  - Restrictions, rebates, retro-fit, behavior change programs, pricing

The answers are dependent on the decisions of millions of *different* individual consumers/people



### Factors that impact water demand

- Population trends and dynamics
  - Population growth & demographic change e.g. household structure and size
  - Change in household allotment/garden size e.g. getting smaller
- Products or appliances used
  - Uptake and penetration
  - Efficiency and consumption (water, energy, carbon) e.g. becoming more efficient
- Consumer behavior
  - Consumers usage of appliances range of *possible and rational* behaviors
  - Frequency and duration of use, per household or per person
  - Interdependencies: seasonal factors, demographic factors (e.g. age & bath use)
- Behavior change & maintenance from influences (strategies and policies)
  - Factors: social, economic, environmental, political
  - Water conservation: restrictions (gardens, cars, pools), rebates, retrofit
  - Price: discretionary and non-discretionary
  - Marketing & media on the water situation e.g. drought & water levels
  - Different consumers respond differently within range of behaviors e.g. income level, preferences for different demographics, duration persisting with behavior, etc.

#### Need to consider all of these factors



## **Data Analytics & Decision Process**



\* Based on Gartner's model of analytics

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# **Current Approaches**

#### Spreadsheets

- a 2D tool (rows and columns) to tackle an multi-dimensional problem
- Limited scalability

#### "Econometric Only" models

- Limited in addressing these non-linear, dynamic, human-centric problems
- Limited detail, unrealistic assumptions about decision making, ...

#### Statistics, data mining, and mathematical models

- Observes and forecasts what people do, no insight into "why" they do it
- Inability to effectively represent complex consumer behavior, and the impact individual behavior has on aggregated results
- Single purpose (forecasting) difficult to address other business problems

#### Past demand may not be a good predictor of the future



# What is SimulAIt?



Agent-based micro-simulation platform that can accurately <u>predict</u> and explore options to <u>influence</u> mass-consumer behavior and decision making

- Simulates populations of all sizes with regional breakdown
- Models reactions and behaviors of individual consumers to new strategies, policies, products, prices and competitive strategies
- Handles different types of *complex* data to incorporate many consumer decision making factors
  - Qualitative and quantitative data
  - Social, economic, environmental and political data
- Incorporates different technologies from Defence
  - AI, Agent-Based Modeling, Human Cognition Reasoning Engine, Dynamic Multi-Dimensional Database, Micro-simulation



# **Rigorous Validation**

- Accurate: proven approach, demonstrated over 95% accuracy
  - Model not built on past demand data demand data used to validate the model
  - Accuracy due to greater representation of a broad range of consumer factors





### **Energy: Businesses, 30mins**

	Energy load forecasting accuracy														
	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
2008	99.0%	99.2%	97.9%	98.8%	98.0%	95.0%	98.5%	99.6%	97.0%	99.6%	98.7%	96.5%	85.0%		
2009	99.8%	96.7%	99.3%	99.3%	99.0%	98.9%	98.4%	98.8%	95.1%	97.3%	93.1%	98.6%	98.3%		
2010	98.3%	91.9%	97.9%	97.1%	97.6%	98.6%	98.1%	99.1%	97.1%	87.8%					



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### **SimulAIt Technology**



Different consumers



Agent-Based Modeling: software agents represent different consumers in the virtual simulation environment



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# **SimulAIt Architecture**





# Water Forecasting Model

# SimulAIt is used to create a detailed simulation of water customers

- Simulated how consumers use water and make decisions in the garden, kitchen, bathroom, laundry, etc.
  - What products they use, how they use the products, how this changes over time
- Simulate how consumers' decisions are influenced by different policies and communication signals, such as media communications



#### **Behavioral Model**

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# Credentials



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### **Case Study 1: Melbourne Water Utilities**

#### Objectives

- Blind validation: Used 4 yrs of demand data to calibrate outdoor water use and then forecast next 6 years of demand without access to actual demand data
- Separate models created for Yarra Valley Water, City West Water and South East Water and participation from Melbourne Water
- Forecast bounce-back in demand from easing restrictions & price increases
- Flexibility to investigate customer water use behaviors and uptake of efficient appliances



### **Case Study 1: Melbourne Water Utilities**

#### Key outcomes and benefits

- Blind validation provided greater confidence in the model and forecasts
  - Ability to investigate bounce-back in demand
  - Minimizes risk and enables optimisation of strategies
  - Potential use in pricing submissions to regulators
- Share a consistent and accurate model





### **Case Study 2: Central Highlands Water**

#### **Objectives**

- Evaluate past strategies, and forecast bounce-back in demand from easing water restrictions
- Assess impact of price rises on water demand
- Assess impact of product uptake on revenue
- Build a business case to industry regulators
- Build demographic demand profiles



### **Case Study 2: Central Highlands Water**

#### Key outcomes and benefits

- Informed capital expenditure, corporate plans, restriction setting
- Rigorous business case to industry regulators to maximise product price and revenue
- Isolated and quantified the effectiveness of past & future strategies (campaign analysis)
- Inform & increase ROI on future strategies



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### **Retro-fit Programs: Project Aquarius**



### **Voluntary Behavior Change**



### **Future Forecasts**

#### **Comparison of scenarios (KL/HH/yr)**





### **Demand Bounce Back**

- Theoretical maximum bounce back
  - Natural decrease in demand from uptake of efficient appliances and population dynamics
- Behavior maintenance/change
  - Test different levels of behavior maintenance (sensitivity analysis)



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### **Price Rises**

- Forecasts show that two 10% price increases from 2013 results in a 1.5kL (0.9%) reduction in household water consumption per annum
- Economic analysis shows a 6.3 kL (4.2%) drop in water consumption
- SimulAIt results show the current high level of behavior change in the Ballarat community provides little opportunity to reduce water consumption from price rises



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## **Case Study 3: Rebates**



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#### Objective

- Identify a mix of products and prices for the water rebates program that maximises efficiency and keeps within the program budget
- Three projects, and now a 3 year license to 2015

#### Approach

- Simulated 2 million households, 4.5 million consumers
- Incorporated consumer preference and affordability, and product age, failure and price
- Simulated product uptake and efficiency with different prices

#### Key outcomes and benefits

- Accurate predictions of product up-take and budget spend
- Prevented budgets blow-outs
- Cost/benefit (triple bottom line) analysis of different strategies
- Forecast the ROI of different demographics and regions, and to assist with targeted (micro)-marketing of the rebate program



## **SimulAIt Online (SOL)**

- Access SimulAIt via a web browser
- SimulAIt Online allows:
  - Access your validated model online
  - Add many users
  - Create multiple scenarios test assumptions and what-if analysis
  - Share scenarios (models), results, notes and descriptions
  - Refresh data and configure assumptions, parameters, etc...
  - Run simulations
  - Download results disaggregated via region, and time or appliance
- Benefits
  - On-demand access to models, for technical and *non-technical* users
  - Control, visibility, ease of use
  - Facilitates collaboration and consistency: share scenarios and results
  - Maximise ROI: execute many scenarios when required
  - Hosted solution: no installation of software or hardware required to run large scale simulations



SimulAIt Online

WATER

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## **Case Study 4: SOL**



#### Challenge

 Limited availability of suitable data and forecasting models presents a challenge for regional water retailers to produce accurate forecasts for their pricing review

#### Approach

- Team members collaboratively used SOL to create validated models with minimal data
- Data used: Census regions, weather, schedule of restrictions and prices, and one year (pre-restriction) historical demand data to calibrate some outdoor watering parameters

#### Key outcomes and benefits

- SOL enabled team members to access, configure, validate, and share models and forecast results
- Demand forecasts used to support their pricing review



### Conclusions

- New emerging micro-simulation approaches such as agent-based modeling provide a suitable model to represent complex consumer environments
- Case studies presented show practical application of SimulAIt microsimulation to forecast water demand:
  - Bounce-back in demand
  - Effectiveness of water efficiency programs
  - Rebates and incentives
  - Pricing
- Models can be validated as minimal historical demand data is used to create the model
  - High-level of accuracy has been achieved
- Minimal data needed to create detailed models
  - Consumer logic/behavior and detailed Census data already built into the model
- SOL can facilitate on-demand access to the water model
  - Provides a collaborative tool for technical and non-technical users to create, validate, update and share scenarios and forecasts



### **Questions?**

#### **Intelligent Software Development (ISD)**

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## **Sub Decks of Slides....**









# **SOL Technical Overview**



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## Main SOL screen



## **Scenario: Configuration**



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### **Run scenario – SimulAIt!**

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## **Scenario: Results**

#### Range of results to download:

Water, energy, carbon, revenue, etc.

Monthly, yearly

Disaggregated into different regions, appliances

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# **Outputs: Monthly Demand**



# **Outputs: Yearly Demand**



# **Outputs: Household Usage**

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"Predict a better future"

Software Development

# **Outputs: Revenue, Water Bills**





## **Outputs: Rebate uptake/efficiency**

