

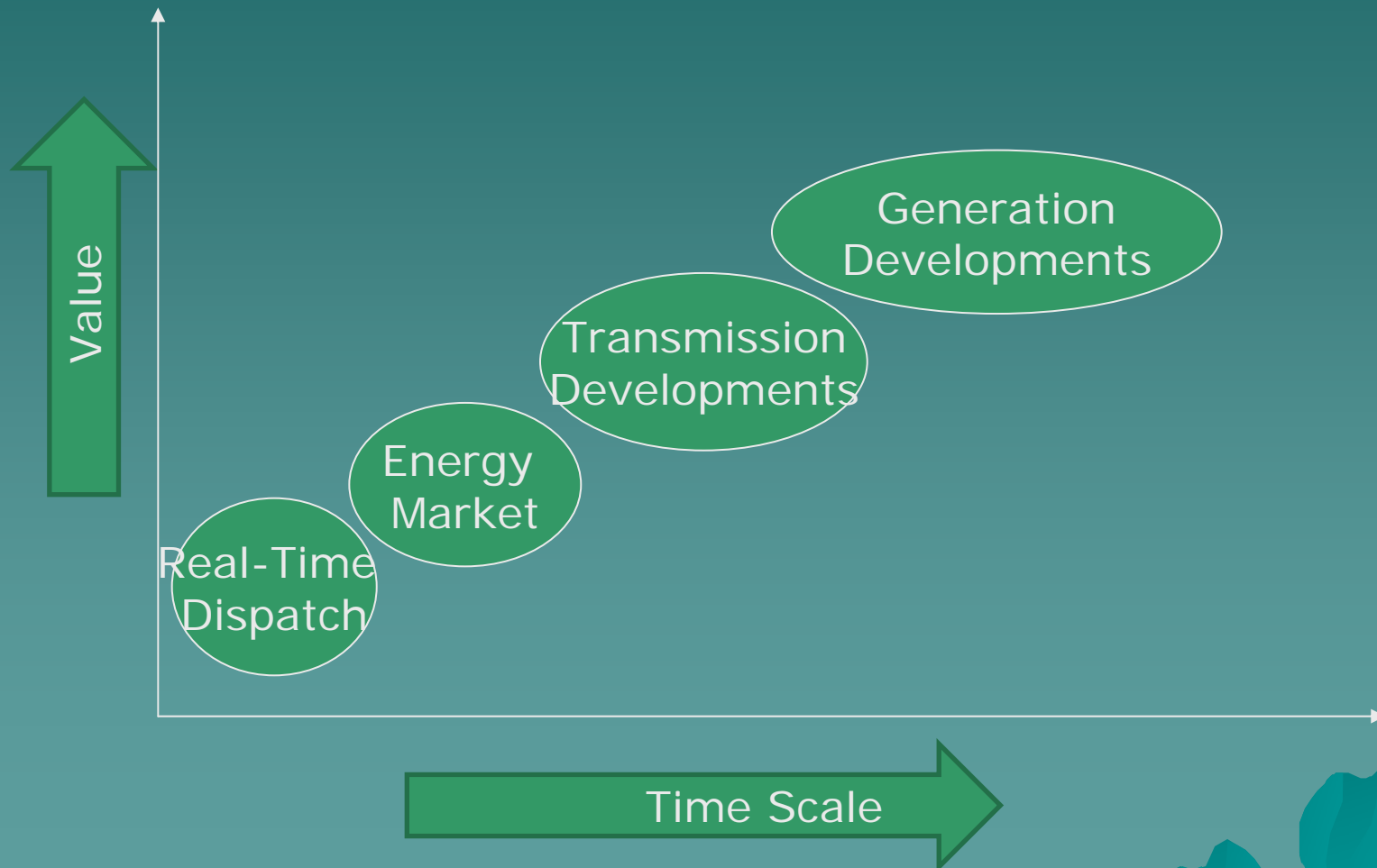
Decision Support Software for Power System Planning & Operations

By
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Presenter's Background

- ◆ Analytical Engineer for HVDC Links
- ◆ Power System Planning Engineer in Power Utility
- ◆ Manager of Technical Computer Services in Utility
- ◆ Consultant in Power System Operations & Automation
 - Responsible for Designing, Specifying & Supervising the development of SCADA and Energy Management Systems in over 20 utilities world-wide

Decision Consequences

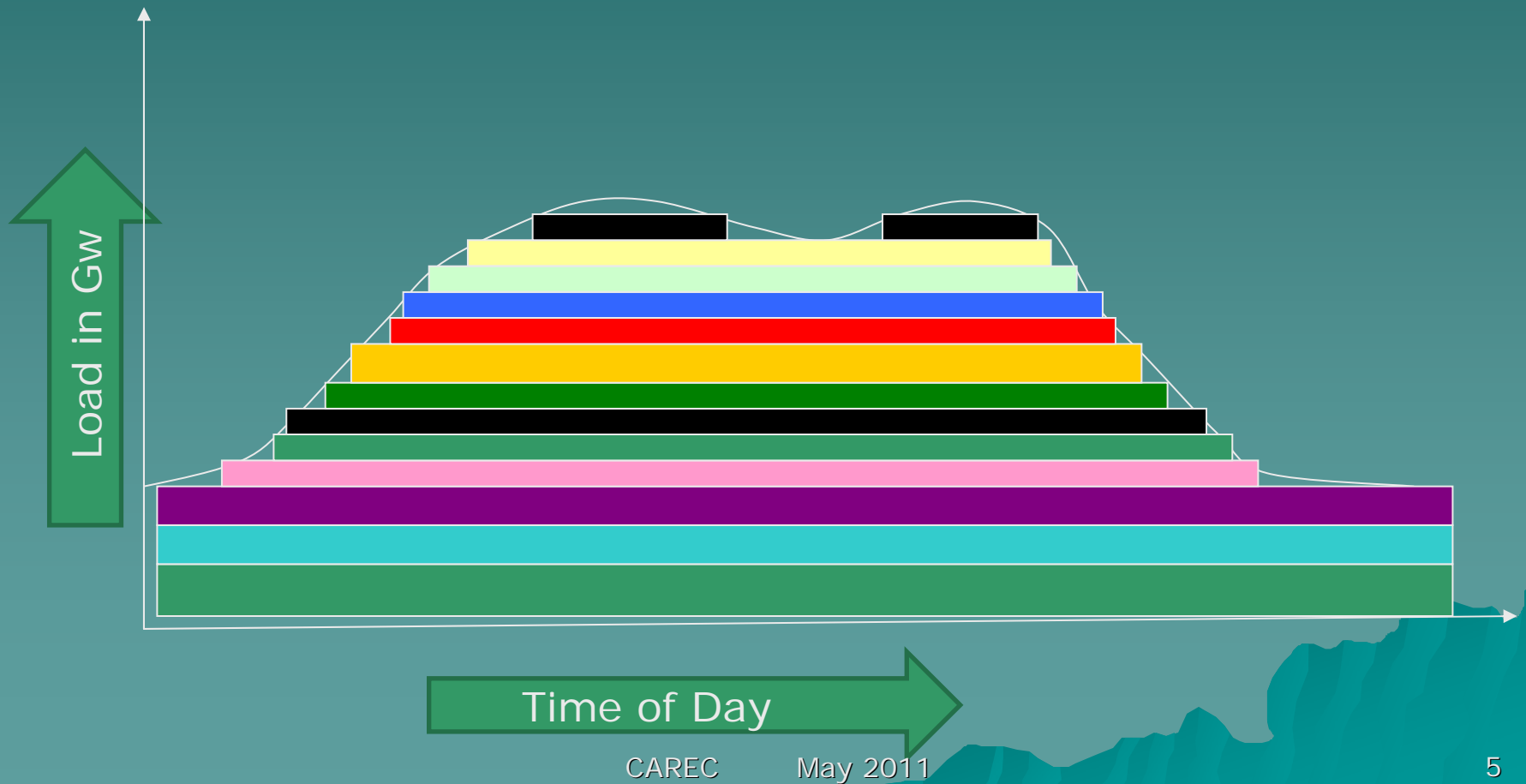


Generation Capacity Planning

Search for 'Least Cost Investment Plan', within

- ◆ Load growth projections
- ◆ Energy Constraints – hydro / hydrocarbon availability
- ◆ Environmental constraints
- ◆ Fuel diversity objectives
- ◆ Regional interconnection plans

Daily Demand Curve



Demand Side

- Econometric model
- System demand projection
- Load Duration Curve
- Energy Growth rate
- Discount rate

Repeated
Modelling of
Dispatch

No
Transmission

Evaluation
based on
LOLE or
VOLL

Supply Side

Generator 3

Generator 2

Generator 1

- Dates in & out
- Capacity
- Fuel type
- Construction Cost
- Operating Cost
- Maintenance Schedule
- Scrap Value

Criteria for Selecting Plan

- ◆ LOLE / LOLP Loss of Load expectation
 - N instances per annum
- ◆ VOLL – Value of Lost Load
 - Depends on state of economic development
 - Depends on estimated value of 1 MWhr non-supplied

Output from Generation Plan

Subject to various stated constraints

- ◆ Costed plan over, say, 30 years
- ◆ List of instances that exceed stated acceptance criteria
- ◆ Based on user chosen schedule of proposed generating plant with
 - Years in and out of service
 - Specified ratings
 - Plant utilisation

WASP

- ◆ Wien Automatic System Planning Package (WASP) - now in V4
- ◆ Model for Analysis of Energy Demand (MAED) helps in predicting demand
- ◆ Originally from TVA..... now available via IAEA
- ◆ Very extensive & detailed models of generation, demand, external factors

WASP offers

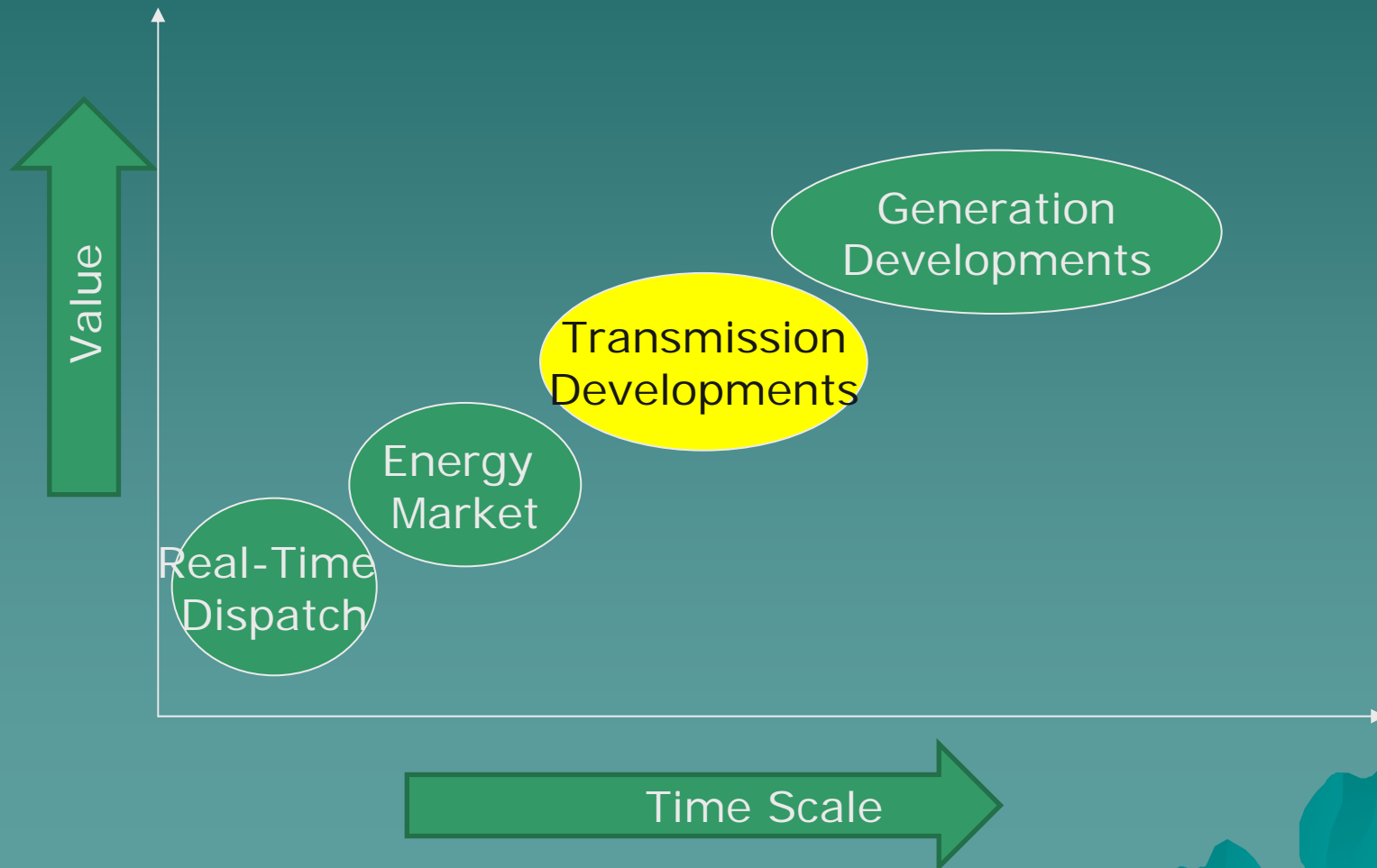
- ◆ Various thermal plant types
- ◆ Various hydro plant & pumped storage types
- ◆ Extensive parameters on plant costs
- ◆ Operational & availability plant parameters
- ◆ Emission constraints (e.g. GHG)
- ◆ Discount rates
- ◆ Energy constraints

- ◆ Extensive Front-end & Back-end support

Other Generation Expansion Software Models

- ◆ EGEAS from EPRI (Electric Generation Expansion Analysis System)
 - Accounts for US style energy market models
- ◆ For others see reference list at end

Decision Consequences



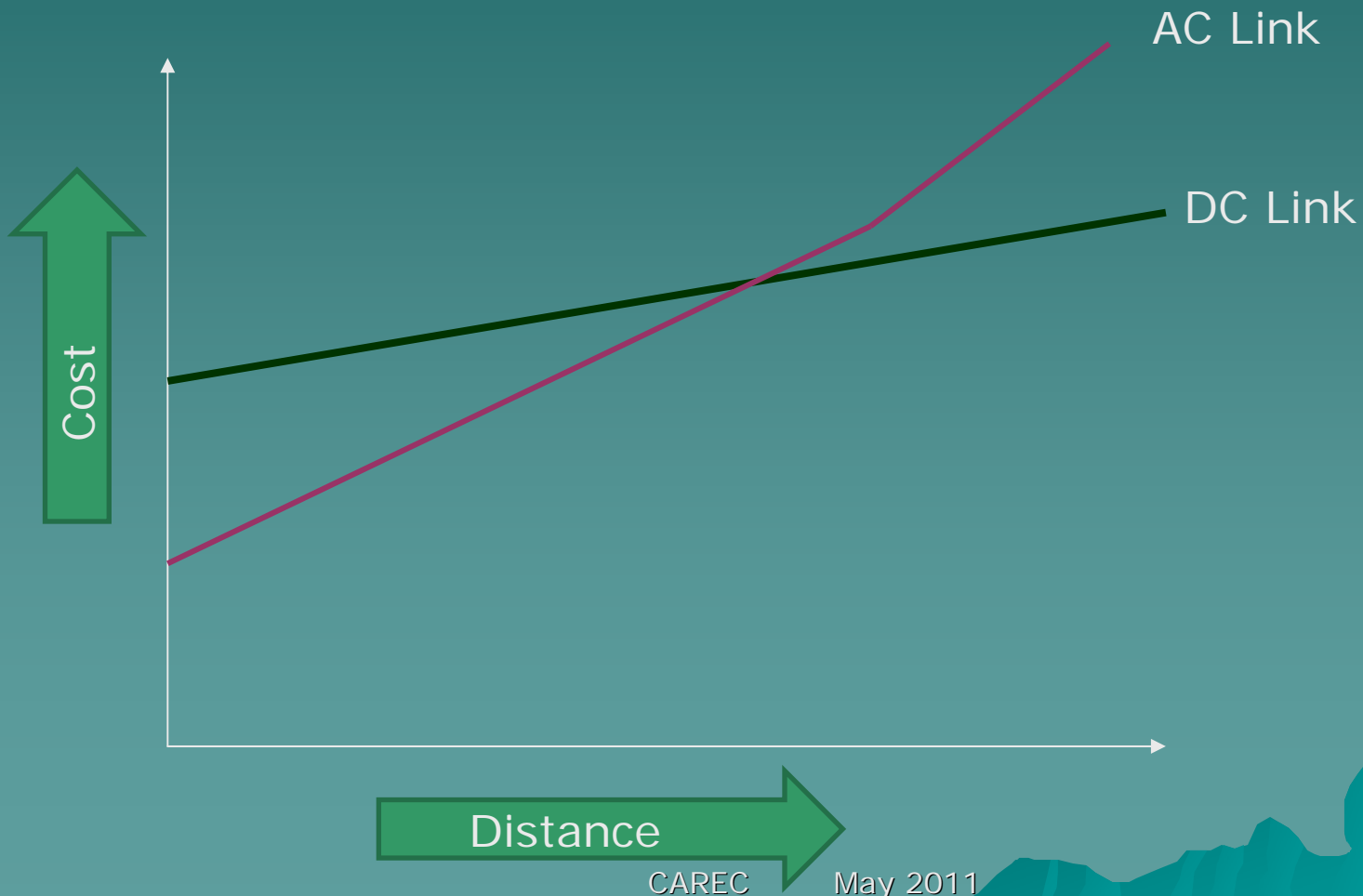
Transmission System Planning

Issues to consider

- ◆ Points of interconnection
- ◆ Type of link
- ◆ Link voltage
- ◆ Technical design parameters

Types of Link

AC or DC or AC + FACTS



Voltage Level

- ◆ 110 kV → 75 MW
- ◆ 220 kV → 280 MW
- ◆ 400 kV → 900 MW
- ◆ 800 kV → 3500 MW

Based on approx Surge Impedance Loading

Technical Issues

- ◆ Line Rating in conservative scenario
- ◆ Fault currents arising from new lines & breaker capacities
- ◆ Stability
 - Transient
 - Voltage
 - Oscillatory
- ◆ Switching Overvoltages

Technical Issues

- ◆ **Line Rating** in conservative scenario → **Load Flow**
- ◆ **Fault currents** arising from new lines & breaker capacities
→ **Short Circuit Analysis**
- ◆ **Stability** → **Stability**
 - Transient
 - Voltage
 - Oscillatory
- ◆ **Switching Overvoltages** → **EMTP**

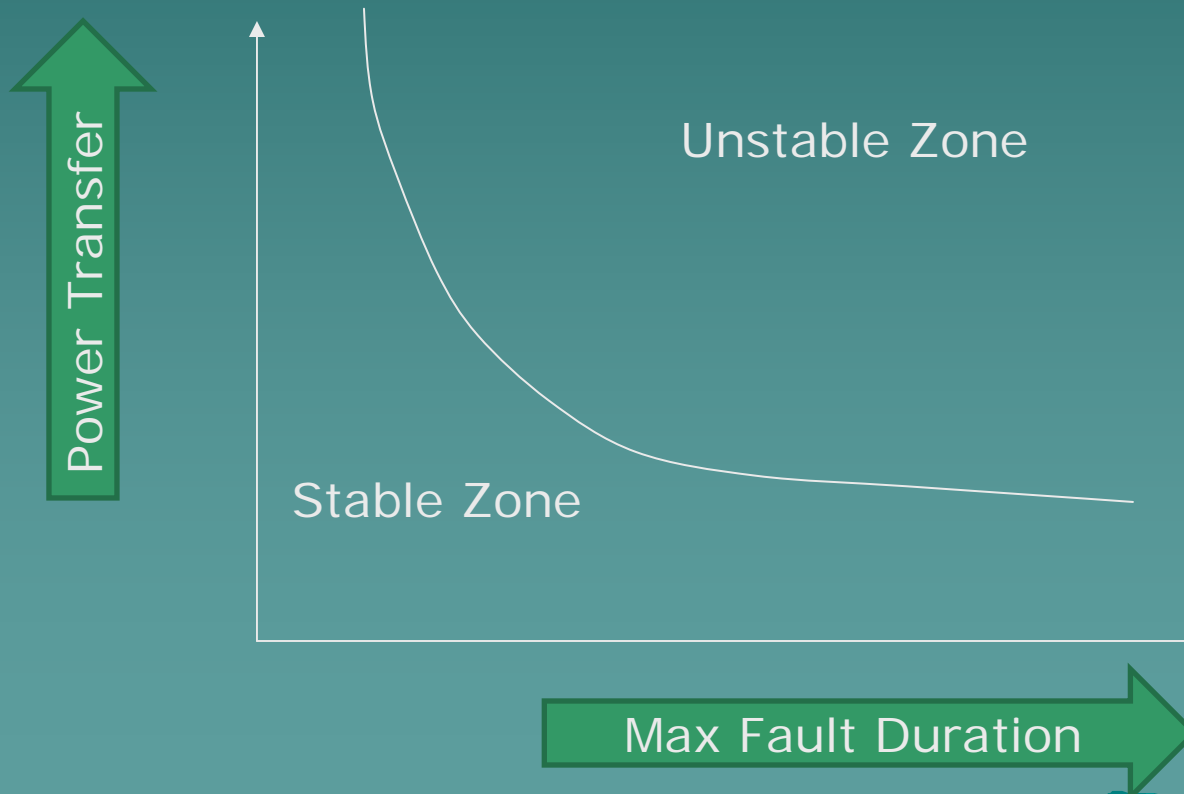
Transmission Planning Scenarios

- ◆ Peak Demand
- ◆ Conservative geographical separation of demand & generation
- ◆ Critical dependency on outage type
 - N-1
 - N-2
 - probabilistic

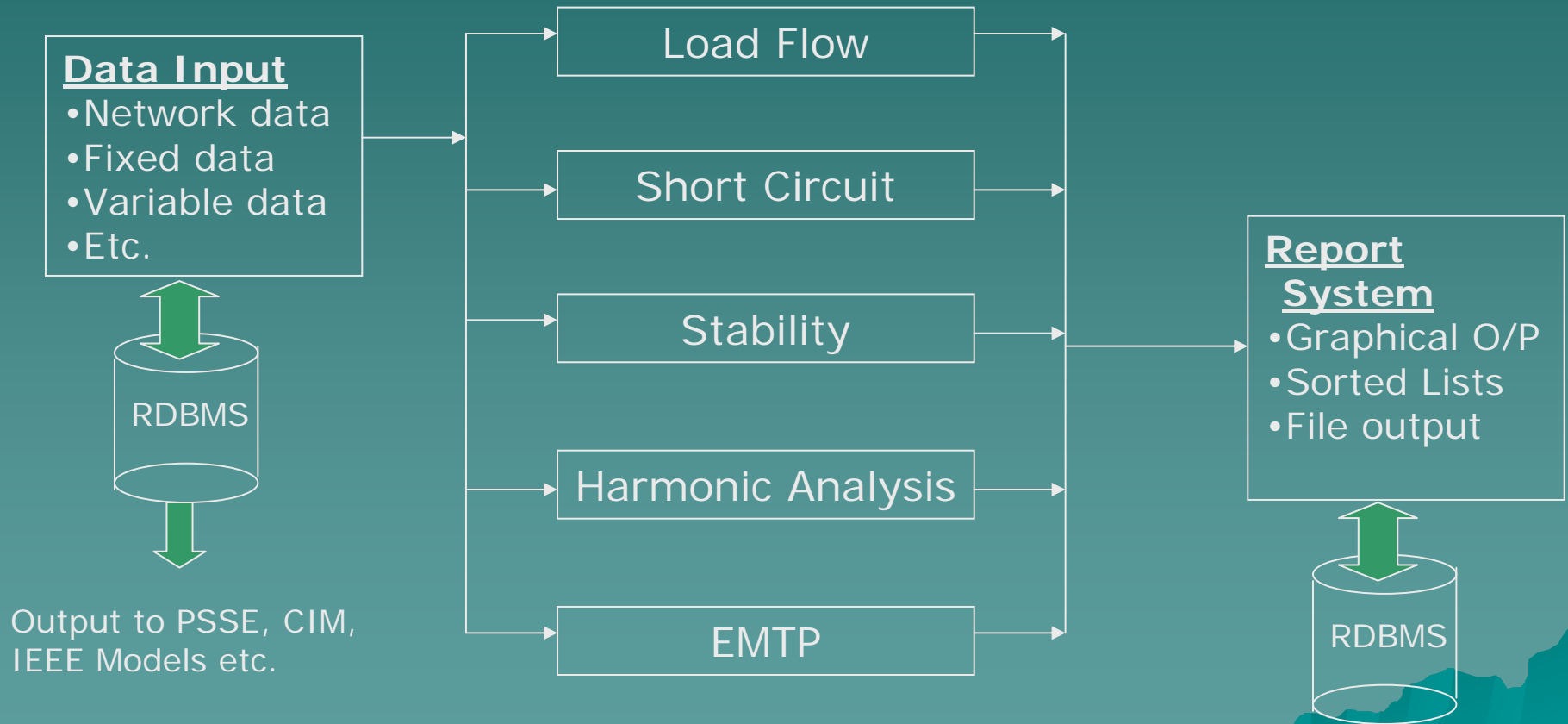
Investment to be minimised !!

Transient Stability

Often arises when load & generation are geographically separated



Schematic Connections of Software Modules



Typical Main Software Package Features

- ◆ Tabular or graphical data input
- ◆ Network size up to 150,000 buses
- ◆ Wide range of modules for
 - Load flow
 - Short circuit analysis
 - Dynamic analysis
 - Harmonic analysis
- ◆ User defined / automated contingency analysis with corrective actions
- ◆ User defined software functions
- ◆ Wide range of data exchange capabilities
- ◆ Extensive data management & reporting

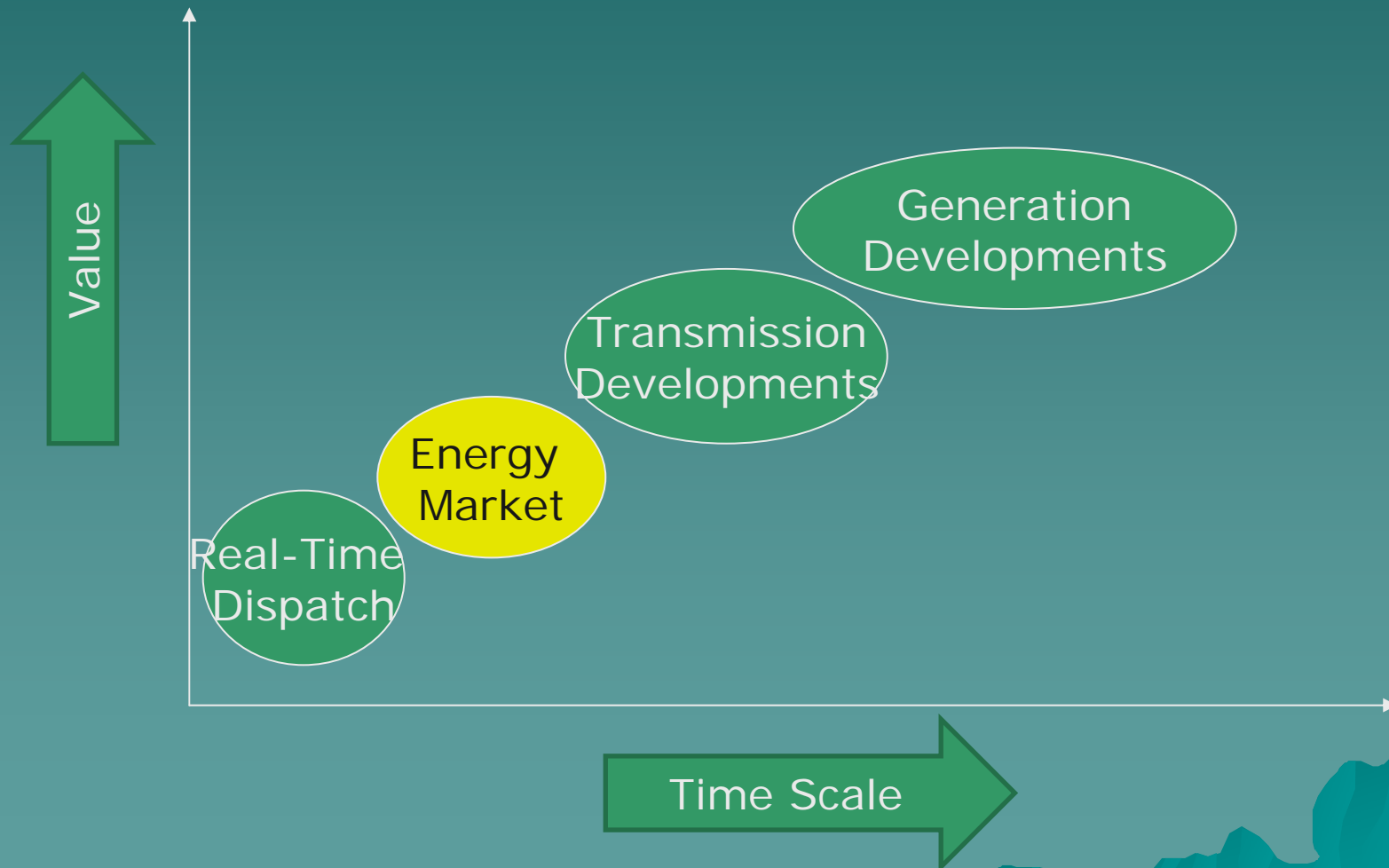
Deferred Design Matters

- ◆ Exact route of line
- ◆ Environmental considerations
- ◆ Conductor design
- ◆ Line mechanical characteristics
- ◆ Tower type & design

Transmission Planning Packages

- ◆ Wide range of similar packages
 - Siemens (PTI) PSSE
 - CYME
 - Digsilent
 - GE PSLF
 - ERACS
 - etc.

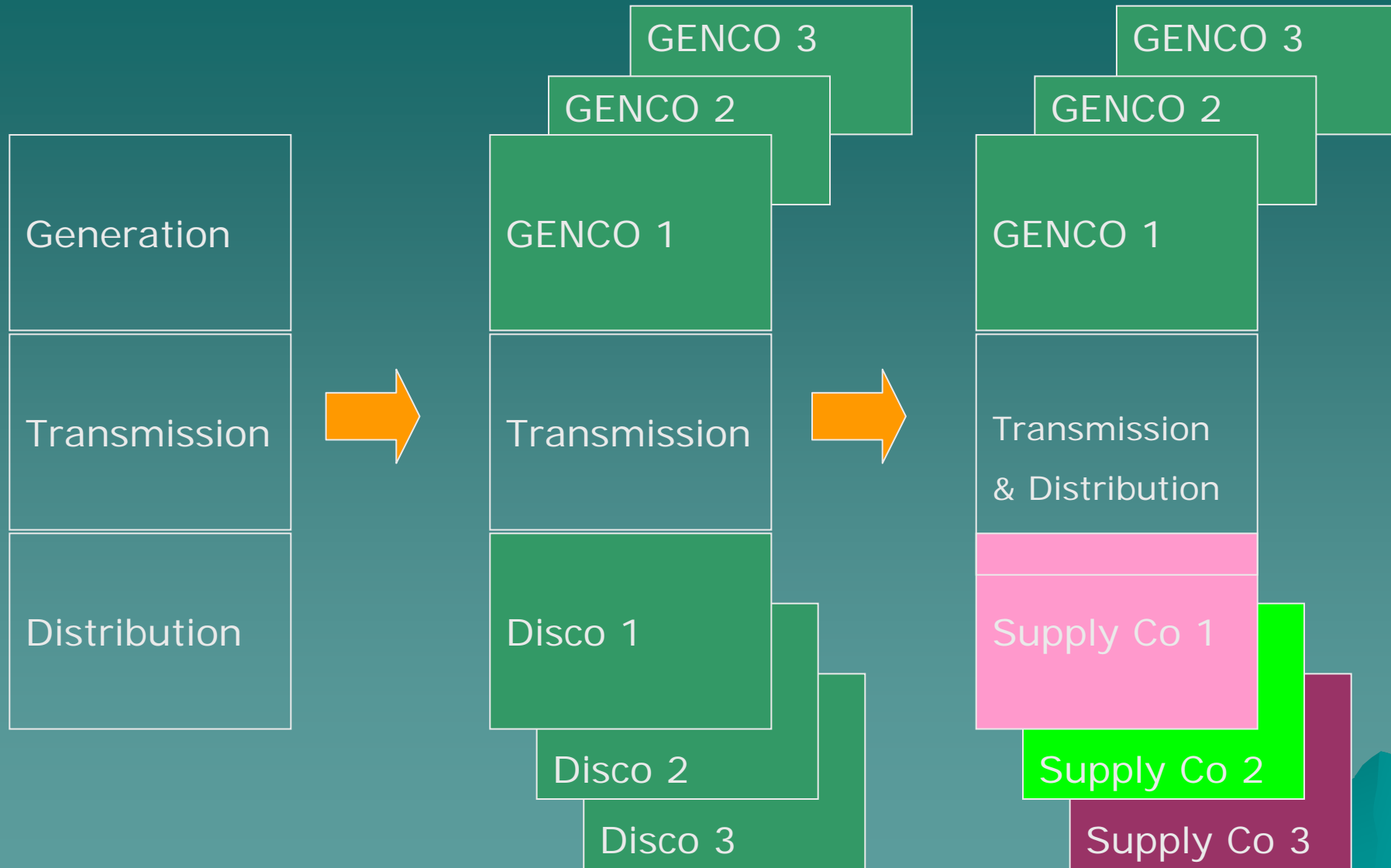
Decision Consequences



Competitive Energy Market

- ◆ Many types – no standard model
- ◆ Complex and costly to establish
- ◆ Minimum size needed for genuine competition
- ◆ Competition in generation and customer supply

Basic Market Model



Key Players in Market

- ◆ Competing Gencos
- ◆ Wires Company – Transmission (& Distribution ?)
- ◆ Competing Supply Companies
- ◆ Market & System Operator
- ◆ Regulator

Market Activities

Generators

- Offer energy at chosen prices
- Supply energy
- Provide capacity
- Provide support services (spinning reserve, MVar, frequency control...)
- Respond to System Operator instructions

Market Activities

Supply Companies

- Procure energy at best rates
- Supply energy to customers
- Negotiate for 'Top-up' or 'Spill'

Market Activities

'Wires' Company

- Maintain & operate transmission (& distribution) system
- Construct new facilities as agreed with Market Operator

Market Activities

Market Operator

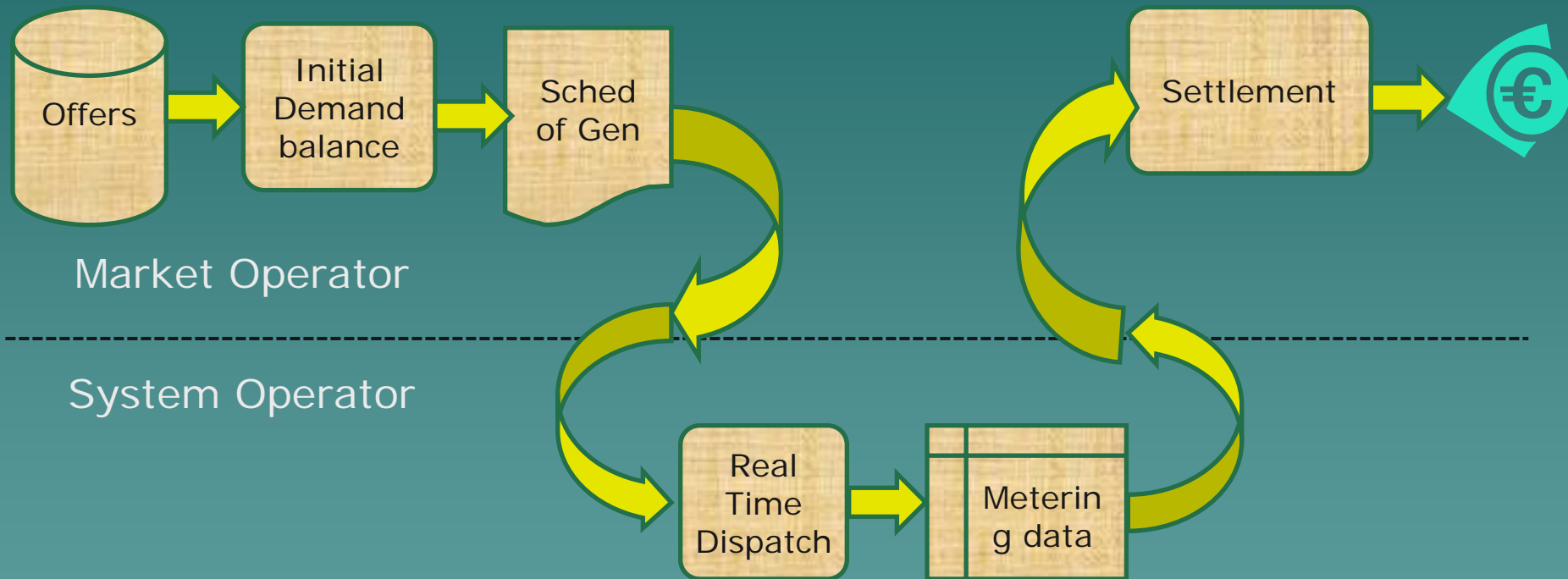
- Forecast daily load (with Supply Companies)
- Conduct bidding process to derive generation schedule for next period
- Acquire system support services
- Maintain security and reserve margins
- Set market prices for energy & capacity
- Inform Gencos of forthcoming schedule
-
- Operate Settlement System

Market Activities

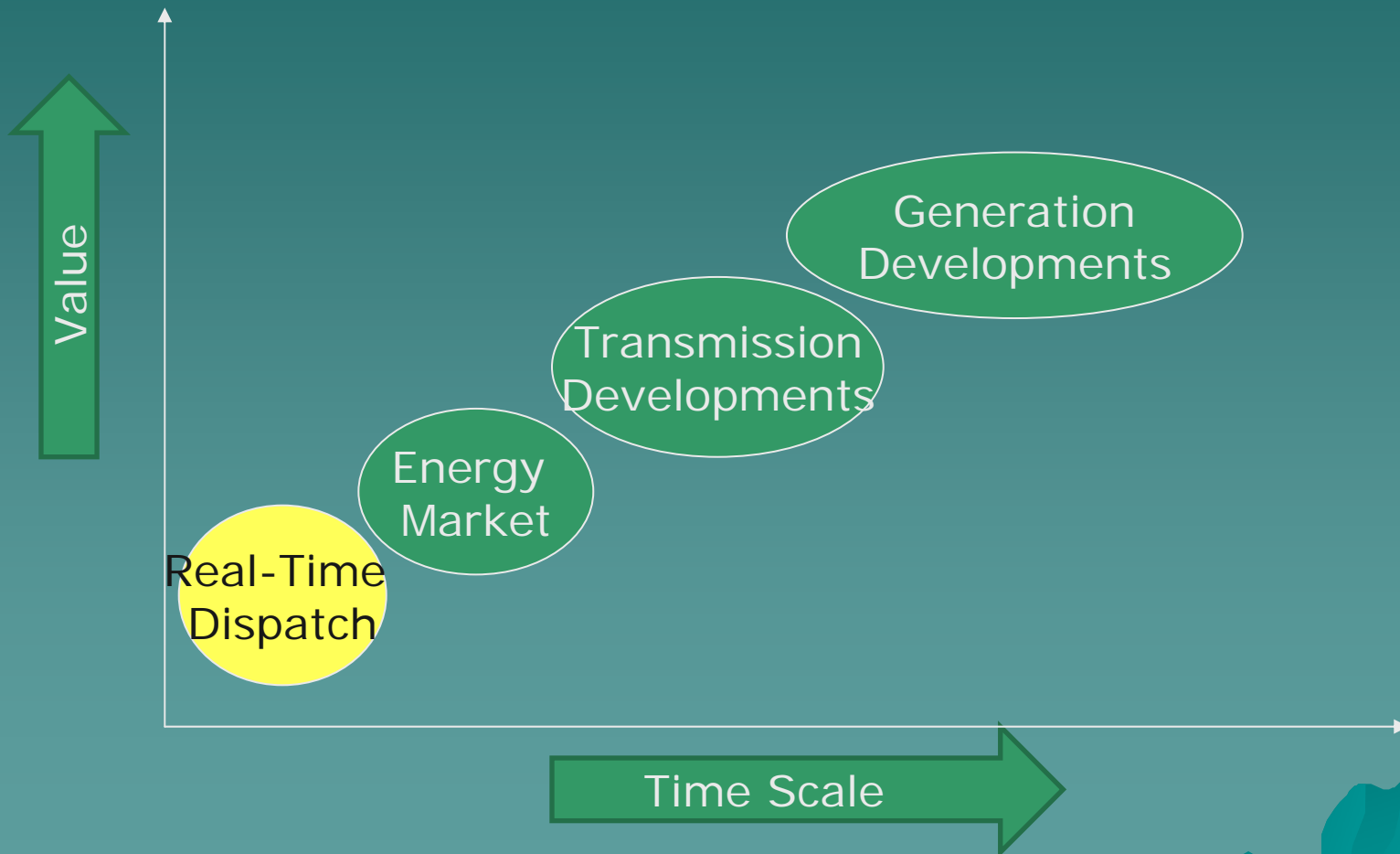
System Operator

- Accept generation schedule from Market Operator
- manage operations in real-time, subject to security, safety & economy
- Monitor and meter energy flows & services provided

Schematic Market Operations



Decision Consequences



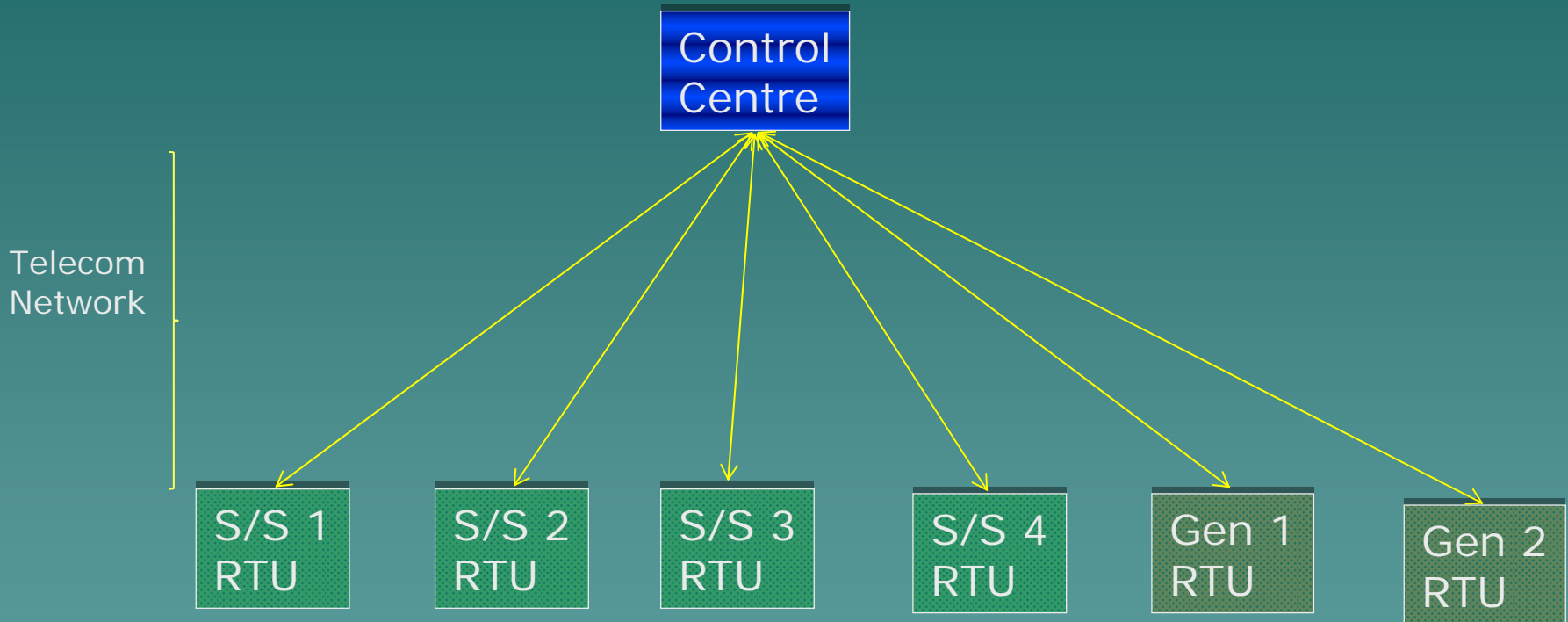
Real-Time Software

- ◆ Known as SCADA (Supervisory Control & Data Acquisition)
- ◆ Employed by System Operator to implement market allocation decisions
- ◆ Supplemented by 'Energy Management System' (EMS)
- ◆ Also used by Discos

Real-Time Software

- ❑ Largely based in Control Centre
- ❑ Data collection / command output processors in each major substation and generating station
- ❑ Extensive IT network

SCADA Scheme



RTU: Remote Terminal Unit

SCADA Functions

- ◆ Monitor breaker status
- ◆ Monitor line amps & volts
- ◆ Supervise alarms in substation
- ◆ Control breakers
- ◆ Control tapchangers
- ◆ Control generator output levels
- ◆ Supervise telecoms network

IT Platforms and Indicative Pricing

Hardware / Software Mixes

Package	Platform Hardware
Generation Planning	PC or shared server
Transmission Planning	PC or shared server
Market System	Complex IT network (some hardware may be independently sourced)
SCADA	Complex IT network (some hardware may be independently sourced)

Indicative Pricing

Generation Planning

- Annual License: WASP-IV is free

Transmission Planning

- Annual time-constrained license: \$6,000+ per user
- Purchase: \$18,000 - \$40,000 per user

SCADA

- Purchase: \$150,000 + hardware + RTUs + telecoms

Transmission System Planning

Limited Feature / Capacity PSSE and CYME
available at approximately

\$5,500 purchase

THANK YOU

ANY QUESTIONS ?

References

General Generation Planning	http://energy.plan.aau.dk/links.php#National_and_Regional_Energy_System_Analysis_Models
WASP	http://www-pub.iaea.org/MTCD/publications/PDF/CMS-16.pdf
EGEAS	http://my.epri.com/portal
PSSE	http://www.energy.siemens.com/hq/en/services/power-transmission-distribution/power-technologies-international/software-solutions/
Digsilent	http://www.digsilent.de/Software/PowerFactory_Applications/Transmission/
GE PSLF	http://www.gepower.com/prod_serv/products/utility_software/en/downloads/pslf05.pdf
CYME	http://www.cyme.com/
SCADA	http://www.energy.siemens.com/us/en/automation/power-transmission-distribution/control-center-and-energy-management-solutions/spectrum-powercc-energy-control.htm http://www.alstom.com/grid/fr/electricScada/ http://www.abb.com/industries/db0003db004333/c12573e7003305cbc125702600386176.aspx http://www.gepower.com/prod_serv/products/scada_software/en/xa21.htm

List of Abbreviations

CIM	Common Information Model (IEC 61970)
CYME	Software from Coopers Electric
Digsilent	Software from Digsilent
Disco	Distribution Company
EMTP	Electro Magnetic Transient Programme
EMS	Energy Management System
EPRI	Electric Power Research Institute
ERACS	Software package from ERA (UK)
FACTS	Flexible AC Transmission System
Genco	Generating Company
GHG	Green House Gases
HVDC	High Voltage Direct Current
IAEA	International Atomic Energy Agency
IEEE	Institution of Electrical & Electronic Engineers
LOLE	Loss of Load Expectation
LOLP	Loss of Load Probability
MAED	Model for Analysis of Energy Demand – from IAEA
PSSE	Power System Simulation Engineering package from Siemens
PTI	Original developer of PSSE
RDBMS	Relational Data Base Management System
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
S/S	Substation
TVA	Tennessee Valley Authority
VOLL	Value of Lost Load
WASP	Wien Automatic System Planning – from IAEA

Typical Market ..1 of 2

- ◆ Gencos offer energy & capacity in 30 minute blocks
- ◆ Bilateral contracts between some Gencos & some supply companies
- ◆ Some supply companies provide energy to non-franchised customers
- ◆ Pool bidding scheme operates between non-franchised customers and Gencos

Typical Market ..2 of 2

- ◆ Market Operator manages bidding process for non-franchised demand
- ◆ Market Operator supervises security & constraints for entire power system
- ◆ Market Operator informs Gencos of final generations schedule
- ◆
- ◆ Market Operator manages Settlement System