# Open-Source Software for Power Industry Research, Teaching, and Training:

## A DC Optimal Power Flow Illustration

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Presented By


Leigh Tesfatsion
Professor of Economics and Mathematics
Iowa State University
http://www.econ.iastate.edu/tesfatsi/

# Acknowledgement

**This research constitutes part of the AMES Market Project**

**Project Director:** **Leigh Tesfatsion** (Professor of Econ & Math, ISU)
**Research Associate:** **Junjie Sun** (Fin. Econ, OCC, U.S. Treasury, Wash, D.C.)
**Research Assistant:** **Hongyan Li** (PhD. Cand, Electrical & Comp Eng., ISU)

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*Work in Progress*

# Presentation Outline

- Why OSS for wholesale power markets?
- DCOPFJ: A DC optimal power flow solver (in Java)
- DCOPFJ Illustration: A Simple 3-Node Test Case
- Release of DCOPFJ as free Java open-source software
- Incorporation of DCOPFJ into AMES Market Package
- Conclusion

**DCOPFJ Home Page (Code Release Site):**

**www.econ.iastate.edu/tesfatsi/DCOPFJHome.htm**

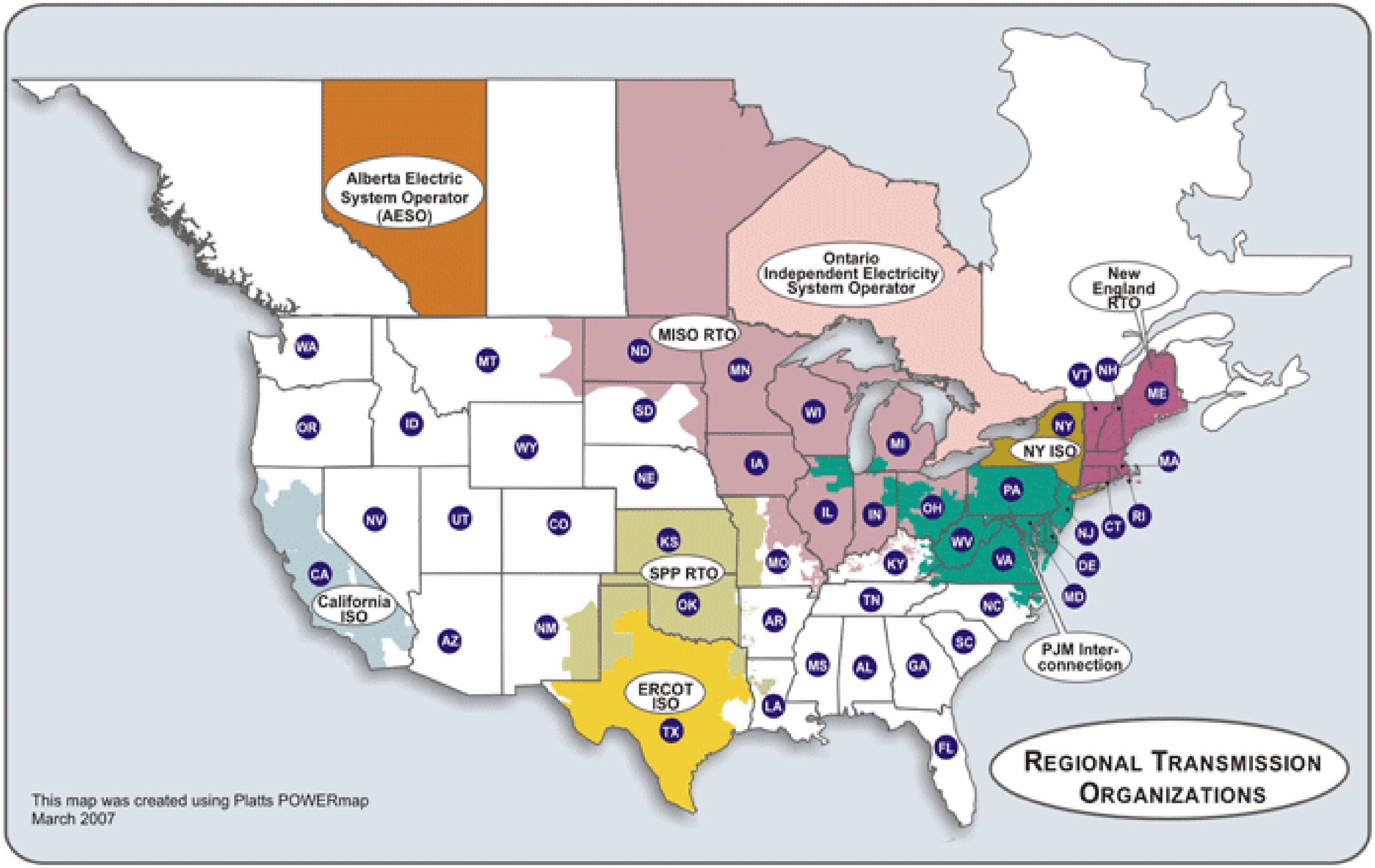
# Why OSS for Wholesale Power Markets?

- In April 2003, the U.S. Federal Energy Regulatory Commission (FERC) proposed the **Wholesale Power Market Platform (WPMP)** for common adoption by all U.S. wholesale power markets.

- About 50% of U.S. electric power generating capacity is now operating under some version of the WPMP market design.

# Regions Adopting Versions of WPMP Design to Date

http://www.ferc.gov/industries/electric/indus-act/rto/rto-map.asp



# Features Generally Shared by These Restructured Wholesale Power Markets

- Their market designs are **complicated!**
- Managed by an Independent System Operator (ISO) or a Regional Transmission Organization (RTO)
- Day-ahead & real-time markets for power
- Transmission grid congestion managed via some variant of Locational Marginal Pricing (LMP)
- Prices/power levels typically determined by ISO/RTO as solutions to **DC optimal power flow (DC-OPF) problems**

# Software Availability

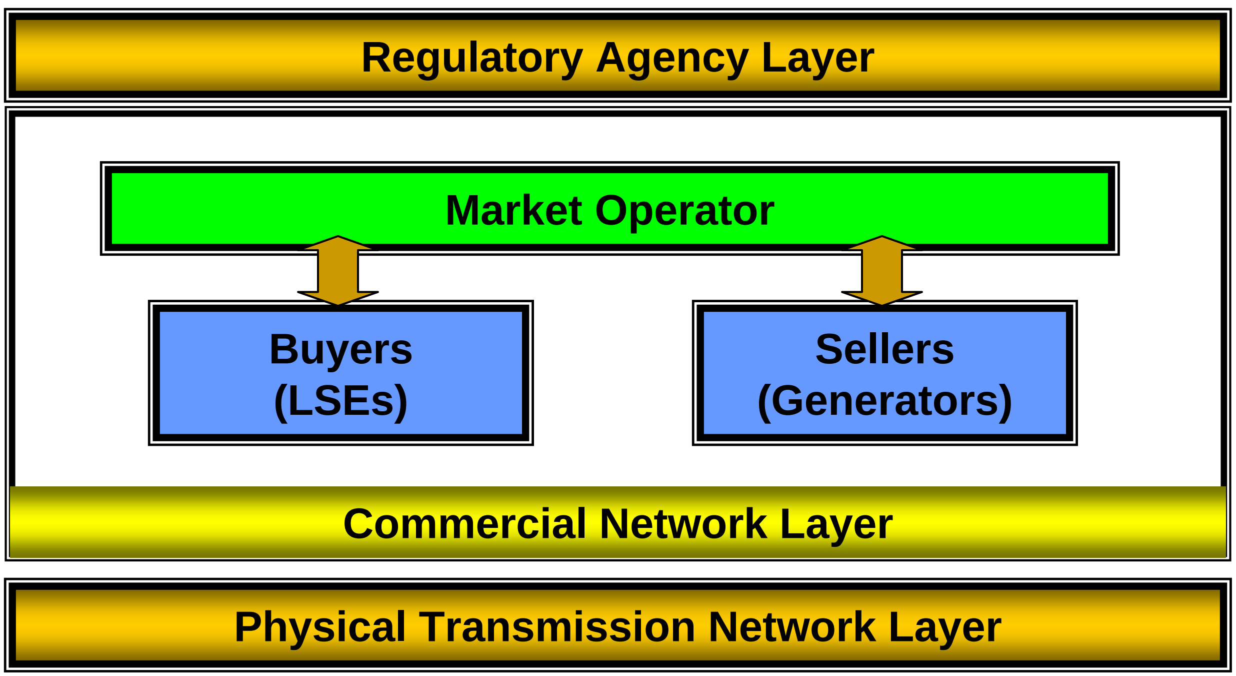
- Many commercial packages now include components suitable for the simulation of restructured wholesale power markets.

- But lack of open-source access
  - prevents accurate understanding of implementation
  - restricts experimentation with new features
  - hinders tailoring software to specific needs

# New Open-Source Software (OSS) Website

## OSS for Electricity Market Research, Teaching, and Training

**http://www.econ.iastate.edu/tesfatsi/ElectricOSS.htm**



# Postings to Date at this OSS Electricity Market Website

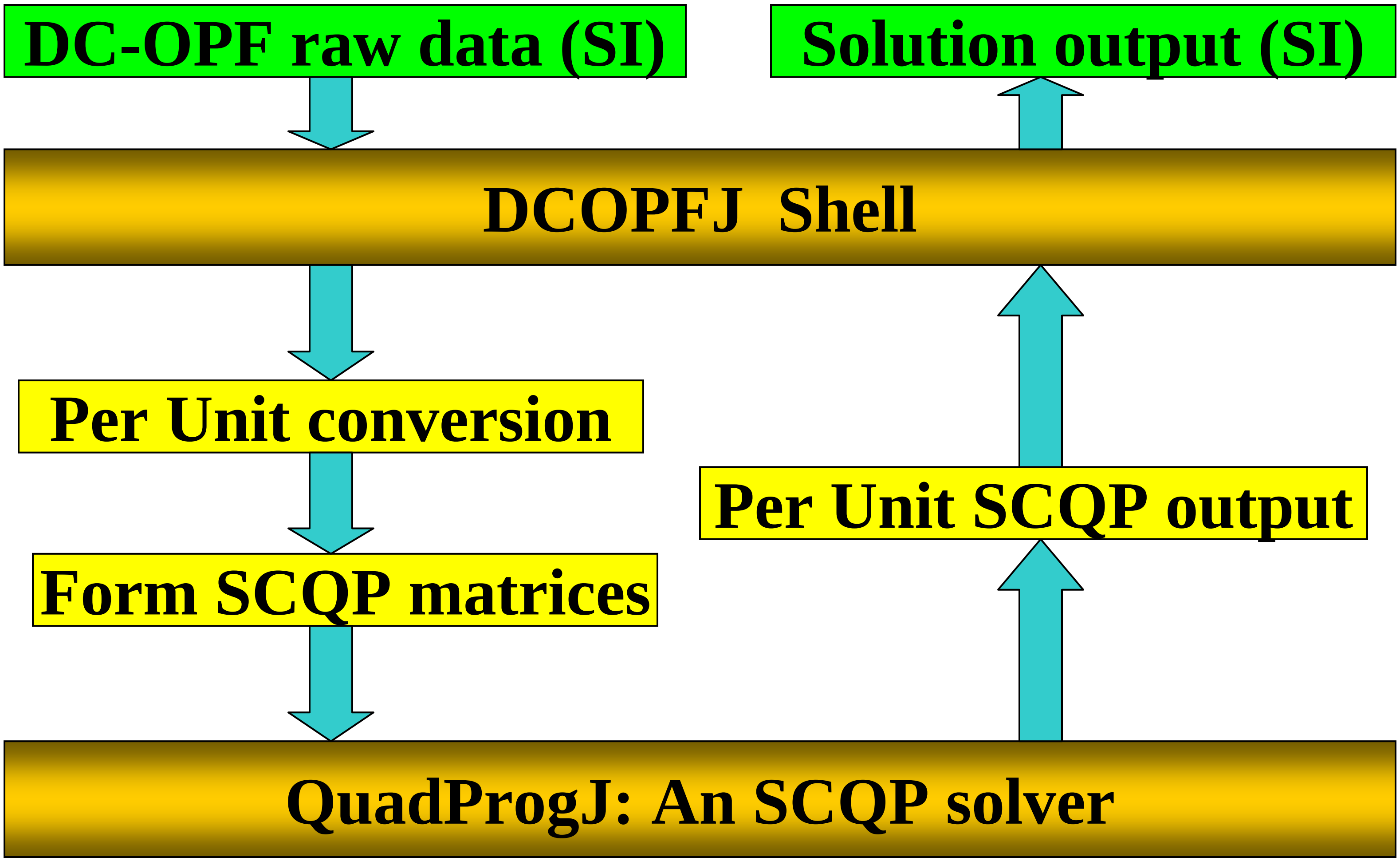
- Market Simulators
  - AMES Market Package (Java) – Sun, Li, Tesfatsion
  - JASA Class Library (Java) – S. Phelps
- Optimal Power Flow (OPF) Solvers
  - DCOPFJ (Java) -- J. Sun & L. Tesfatsion
  - MATPOWER (Matlab-based) -- R. Zimmermann et al.
  - PSAT (Matlab-based) -- F. Milano

# DCOPFJ: A Java DC-OPF Solver

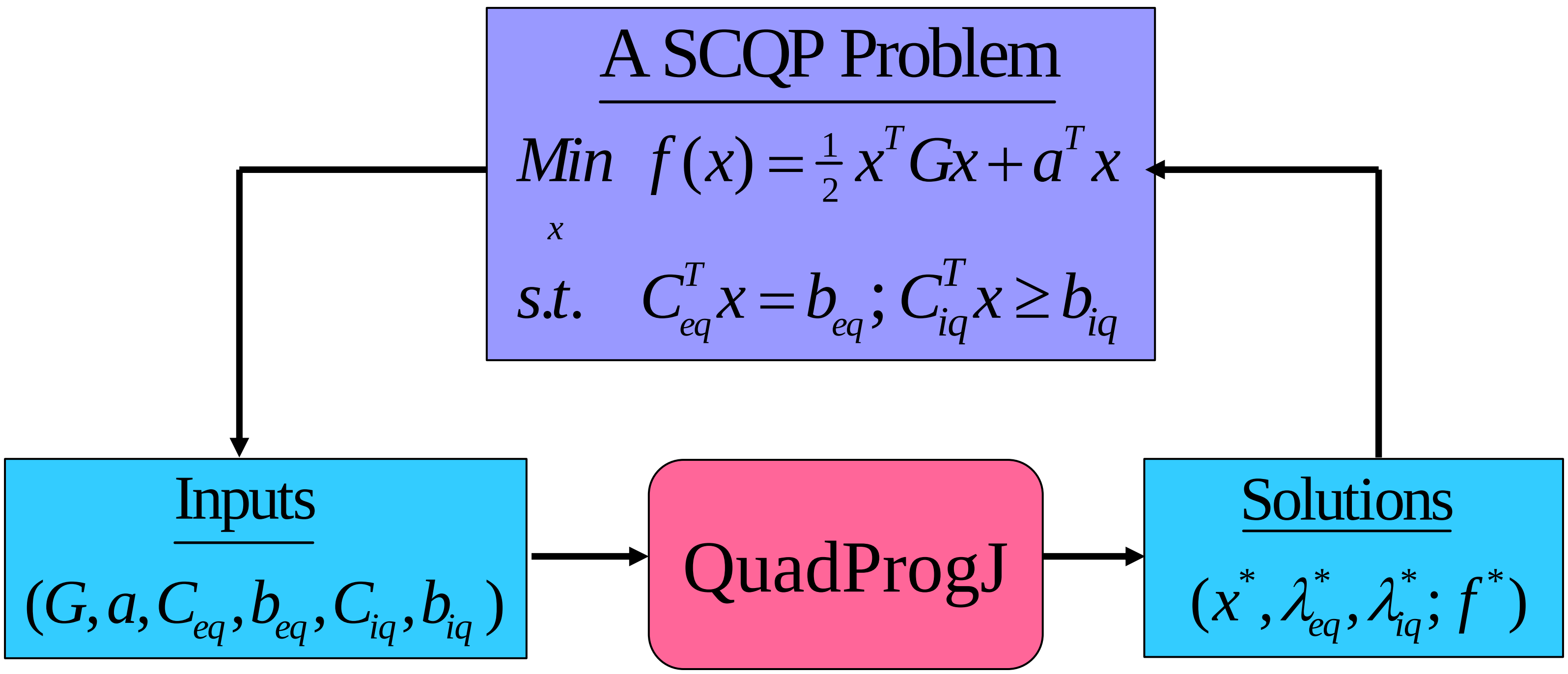
## (Sun & Tesfatsion, *Proceedings*, IEEE PES GM 2007, www.econ.iastate.edu/tesfatsi/DCOPFJHome.htm)

- Standard DC-OPF problems can usefully be augmented by a soft penalty function that controls the size of squared voltage angle differences.
- Such augmented DC-OPF problems can be formulated as ***strictly convex quadratic programming (SCQP)*** problems.
- SCQP problems can be solved by ***QuadProgJ***, a stable accurate Java SCQP solver incorporated into DCOPFJ.
- *The DCOPFJ shell* transforms augmented DC-OPF input data from SI to PU, fills matrices needed by QuadProgJ, invokes QuadProgJ, and returns solution output in SI.

# DCOPFJ: A DC-OPF Solver (Java)



# QuadProgJ: A Java SCQP Solver Incorporated Into DCOPFJ



# Brief Description of QuadProgJ
## (Sun/Tesfatsion, ISU Econ WP 06025, Revised 7/07)

- Appears to be the **first open-source Java SCQP solver**
- Implements the well-known dual active-set SCQP algorithm developed by Goldfarb and Idnani (1983)
- Can be used as a stand-alone SCQP solver or as a plug-and-play SCQP solution module
- Numerically stable (uses Cholesky decomposition, QR factorization, etc.)
- Accuracy tested on a repository of small-to-medium-sized SCQP problems. Performance matches or exceeds that of BPMPD, a well-known **proprietary** C-language QP solver recommended highly in the *MATPOWER User's Manual*

# Repository of QP Min Problems with BPMPD Solutions
## (TN = Total Number of Constraints Plus Decision Variables)

Table 3: SCQP Test Cases: Structural Attributes and BPMPD Solution Values

| NAME[a] | TND[b] | TNEC[c] | TNIC[d] | TNC[e] | TN[f] | fBPMPD[g] |
|---|---|---|---|---|---|---|
| DUAL1 | 85 | 1 | 170 | 171 | 256 | 3.50129662E-02 |
| DUAL2 | 96 | 1 | 192 | 193 | 289 | 3.37336761E-02 |
| DUAL3 | 111 | 1 | 222 | 223 | 234 | 1.35755839E-01 |
| DUAL4 | 75 | 1 | 150 | 151 | 226 | 7.46090842E-01 |
| DUALC1 | 9 | 1 | 232 | 233 | 242 | 6.15525083E+03 |
| DUALC5 | 8 | 1 | 293 | 294 | 302 | 4.27232327E+02 |
| HS118 | 15 | 0 | 59 | 59 | 74 | 6.64820452E+02 |
| HS21 | 2 | 0 | 5 | 5 | 7 | -9.99599999E+01 |
| HS268 | 5 | 0 | 5 | 5 | 10 | 5.73107049E-07 |
| HS35 | 3 | 0 | 4 | 4 | 7 | 1.11111111E-01 |
| HS35MOD | 3 | 0 | 5 | 5 | 8 | 2.50000001E-01 |
| HS76 | 4 | 0 | 7 | 7 | 11 | -4.68181818E+00 |
| KSIP | 20 | 0 | 1001 | 1001 | 1021 | 5.757979412E-01 |
| QPCBLEND | 83 | 43 | 114 | 157 | 240 | -7.84254092E-03 |
| QPCBOEI1 | 384 | 9 | 971 | 980 | 1364 | 1.15039140E+07 |
| QPCBOEI2 | 143 | 4 | 378 | 382 | 525 | 8.17196225E+06 |
| QPCSTAIR | 467 | 209 | 696 | 905 | 1372 | 6.20438748E+06 |
| S268 | 5 | 0 | 5 | 5 | 10 | 5.73107049E-07 |
| MOSARQP2 | 900 | 0 | 600 | 600 | 1500 | -0.159748211E+04 |

# RD = [QuadProg – BPMPD]/|BPMPD|

## (All Test Cases Run on a Laptop PC operating under Win XP SP2)

Table 4: QuadProgJ Test Case Results

| NAME | Mean\|ECE\|[a] | Max\|ECE\|[b] | NVIC[c] | f*[d] | RD[e] |
|---|---|---|---|---|---|
| DUAL1 | 0.0 | 0.0 | 0 | 3.50129657E-2 | -1.42804239E-8 |
| DUAL2 | 0.0 | 0.0 | 0 | 3.37336761E-2 | 0.0 |
| DUAL3 | 6.66E-16 | 6.66E-16 | 0 | 1.35755837E-1 | -1.47323313E-8 |
| DUAL4 | 2.11E-15 | 2.11E-15 | 0 | 7.46090842E-1 | 0.0 |
| DUALC1 | 2.40E-12 | 2.40E-12 | 0 | 6.15525083E+3 | 0.0 |
| DUALC5 | 5.33E-15 | 5.33E-15 | 0 | 4.27232327E+2 | 0.0 |
| HS118 | NA[f] | NA | 0 | 6.64820450E+2 | -3.00833103E-9 |
| HS21 | NA | NA | 0 | -99.96 | -1.00040010E-9 |
| HS268 | NA | NA | 0 | -5.47370291E-8 | -1.09550926 |
| HS35 | NA | NA | 0 | 1.11111111E-1 | 0.0 |
| HS35MOD | NA | NA | 0 | 2.50000000E-1 | -4.00000009E-9 |
| HS76 | NA | NA | 0 | -4.68181818 | 0.0 |
| KSIP | NA | NA | 0 | 5.75797941E-1 | 0.0 |
| QPCBLEND | 5.66E-16 | 8.94E-15 | 0 | -7.84254307E-3 | -2.74145844E-7 |
| QPCBOEI1 | 2.05E-6 | 9.58E-6 | 0 | 1.15039140E+7 | 0.0 |
| QPCBOEI2 | 3.42E-6 | 1.37E-5 | 0 | 8.17196224E+6 | -1.22369628E-9 |
| QPCSTAIR | 4.34E-7 | 6.01E-6 | 0 | 6.20438745E+6 | -4.83528799E-9 |
| S268 | NA | NA | 0 | -5.47370291E-8 | -1.09550926 |
| MOSARQP2 | NA | NA | -- | Out of Memory Error | — |

# Augmented DC-OPF Problem (SI) with LSE Fixed Demand Bids (Solved by DCOPFJ-Version 1.1)

Generator total variable costs

Voltage angle for node k

Minimize $\sum_{i=1}^{I}[A_i \, p_{Gi} + B_i \, p_{Gi}^2] + \pi \left[ \sum_{km \in BR} [\delta_k - \delta_m]^2 \right]$

w.r.t. $p_{Gi}, i = 1, ..., I; \quad \delta_k, k = 1, ..., K$

Power level for Generator i=1,…,I

subject to

Balance constraints:

Shadow price for node k balance constraint gives LMP for node k

$$0 = \sum_{j \in J_k} p_{Lj} - \sum_{i \in I_k} p_{Gi} + \sum_{km \text{ or } mk \in BR} y_{km}(\delta_k - \delta_m)$$

Fixed demand bid (load) for LSE j

Branch flow (thermal) constraints:

$$| y_{km}(\delta_k - \delta_m) | \leq F^U_{km}$$

Reported production capacity constraints:

$$P^L_{Gi} \leq p_{Gi} \leq P^U_{Gi}$$

Shadow price for each inequality constraint is also determined

Voltage angle setting at reference node 1:

$$\delta_1 = 0$$

# Augmented DC-OPF Problem (SI) with LSE Fixed and/or Price-Sensitive Demand Bids (Solved by DCOPFJ - Version 2.0)

Minimize

$$\sum_{i=1}^{I}[a_i p_{Gi} + b_i p_{Gi}^2] - \sum_{j=1}^{J}[c_j p_{Lj}^S - d_j {p_{Lj}^S}^2] + \pi \left[ \sum_{km \in BR} [\delta_k - \delta_m]^2 \right]$$

LSE gross buyer surplus

Generator total variable costs

w.r.t. $\quad p_{Gi},\ i = 1, ..., I;\ p_{Lj}^S,\ j = 1, ..., J;\ \delta_k,\ k = 1, ..., K$

Subject to

$$\sum_{i \in I_k} p_{Gi} - \sum_{j \in J_k} (p_{Lj}^F + p_{Lj}^S) - \sum_{km \text{ or } mk \in BR} y_{km}\, [\delta_k - \delta_m] = 0$$

$$|y_{km}\, [\delta_k - \delta_m]| \leq F^U{}_{km}$$

$$P^L{}_{Gi} \leq p_{Gi} \leq P^U{}_{Gi}$$

$$SLoad_j^L \leq p_{Lj}^S \leq SLoad_j^U$$

$$\delta_1 = 0$$

Fixed and price-sensitive demand bids for LSE j

# Augmented DC-OPF Problem in SCQP Form Suitable for QuadProgJ

## (Same general form for fixed or price-sensitive demand)

Minimize

$$\mathrm{f(x)} = \frac{1}{2}\mathrm{x^T G x} + \mathrm{a^T x}$$

with respect to

$$\mathrm{x} \;=\; (\mathrm{x_1}, \mathrm{x_2}, \ldots, \mathrm{x_M})^{\mathbf{T}}$$

subject to

$$\mathrm{C_{eq}^T x} = \mathrm{b_{eq}}$$

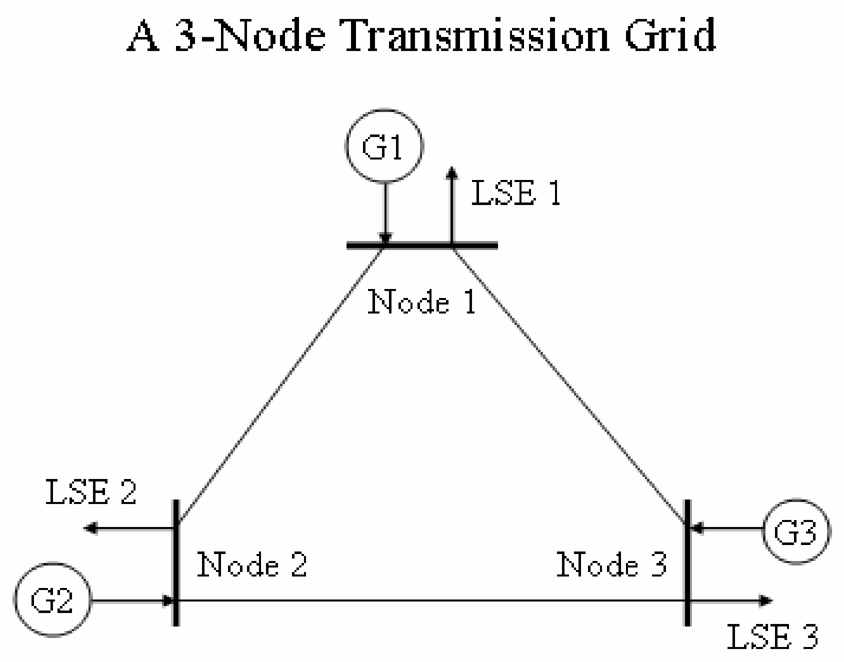
$$\mathrm{C_{iq}^T x} \geq \mathrm{b_{iq}}$$

where **G** is an **M**×**M** symmetric positive definite matrix.

# DCOPFJ Illustration: A Simple 3-Node Test Case

- A 3-node DC-OPF problem with LSE fixed demand bids (no price-sensitive demand)
- DC-OPF problem for each hour formulated as a matrix SCQP Problem
  $(x, G, a, C_{eq}, b_{eq}, C_{iq}, b_{iq})$
- DC-OPF solutions for 24 successive hours obtained by DCOPFJ (Version 1.1) through invocation of its internal SCQP solver QuadProgJ
- Unit conversions (SI-to-PU-to-SI) omitted for expositional simplicity

# Transmission Grid for 3-Node Test Case



# 24-Hour DC-OPF Input Data (SI) for 3-Node Test Case

Base Values

| $S_o$ | $V_o$ |
|---|---|
| 100 | 10 |

| $K$ | $\pi$ |
|---|---|
| 3 | 0.05 |

Branch

| From | To | $F^U_{km}$ | Reactance $x_{km}$ |
|---|---|---|---|
| 1 | 2 | 55 | 0.20 |
| 1 | 3 | 55 | 0.40 |
| 2 | 3 | 55 | 0.25 |

Gen

| ID | atNode | FCost | Cost Parameters $A_i$,$B_i$ | | $P_{Gi}^L$ | $P_{Gi}^U$ |
|---|---|---|---|---|---|---|
| 1 | 1 | 14 | 10.6940 | 0.00463 | 20 | 200 |
| 2 | 2 | 21 | 18.1000 | 0.00612 | 10 | 150 |
| 3 | 3 | 11 | 37.8896 | 0.01433 | 5 | 20 |

LSE Hourly Loads $P_{Lj}$

| ID | atNode | L-01 | L-02 | L-03 | L-04 | L-05 | L-06 | L-07 | L-08 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 132.66 | 122.4 | 115.62 | 112.2 | 108.84 | 110.52 | 112.2 | 119.04 |
| 2 | 2 | 44.22 | 40.8 | 38.54 | 37.4 | 36.28 | 36.84 | 37.4 | 39.68 |
| 3 | 3 | 44.22 | 40.8 | 38.54 | 37.4 | 36.28 | 36.84 | 37.4 | 39.68 |
| ID | atNode | L-09 | L-10 | L-11 | L-12 | L-13 | L-14 | L-15 | L-16 |
| 1 | 1 | 136.02 | 149.64 | 153.06 | 154.74 | 153.06 | 149.64 | 147.96 | 147.96 |
| 2 | 2 | 45.34 | 49.88 | 51.02 | 51.58 | 51.02 | 49.88 | 49.32 | 49.32 |
| 3 | 3 | 45.34 | 49.88 | 51.02 | 51.58 | 51.02 | 49.88 | 49.32 | 49.32 |
| ID | atNode | L-17 | L-18 | L-19 | L-20 | L-21 | L-22 | L-23 | L-24 |
| 1 | 1 | 154.74 | 170.04 | 163.26 | 161.52 | 159.84 | 156.42 | 147.96 | 137.76 |
| 2 | 2 | 51.58 | 56.68 | 54.42 | 53.84 | 53.28 | 52.14 | 49.32 | 45.92 |
| 3 | 3 | 51.58 | 56.68 | 54.42 | 53.84 | 53.28 | 52.14 | 49.32 | 45.92 |

# 3-Node Test Case…Continued
# SCQP Matrices/Vectors

## (x, G, a, $C_{eq}$, $b_{eq}$, $C_{iq}$, $b_{iq}$)

$$\mathbf{x} = [P_{G1}, P_{G2}, P_{G3}, \delta_2, \delta_3]^{\mathbf{T}}_{(5\times 1)}$$

$$\mathbf{G} = \begin{bmatrix} 2B_1 & 0 & 0 & 0 & 0 \\ 0 & 2B_2 & 0 & 0 & 0 \\ 0 & 0 & 2B_3 & 0 & 0 \\ 0 & 0 & 0 & 4\pi & -2\pi \\ 0 & 0 & 0 & -2\pi & 4\pi \end{bmatrix}_{(5\times 5)}$$

$$\mathbf{a}^{\mathbf{T}} = \begin{bmatrix} A_1 & A_2 & A_3 & 0 & 0 \end{bmatrix}_{(1\times 5)}$$

$$\mathbf{C}_{\mathbf{eq}}^{\mathbf{T}} = \begin{bmatrix} 1 & 0 & 0 & y_{12} & y_{13} \\ 0 & 1 & 0 & -(y_{12}+y_{23}) & y_{23} \\ 0 & 0 & 1 & y_{23} & -(y_{13}+y_{23}) \end{bmatrix}_{(3\times 5)}$$

$$\mathbf{b}_{\mathbf{eq}} = \begin{bmatrix} P_{L1} & P_{L2} & P_{L3} \end{bmatrix}_{(3\times 1)}^{\mathbf{T}}$$

$y_{km} = 1/x_{km}$

$$\mathbf{C}_{\mathbf{iq}}^{\mathbf{T}} = \begin{bmatrix} 0 & 0 & 0 & y_{12} & 0 \\ 0 & 0 & 0 & 0 & y_{13} \\ 0 & 0 & 0 & -y_{23} & y_{23} \\ 0 & 0 & 0 & -y_{12} & 0 \\ 0 & 0 & 0 & 0 & -y_{13} \\ 0 & 0 & 0 & y_{23} & -y_{23} \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{bmatrix}_{(12\times 5)}$$

$$\mathbf{b}_{\mathbf{iq}} = \begin{bmatrix} -F_{12}^{U} & -F_{13}^{U} & -F_{23}^{U} & -F_{12}^{U} & -F_{13}^{U} & -F_{23}^{U} & P_{G1}^{L} & P_{G2}^{L} & P_{G3}^{L} & -P_{G1}^{U} & -P_{G2}^{U} & -P_{G3}^{U} \end{bmatrix}_{(12\times 1)}^{\mathbf{T}}$$

# DCOPFJ Solution Output (SI) for 3-Node Test Case

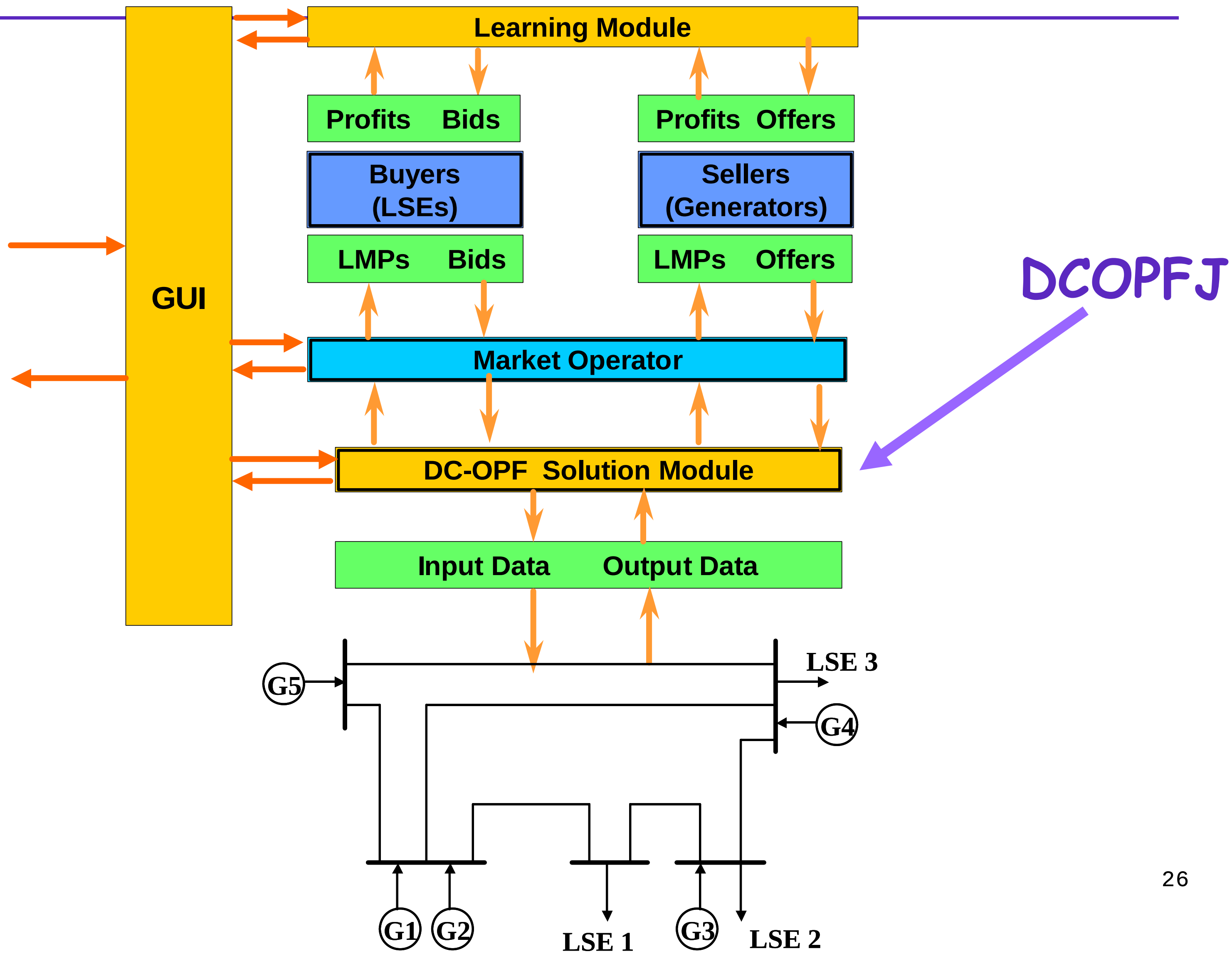
| Hour | $p^*_{G1}$ | $p^*_{G2}$ | $p^*_{G3}$ | $\delta^*_2$ | $\delta^*_3$ | $LMP_1$ | $LMP_2$ | $LMP_3$ | minTVC |
|---|---|---|---|---|---|---|---|---|---|
| 01 | 200.0 | 16.1 | 5.0 | -0.0799 | -0.1095 | 18.30 | 18.30 | 18.30 | 2993.95 |
| 02 | 189.0 | 10.0 | 5.0 | -0.0808 | -0.1048 | 12.44 | 12.44 | 12.44 | 2724.33 |
| 03 | 177.7 | 10.0 | 5.0 | -0.0752 | -0.0979 | 12.34 | 12.34 | 12.34 | 2565.12 |
| 04 | 172.0 | 10.0 | 5.0 | -0.0724 | -0.0944 | 12.29 | 12.29 | 12.29 | 2485.70 |
| 05 | 166.4 | 10.0 | 5.0 | -0.0696 | -0.0910 | 12.23 | 12.23 | 12.23 | 2408.27 |
| 06 | 169.2 | 10.0 | 5.0 | -0.0710 | -0.0927 | 12.26 | 12.26 | 12.26 | 2446.91 |
| 07 | 172.0 | 10.0 | 5.0 | -0.0724 | -0.0944 | 12.29 | 12.29 | 12.29 | 2485.70 |
| 08 | 183.4 | 10.0 | 5.0 | -0.0780 | -0.1014 | 12.39 | 12.39 | 12.39 | 2645.13 |
| 09 | 200.0 | 21.7 | 5.0 | -0.0741 | -0.1077 | 18.37 | 18.37 | 18.37 | 3097.90 |
| 10 | 200.0 | 44.4 | 5.0 | -0.0506 | -0.1002 | 18.64 | 18.64 | 18.64 | 3527.13 |
| 11 | 200.0 | 50.1 | 5.0 | -0.0447 | -0.0983 | 18.71 | 18.71 | 18.71 | 3636.90 |
| 12 | 200.0 | 52.9 | 5.0 | -0.0418 | -0.0974 | 18.75 | 18.75 | 18.75 | 3691.11 |
| 13 | 200.0 | 50.1 | 5.0 | -0.0447 | -0.0983 | 18.71 | 18.71 | 18.71 | 3636.90 |
| 14 | 200.0 | 44.4 | 5.0 | -0.0506 | -0.1002 | 18.64 | 18.64 | 18.64 | 3527.13 |
| 15 | 200.0 | 41.6 | 5.0 | -0.0535 | -0.1011 | 18.61 | 18.61 | 18.61 | 3473.51 |
| 16 | 200.0 | 41.6 | 5.0 | -0.0535 | -0.1011 | 18.61 | 18.61 | 18.61 | 3473.51 |
| 17 | 200.0 | 52.9 | 5.0 | -0.0418 | -0.0974 | 18.75 | 18.75 | 18.75 | 3691.11 |
| 18 | 200.0 | 78.4 | 5.0 | -0.0154 | -0.0890 | 19.06 | 19.06 | 19.06 | 4193.64 |
| 19 | 200.0 | 67.1 | 5.0 | -0.0271 | -0.0927 | 18.92 | 18.92 | 18.92 | 3968.98 |
| 20 | 200.0 | 64.2 | 5.0 | -0.0301 | -0.0937 | 18.89 | 18.89 | 18.89 | 3911.83 |
| 21 | 200.0 | 61.4 | 5.0 | -0.0330 | -0.0946 | 18.85 | 18.85 | 18.85 | 3856.85 |
| 22 | 200.0 | 55.7 | 5.0 | -0.0389 | -0.0965 | 18.78 | 18.78 | 18.78 | 3745.51 |
| 23 | 200.0 | 41.6 | 5.0 | -0.0535 | -0.1011 | 18.61 | 18.61 | 18.61 | 3473.51 |
| 24 | 200.0 | 24.6 | 5.0 | -0.0711 | -0.1067 | 18.40 | 18.40 | 18.40 | 3152.03 |

# Release of DCOPFJ as Free Java OSS: The DCOPFJ Package

- DCOPFJ is implemented as a stand-alone Java DC-OPF solver by the DCOPFJ Package
- Versions 1.1 and 2.0 of the DCOPFJ Package have been released as free open-source software under the terms of the GNU General Public License (GPL)
- **For software downloads, manuals, and research pubs, see the DCOPFJ Package Home Page:**

**www.econ.iastate.edu/tesfatsi/DCOPFJHome.htm**

# Incorporation of DCOPFJ into the AMES Market Package (Java OSS)



# AMES Market Project
## (AMES = Agent-based Modeling of Electricity Systems)

- **Development of Agent-Based Wholesale Power Market Framework**
- **Implemented by AMES Market Package (free OSS Java)**
  **www.econ.iastate.edu/tesfatsi/AMESMarketHome.htm**
- **Target Package Features**
  - **Research/teaching grade test-bed (2-500 pricing nodes)**
  - **Operational validity** (structure, rules, behavioral dispositions)
  - Permits **dynamic** testing with **learning traders**
  - Permits **intensive experimentation** with alternative scenarios
  - **Free open-source Java implementation** (full access to code)
  - **Easily modified** (extensible/modular architecture)

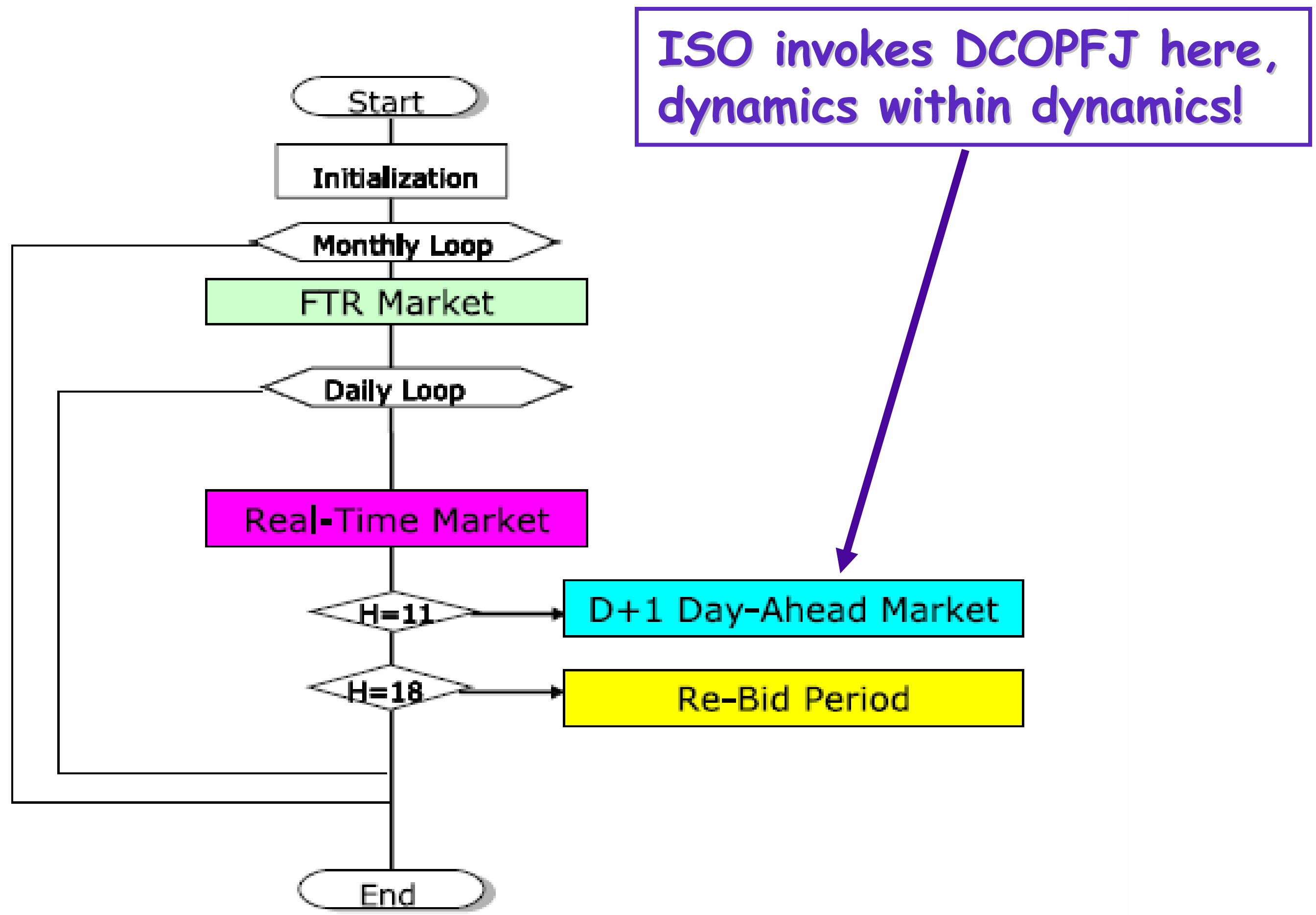
# Key Components of AMES Market Test-Bed (Based on Business Practices Manuals for MISO/ISO-NE)

- **Traders**
  - Sellers and buyers
  - Follow market rules
  - Learning abilities
- **Independent System Operator (ISO)**
  - System reliability assessments
  - Day-ahead bid-based unit commitment (via DC OPF)
  - Real-time dispatch

DCOPFJ!

- **Two-settlement process**
  - Day-ahead market (double auction, financial contracts)
  - Real-time market (settlement of differences)
- **AC transmission grid**
  - Sellers/buyers located at various transmission nodes
  - Congestion managed via Locational Marginal Pricing (LMP)

# AMES Market Dynamics: Broad Overview



# Conclusion

- Most simulation software available today for restructured electricity markets is proprietary.
- Open-source software is important for facilitating the rigorous performance study of these markets.
- It is hoped that the free open-source release of DCOPFJ and the AMES Market Package will encourage the development of open-source software for the study of restructured electricity markets.

# Resource Links for Electricity Market Open-Source Software

- **Open-Source Software for Electricity Market Research, Teaching, and Training**
  http://www.econ.iastate.edu/tesfatsi/ElectricOSS.htm
- **The AMES Market Package: A Free Open-Source Test-Bed for the *A*gent-based *M*odeling of *E*lectricity *S*ystems (Java)**
  http://www.econ.iastate.edu/tesfatsi/AMESMarketHome.htm
- **DCOPFJ: A Free Open-Source Solver for DC Optimal Power Flow Problems (Java)**
  http://www.econ.iastate.edu/tesfatsi/DCOPFJHome.htm