Markron Technologies LLC

Specialists in Low Cost Solar Integration

# Solar Integration of Existing Coal Plants for CO2 Reduction

***Presented to the Economic and Technology Advancement Advisory Committee (ETAAC) of the California Air Resources Board (ARB)***

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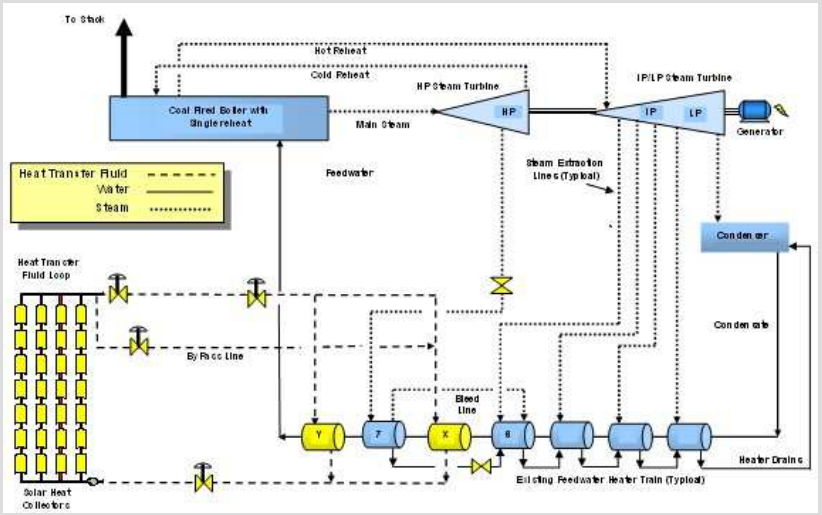
**For Inquiries Please Contact:**

**Mark J. Skowronski**
**Chief Technology Officer**
**3052 Inverness Drive**
**Los Alamitos, CA 90720**

**Office: 562.431.1758**
**Cell: 714.317.5016**
**Fax: 562.431.1796**
**Email: mark@markrontech.com**

# The Solar Technology and Integration Process*



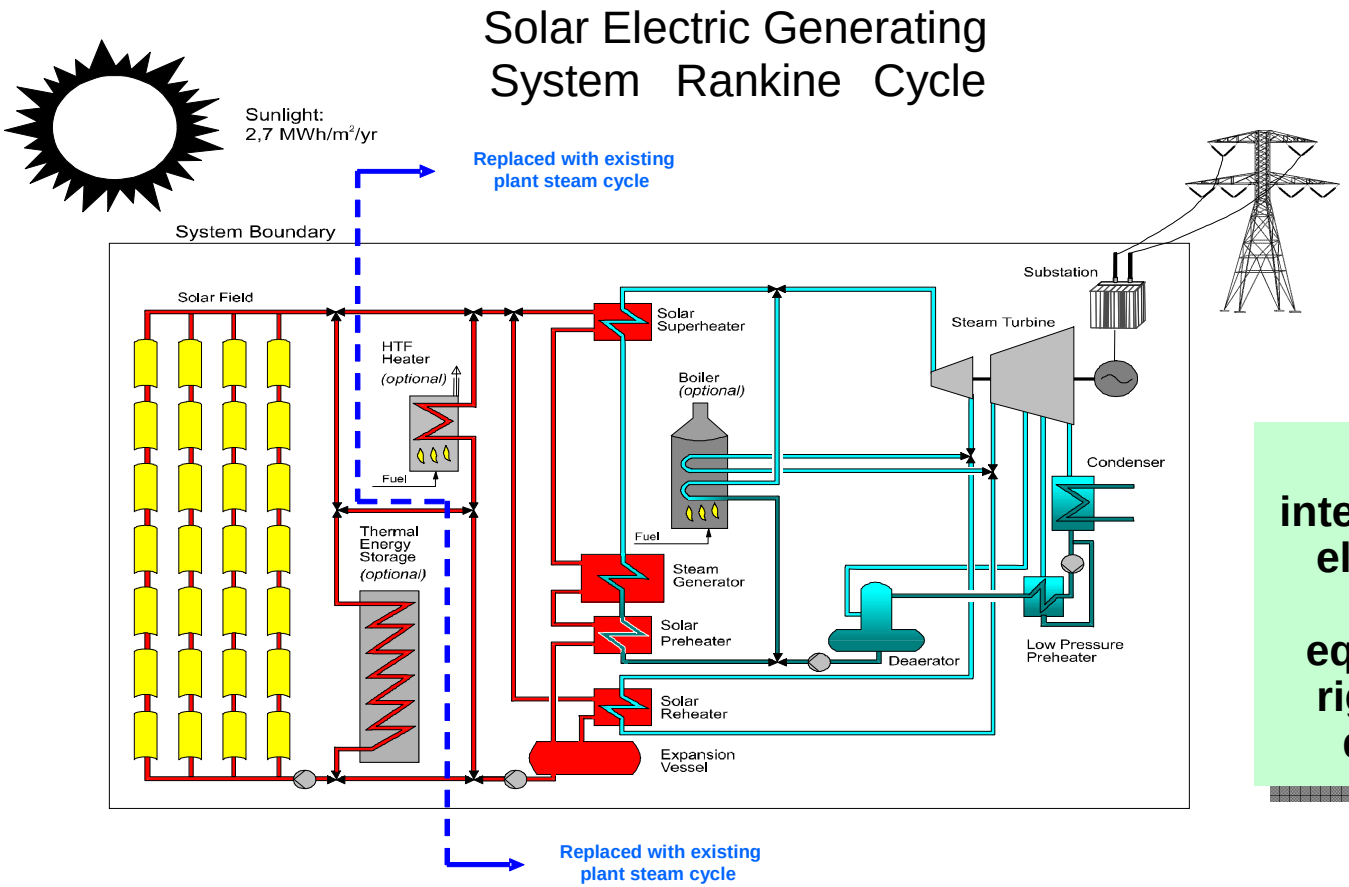

*** Patent pending.**

# **Solar Information** - Technology Selection

**The projects will utilize proven solar thermal trough technology which has been in use at SEGS in California for over 20 years.**

# **Business Focus** - Solar Thermal Integration Strategy

**Markron's integration process leverages the installed capacity and related infrastructure of existing coal plants to reduce solar energy costs by up to 40% and with minimal intrusion to the host plant.**




**The Markron integration process eliminates all or most of the equipment to the right of the blue dashed lines.**

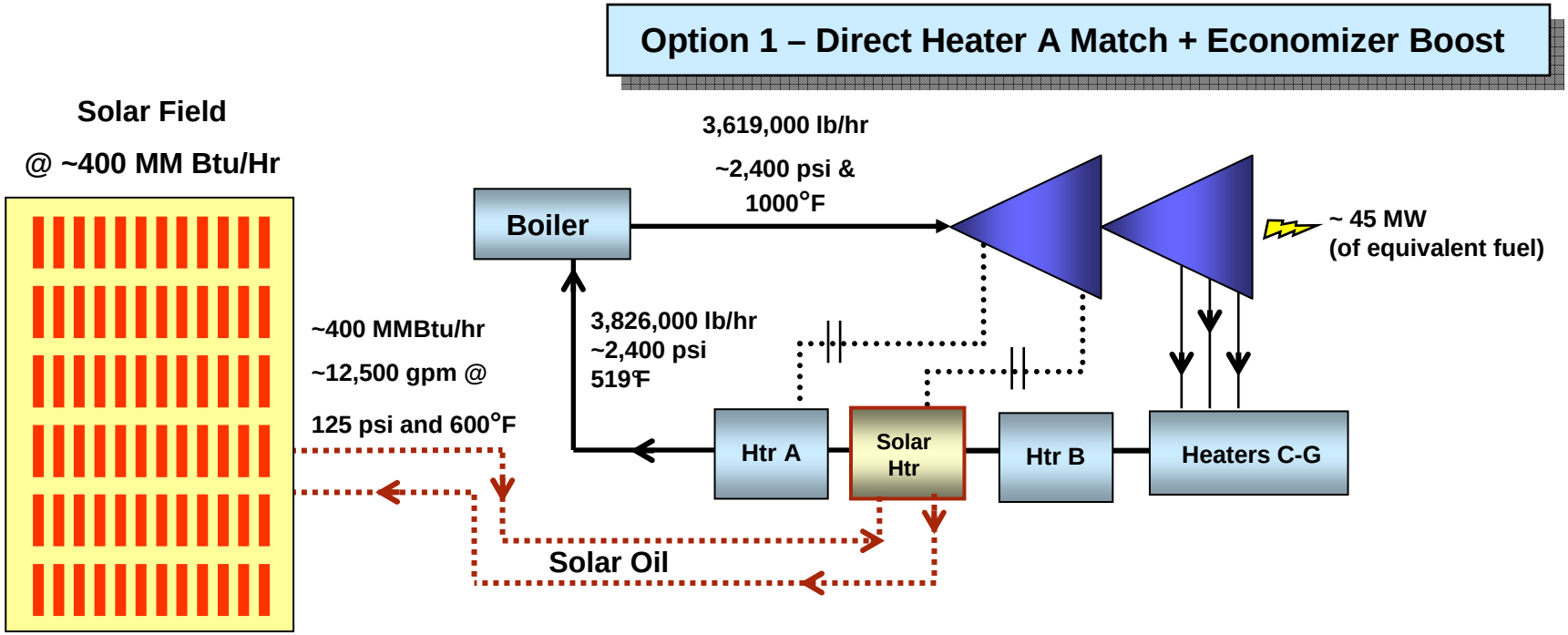
# **Solar Integration Advantage** - Capital Cost Reduction

**The solar integration process will require only the mirror collectors thus removing the steam production, generation and transmission equipment normally required in a standalone solar thermal plant.**

# **Solar Integration Advantage** - Capital Cost Reduction

**The elimination of the equipment not needed via integration can reduce the solar thermal project cost by up to 40%.**

# *Solar/FW* Integration Flow Diagram for Typical 500 MW Coal Plant




| Solar Input Scenario | Oil Pressure at Heater | Oil Temp | Oil Flow (Lbs/hr) | Enthalpy To Heater A (MMBTU/hr) | Enthalpy To Economizer (MMBTU/hr) | Displaced MW [1] | Displaced MWH/yr [1] | Coal Displaced (Tons/Yr) [2] | CO2 Displaced (Tons/Yr) [2] |
|---|---|---|---|---|---|---|---|---|---|
| Heater A & Economizer | 100 psi | 600 F | $4.5 \times 10^6$ | 250 | 150 | 45 | 85,000 | 30,000 | 120,000 |

[1] All steam extraction flows will auto adjust (self-regulate) proportional to solar heat input.
[2] Based on equivalent net solar HR of 9,200 BTU/kWh (no boiler losses, HHV losses or auxiliary loads); no attemperation benefits are assumed with this analysis.

(Patent Pending)

## Typical Parameters for ~500 MW Coal Plant Integrated With Solar

**A typical 500 MW coal plant would provide up to 45 MW of clean, reliable and locally generated solar thermal power and reduce the plant's annual coal consumption and CO2 output by 50,000 tons and 120,000 tons, respectively.**

- **Electrical generation:**
  - **Max. Capacity: 45 MW (displacement)**
  - **Energy: 85,000 MWh per year (displacement)**
- **Size of solar collector field:**
  - **2,300,000 square feet of mirrors**
  - **Heat output: 400 million btu/hour**
- **Estimated Capital Cost: (Approx 40% < Standalone CSP)**
- **Development/Construction Time: 18 - 24 months**
- **Coal Reduction: 50,000 tons/yr; 1,500,000 tons lifetime**
- **CO2 Reduction: 120,000 tons/yr; 3,600,000 tons lifetime**

## **Business Focus** - Integration Advantages

**The integration of utility scale solar thermal energy with existing coal-fired power plants provides significant benefits not attainable with greenfield solar projects.**

- Produces large scale reduction in CO2 using existing and proven commercial technology at economically attractive pricing
- Integrating solar with a typical 500 MW coal plant results in 3.5 million tons of CO2 reduction over life of plant
- Over 1.5 million tons of reduced coal consumption over plant life (full emission reduction – NOx, Sox, mercury, etc.)
- Can be “de-coupled” from coal plant for standalone operation with addition of balance-of-plant
- Helps utilities meet RPS goals
- Up to 40% less expensive than standalone CSP systems