

An Open Platform
To Speed-Up & Cost-Down
the PV Reliability R&D

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Soo-Young Oh, Won-Shup So, Min-Soo Kim, Jae Hak Jung, Jin-Ho Park

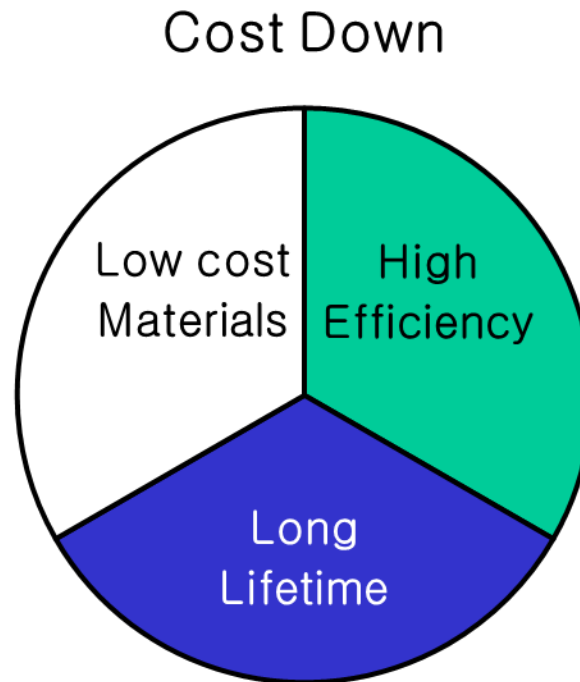
Yeungnam University

This presentation contains no confidential information.

- 1. Introduction**
- 2. SORES (Solar cell REliability Simulator)**
- 3. SORES Application:**
 - Platform for PV Reliability R&D**
- 4. Summary & Future Plan**

1. Introduction (1) : Cost Down

- The Name of the Game in PV Industry is “**Cost Down**”.
- The Means of Cost Down need **Reliability testing**

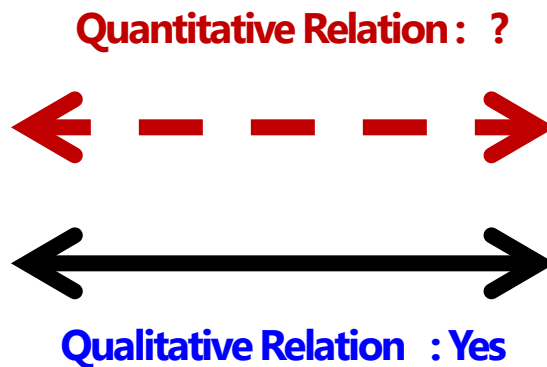


1. Introduction (2) : Reliability Testing

○ Problems of PV Reliability Testing

- ▶ **Qualification (Lab AST)** : Pass/Fail (No data available)
No Guarantee of Lifetime
Time-consuming(3~6Month) & Expensive
- ▶ **Outdoor Field Testing** : Too Long to get Results. (>20 Years)
 - Existing PV Power Generation Plant:
 - * Not well Characterized & Monitored.
 - * Difficult for quantitative analysis

1. Introduction (3) : Missing Link



Lab Accelerated Stress Test

Outdoor Field Performance

1. Introduction (4) : Missing Link

← SORES



Lab Accelerated Stress Test

Quantitative Relation : SORES



Qualitative Relation : Yes



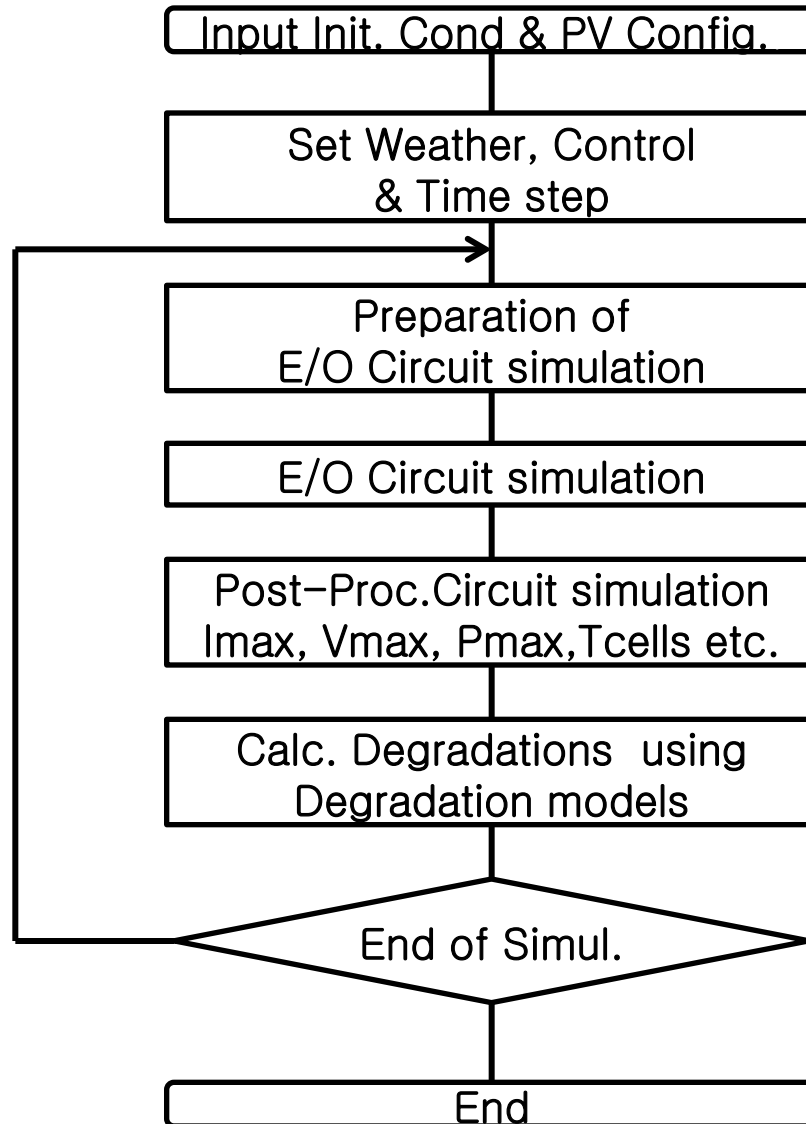
Outdoor Field Performance

2. SORES (1) : Physics-based PV Reliability Simulator

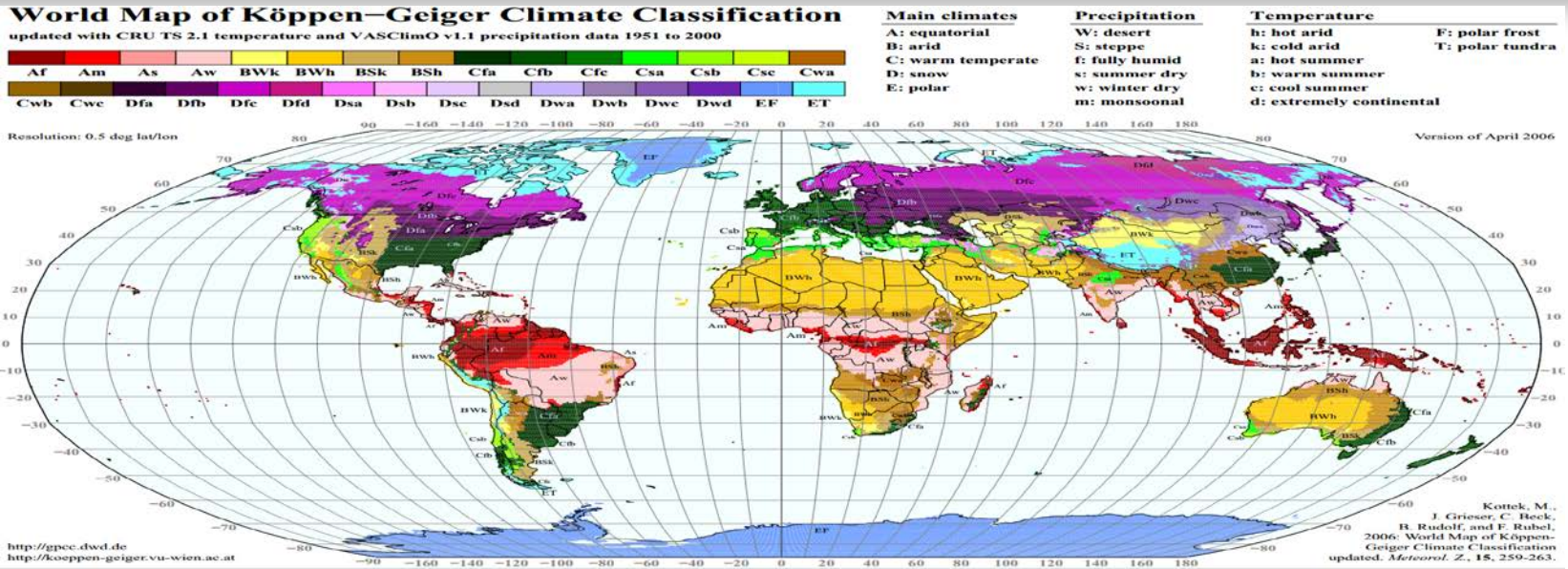
❖ Idea

- PV cell : **Electro-Optical Diode**
- PV Module : **Electro-Optical circuit**
- **Solar Power Generation : Running Electro-Optical circuit**
- **Degradation of Solar Power Generation can be physically simulated by **Time-Evolution Electro-Optical Circuit Simulation with PV Degradation Models.****

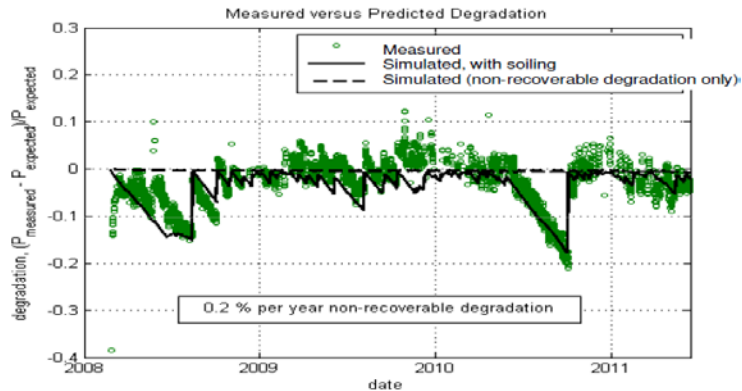
2. SORES (2) : Flow Chart



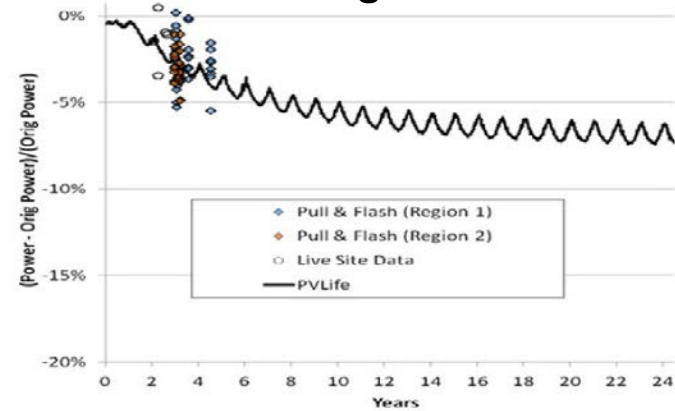
2. SORES (3) : Input-Output



Short-term



Long-term



2. SORES (4) : PV Failure Modes

Failure Modes

Broken Interconnects
Broken Cells
Corrosion
Delamination of Encapsulant
Encapsulant loss of Elasticity or Adhesion
Encapsulant Discoloration
Solder Bond Failure
Broken Glass
Hot Spots
Ground Faults
Junction Box Failures
Connection Failures
Structural Failures
Bypass Diode Failures
Open circuits leading to arcing

2. SORES (5) : Degradation Model Development

Modeling of Encapsulant Decoloration

1) Physical Model :

– M. Mikofski, M. Anderson, S. Caldwell, D. DeGraaff, E. Hasselbrink, D. Kavulak, R. Lacerda, D. Okawa, Y.C. Shen, A. Tedjasaputra, A. Terao and Z. Xie, "A dynamic cell-by-cell pv system model to predict lifetime performance and reliability," *26th European Photovoltaic Solar Energy Conference and Exhibition, pp. 105–112, 2011.*

2. SORES (6) : Degradation Model Development

Modeling of Encapsulant Decoloration

2) Empirical Model : UV Yellowing Measurement : Yellow Index (E313)

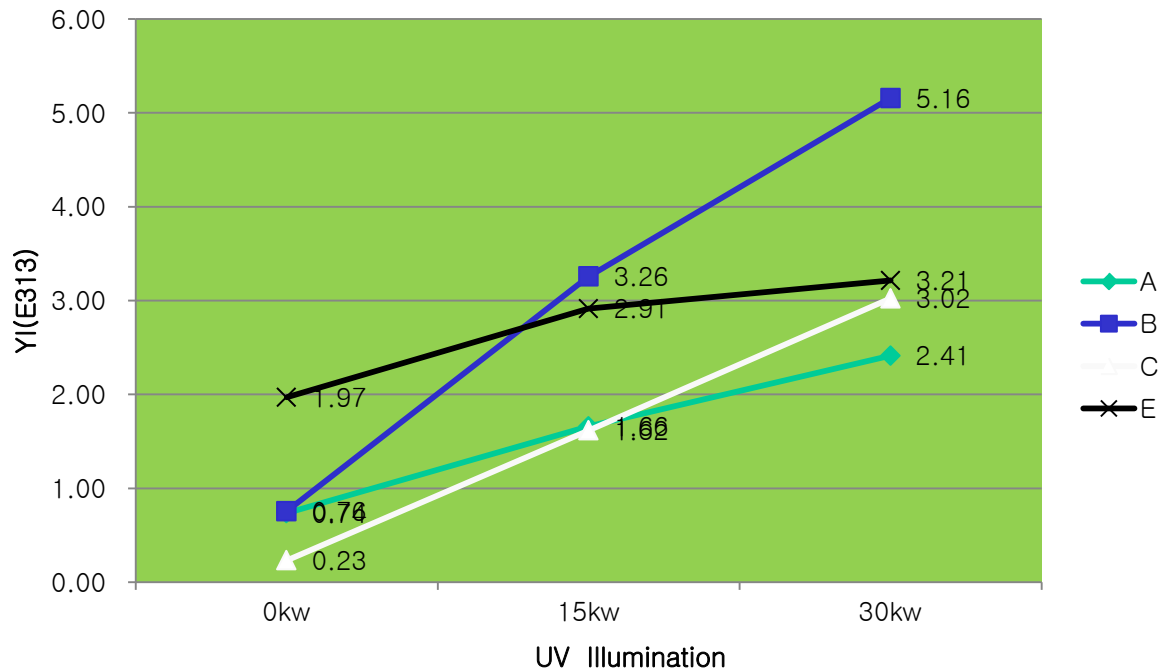


<UV Test Sample Preparation & Measurement>

2. SORES (7) : Degradation Model Development

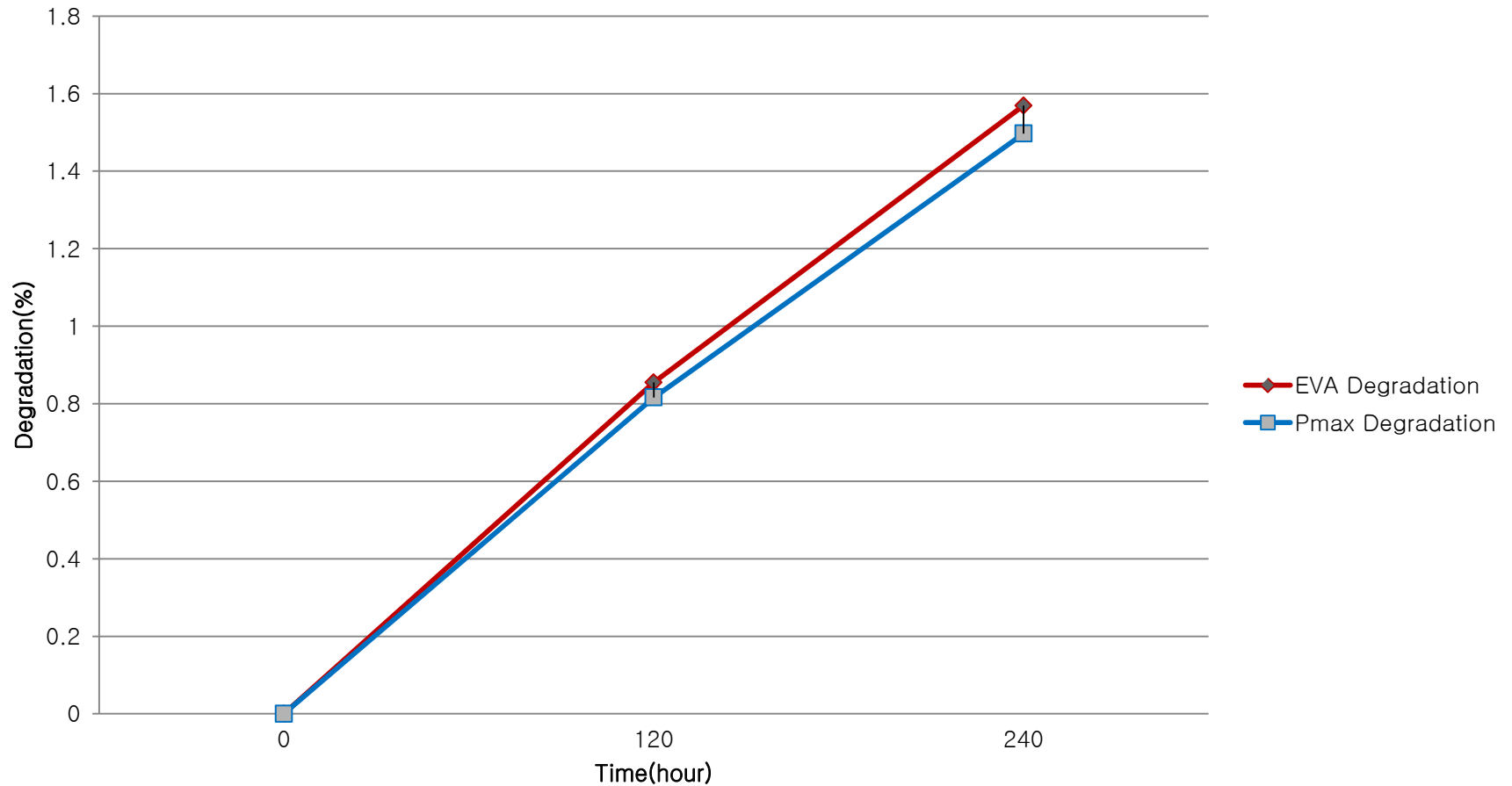
Modeling of Encapsulant Decoloration

2) Empirical Model : UV Yellowing Measurement : Yellow Index (E313)

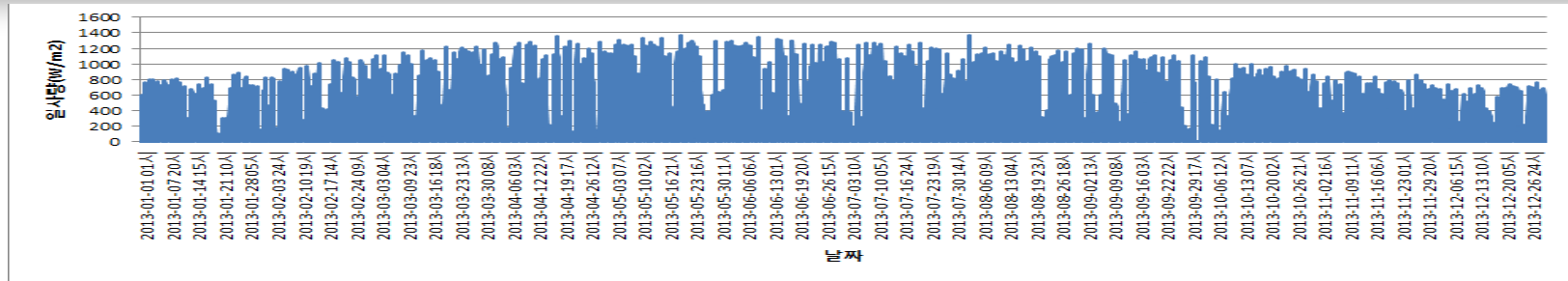


2. SORES (8) : SORES-Lab. AST Benchmark

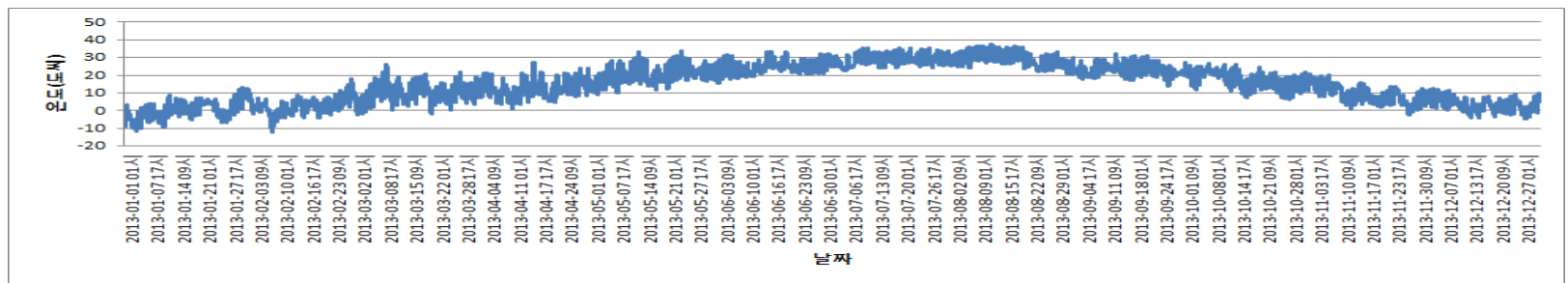
UV Degradation



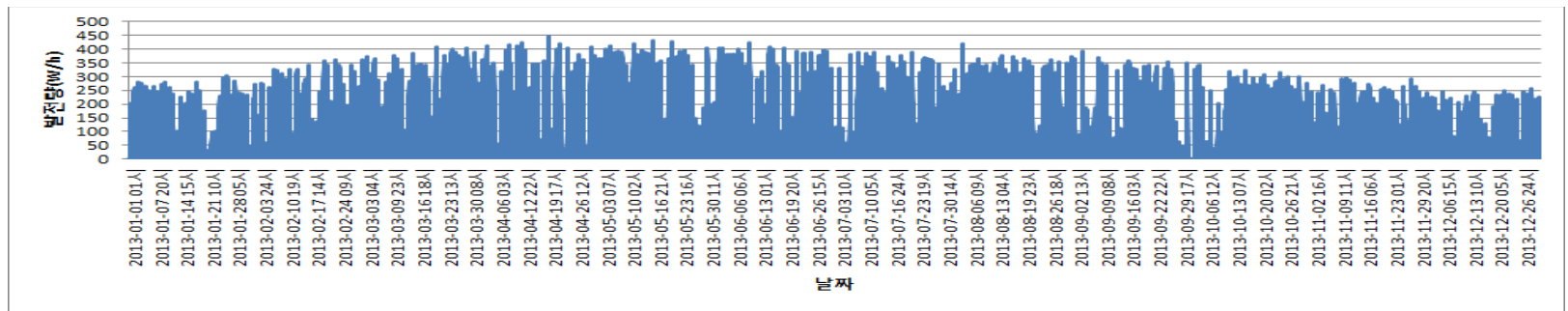
2. SORES (9) : UV Degradation Simulation



<Input : Solar Radiation in Daegu, Korea>

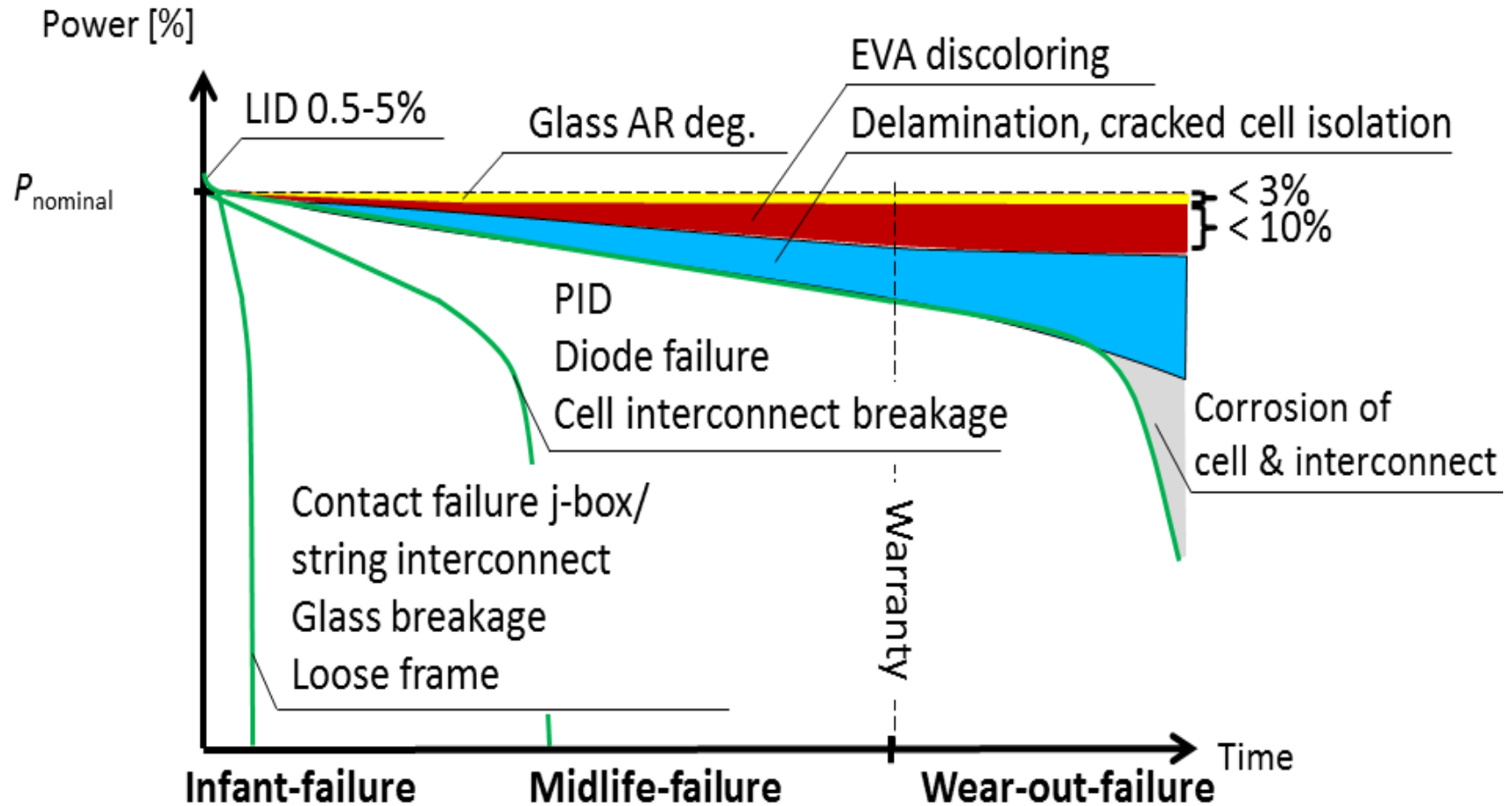


<Input : Temperature in Daegu, Korea>



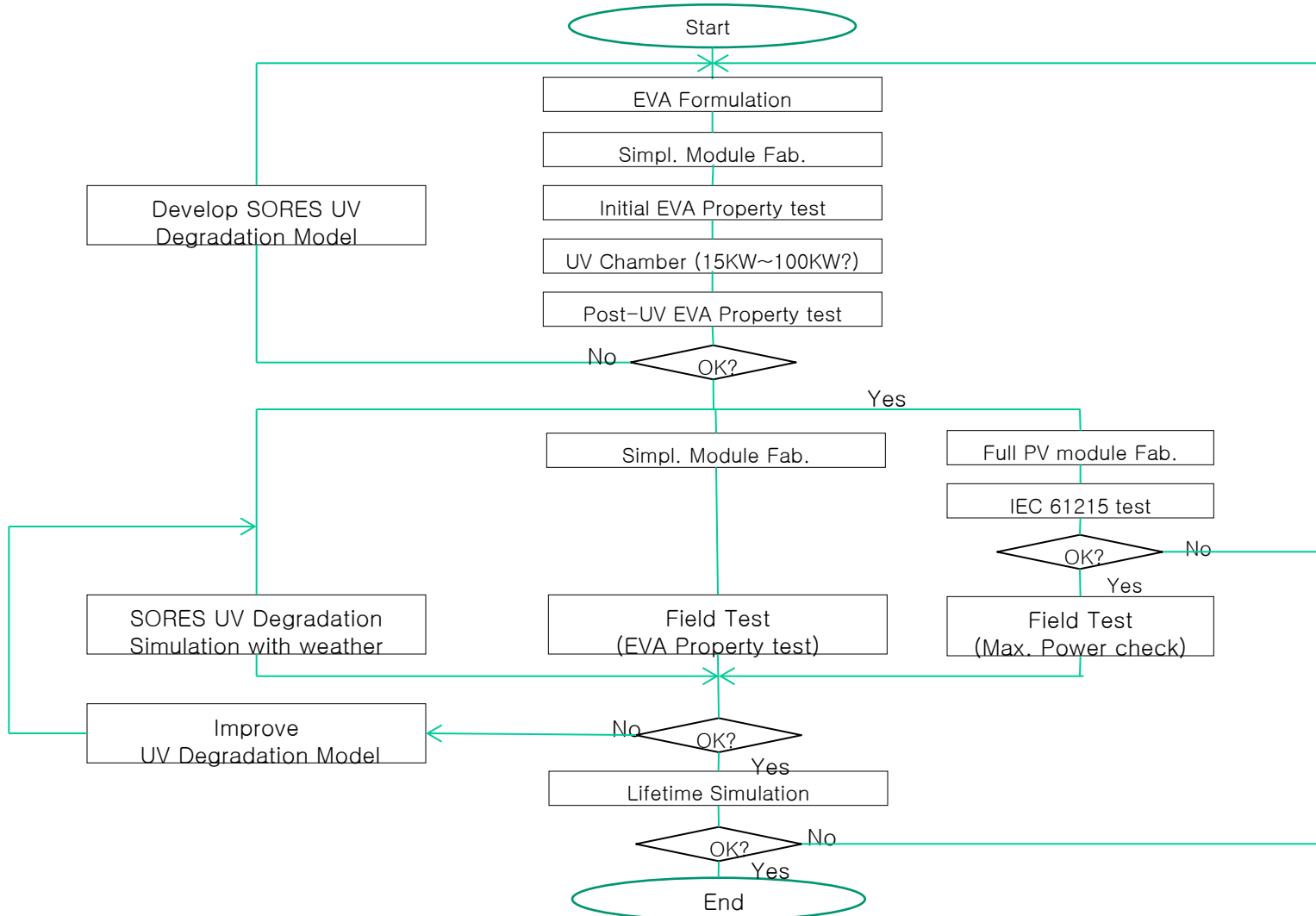
<Output : Solar Power Generation in Daegu, Korea>

3. SORES Application (1) : EVA Development



3. SORES Application (2) : EVA Development

EVA Development Flowchart



4. Summary & Future Plan (1)

- ▶ The Name of the Game in PV Industry is “**Cost Down**”. But the Means of Cost Down need **Reliability testing**.
- ▶ PV Reliability testing is **Time-consuming & Expensive**.
- ▶ PV Qualification **doesn't give the Test Data & guarantee of Lifetime**. It only gives the Pass/Fail.
- ▶ **Missing Link** : Lab. AST \leftrightarrow Outdoor Field Testing
No Quantitative Link

4. Summary & Future Plan (2)

- ▶ **SORES** provides the **Quantitative Link** between Lab. AST & Outdoor Field Testing.
- ▶ **SORES** is the Platform for the PV Reliability R&D.
- ▶ Yeungnam University will provides **SORES** as a **Open Platform** for PV Reliability R&D with the **Degradation Model API**.

Thank You