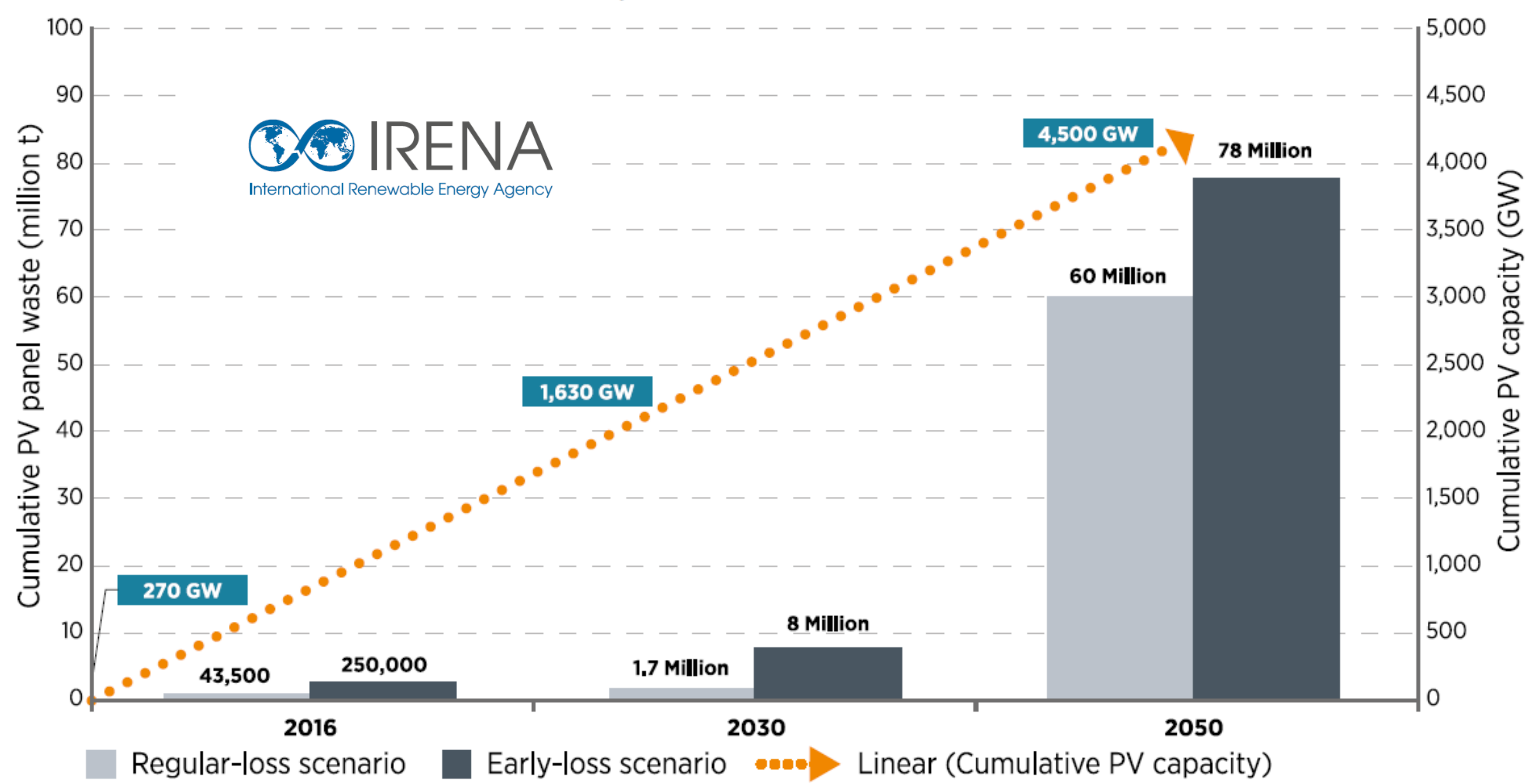


Recycling and Reuse potential of NICE™ PV-Modules

Introduction: PV module recycling challenges and chances

Overview of global PV panel waste projections, 2016-2050



Ref: IRENA: "End of life Management – Solar Photovoltaic Panels", 2016

- **Projections of future scenario by IRENA, and others:**
 - ➔ Strong continuous growth of PV industry worldwide
 - ➔ Increased PV module waste stream from decommissioned PV installations
- **PV Modules fall under waste regulations and directives**
- **Considerable economic value from end-of-life PV modules**
 - ➔ Potential value creation: up to 15 Billion US\$ (2050)
 - ➔ Potentially valuable materials: Metals (Al, Cu, Ag), Glass, Silicon
 - ➔ Sustainable and cost-effective recycling/reuse technologies required.

Disassembly of NICE™ modules for recycling and reuse of components

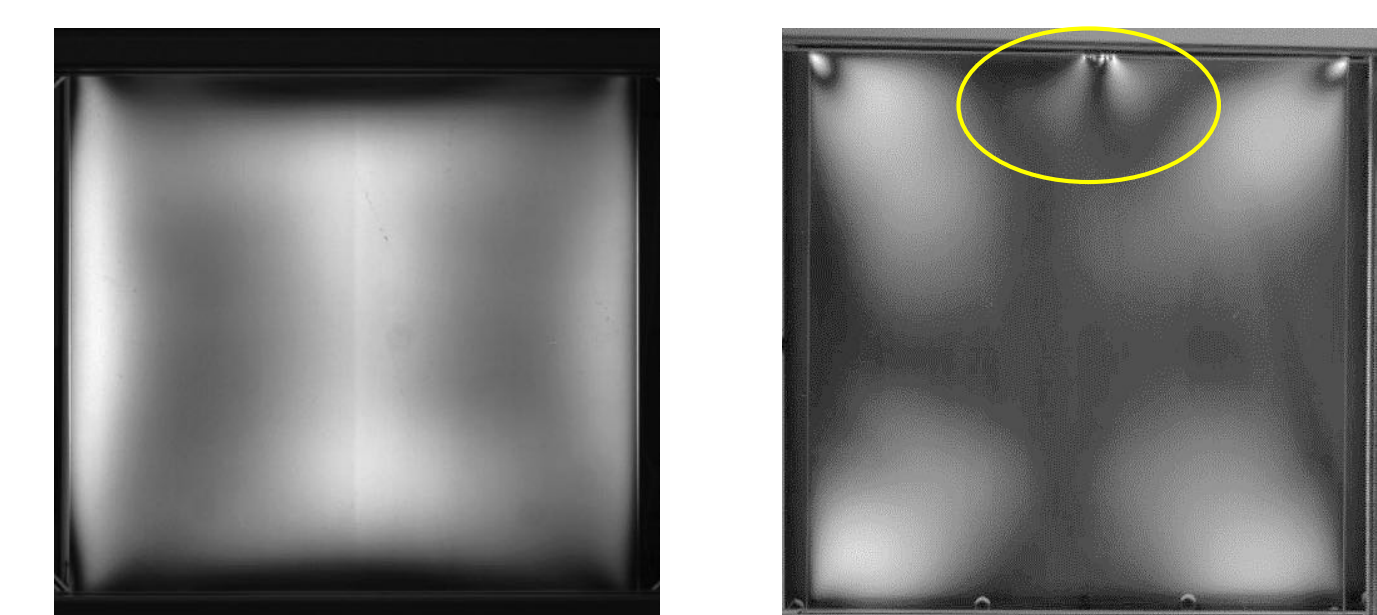
Results from the Module Work-package of the European Horizon 2020-FOF-13-2015 'ECOSOLAR' project

- **Major Characteristics of Apollon Solar's NICE™ modules:**
 - Absence of organic encapsulants and soldering
 - Edge Seal (PIB, Polyisobutylene) for environmental protection and underpressure for electrical contacts between cells and pure copper tabs
 - 90% less use of organic materials compared to standard encapsulated PV modules
- **Disassembly of NICE™ modules into components**



- **Disassembly techniques investigated**
 - Edge seal opening: Thermo cutter, laser
 - Detachment of PIB from glass, copper: pulsed ns IR laser, chemicals solvolysis + reacting agents
 - ➔ Less destructive and lower energy consumption than recycling techniques for laminated modules

- **Recovery of major module components as entire pieces**
 - Clean glass sheets and pure copper tabs (99,93% Cu according to ICP OES analysis)
 - ➔ Higher recycling value compared to shredded and partially contaminated granules from laminated modules
- **Diagnostic techniques for failure modules + components**
 - Old modules diagnosed by EL and IR imaging to detect cells with failures
 - Photoelasticity images of glass to detect stress (image shows stress free sample (left) and laser induced stress (right))



- **Reuse of glass for new modules**
 - Laminated 60 cells (multi-c Si Al-BSF) modules with recovered front glass from old NICE modules
 - Working modules obtained, rel. low current due to absence of AR coating



Module ID	Recovered Glass #1	Recovered Glass #1
<i>Isc [A]</i>	8.87	8.92
<i>Imp [A]</i>	8.29	8.33
<i>Voc [V]</i>	38.26	38.35
<i>Vmp [V]</i>	30.27	30.30
<i>Pmp [W]</i>	250.9	252.5



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