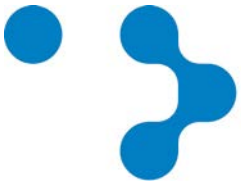

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Assessing Sustainability in Architectural Coatings

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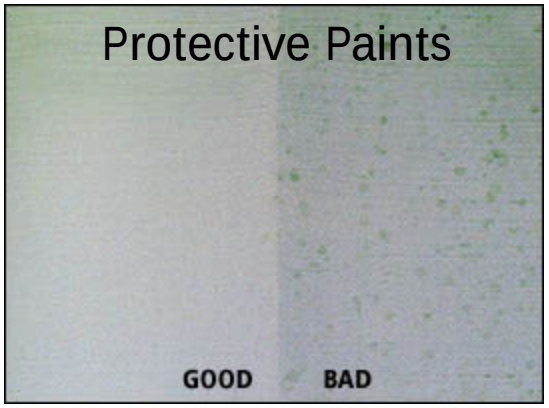
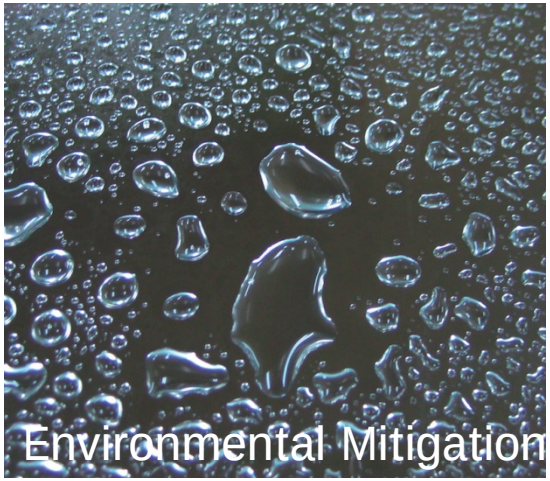
Architectural Coatings Serve Many Purposes





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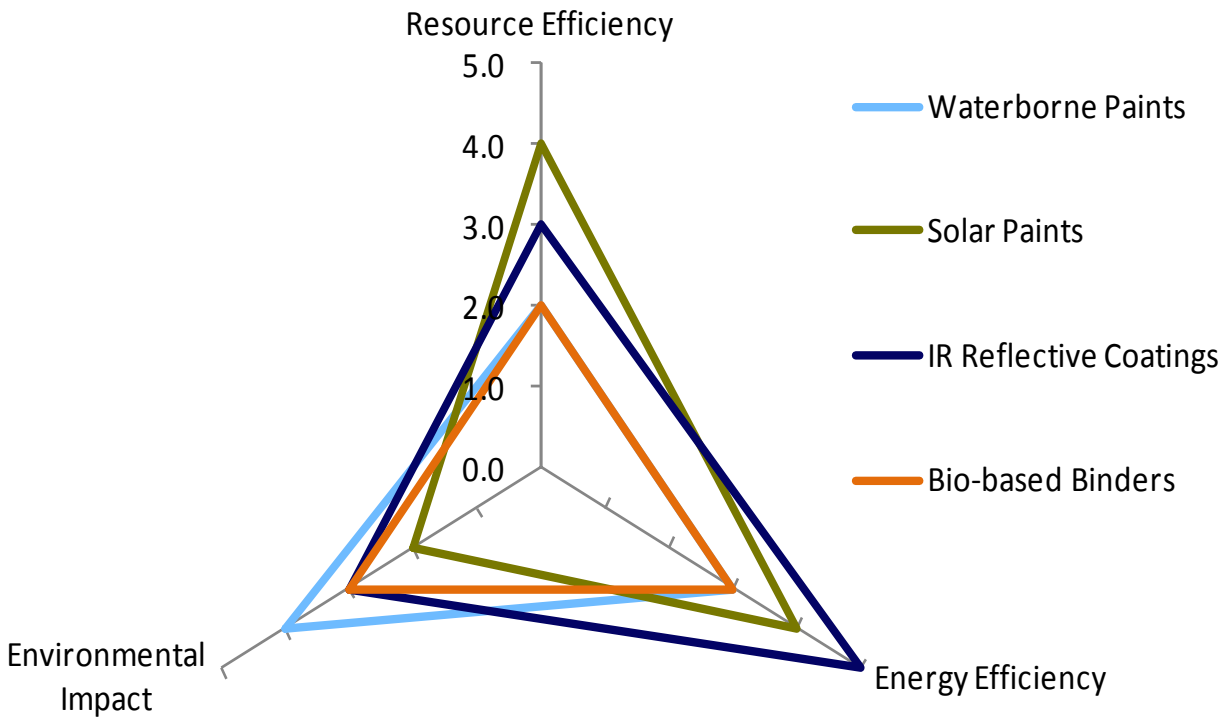
However..architectural coatings have a significant resource footprint

- Architectural coatings consume important resources such as water, petrochemicals, and energy
- According to the AkzoNobel Sustainability Report for 2010, the company consumed 16 m^3 of fresh water, 5.7 GJ of energy, and emitted 267 kg of CO_2 per ton of paint manufactured
- From2011, AkzoNobel bases 50% of the long-term incentives for senior executives on sustainability performance
- Although, sustainability is clearly becoming important, it is not clear which coating technologies are truly sustainable and which are really "greenwashed"

Consumer Awareness, Regulations, and Building Norms Drive Sustainable Coating Development

- Regulations on volatile organic chemicals (VOC) have driven the first wave of innovation
- Consumers are willing to pay more for low-VOC and low-allergen products, creating a pull
- Corporate social responsibility goals are providing the push
- Building codes, third party standards such as LEED, and mandates for Nearly-Zero Energy Buildings have lead to coatings enabling energy efficiency

Defining Sustainability in a Comprehensive Manner is Key to Bringing the Trade-offs in Focus



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Methodology

- Interviews with stakeholders
- Review of regulations
- Patent analysis
- Publication analysis

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Value Chain Features Multiple Stakeholders with Conflicting Interests

- Coating suppliers, architects, construction companies, and building owners form a complex web of decision makers
- Coating suppliers feel the need to educate architects on paint application and pricing
- Architect's job ends after specifications; construction companies work out the details of application process, oftentimes incorrectly
- Architectural coatings only make up 3% of the total building materials cost and hence are rarely at the front and center of architects and design firms

Examples of Key Regulations and Standards

Country/Region	Agency	Regulations/Standards
U.S.	EPA	**Regulations of VOC, ozone under the Clean Air Act of 1996**
U.S.	OSHA	**Regulations on formaldehyde and other VOCs mandating 0.75 ppm in residential construction and 0.50 ppm in hospitals and food processing facilities**
U.S.	LEED	**Two credits for using paints with less than 50 g/L of VOC**
Canada	Canadian Environmental Protection Act	**VOC limit of 400 g/L for all interior applications and 600 g/L for exterior applications**
EU	European Commission	**Directive 2004/42/EC demands emission reporting for all paints according to ISO 16000-9 and that all paints be free of APEO and VOC**
France	MINISTÈRE DE L'ÉCOLOGIE, DU DÉVELOPPEMENT DURABLE, DES TRANSPORTS ET DU LOGEMENT	**Mandatory labeling of VOC content for all construction products including paints, VOC limit of 100 g/L for most products**
UAE	Municipality of Dubai	**All exterior paints need to undergo tests for heavy metal content, VOC, solar heat gain, and solar reflectance**
Singapore	Building Construction Authority	**Greenmark Certification- points for low VOC paints, energy-efficient exterior coatings, Globally Harmonized System (GHS) for labeling coating components, heavy metal limit of 5 ppm**

Established Coatings Technologies Enabling Sustainability

Technology	Description	Developers
Waterborne acrylic coatings	Coatings containing acrylic binder and water as the main solvent	**AkzoNobel, Sherwin-Williams, Benajmin Moore, Bayer, BASF, Asian Paints, Mythic Paints**
Waterborne polyurethane coatings	Coatings containing polyurethane binder and water as the main solvent	**Bayer, Dow Chemical, Wuxi Shanli High Temperature Paint Compnay, Sound Speciality Coatings**
100% solid powder coatings	Coatings based on epoxy or polyurea containing no solvent, applied via electrostatic spraying or dip coating followed by thermal curing	**Creative Material Technologies, AkzoNobel**
Elastomeric cool roof coatings	TiO_2 or ZnO filled elastomeric coatings to reduce the solar heat gain	**Sika Sarnafil, Saint-Gobain CertainTeed, Dow Chemical**
IR reflective coatings	Coatings that reflect short wave infrared radiation and reduce the solar heat gain	**Industrial Nanotech, Kriya Materials**
Coatings with enhanced hiding power	Coatings containing voids or, polymer coated TiO_2 for improved opacifier distribution	**Arkema, Dow Chemical, Socal Paints**
Low VOC coalescing agents, co-solvents and surfactants	APEO-free foam based surfactants, dibasic ester based coalescing agents, co-solvent free coatings	**Rhodia, Dow Chemical, Mythic Paints**

- Focus has shifted from solvents to surfactants and coalescing agents to reduce the VOC content further
- Roof coatings incorporating reflective pigments are well established

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Emerging Coatings Technologies Enabling Sustainability

Technology	Description	Developers
Waterborne alkyd coatings	Coatings containing alkyd or epoxy binder and water as the main solvent	**Reichhold Coatings, Cytec**
Light-reflective paints	Lighter color palette plus higher sheen via increased binder content reduces the need for artificial lighting indoors	**AkzoNobel, Sherwin-Williams, ICI**
Solar paints	Solar photovoltaic material that can be applied as an exterior paint	**University of Notre-Dame, University of Texas Austin, NextGen Solar**
Thermally responsive cool-roof coatings	Coatings containing an active molecule in the backbone or a solid-to-liquid gel	**Creative Material Technologies, Thermeleon**
Photocatalytic coatings	Oxygen activated by photocatalytic TiO_2 reacts with and neutralizes SOx and NOx	**Toto, Pureti, Alcoa**
Bio-based binders and solvents	Using biological feedstocks such as castor oil to synthesize monomers or polymers	**DSM, Ebrabiotech, Nippon Chemical, Novomer, Naturepaint, Shanghai Jesii Cowel**
Chromate free anti-corrosion coatings	Coatings that use alternative anti-corrosion agents such as electro active polymers or ceramics instead of hexavalent chromium	**Kansai Paint, Posco, MesoCoate, Cross-link USA**
Self-healing coatings	Polymers exhibiting reversible cross-linking or coatings containing monomer-filled microcapsules	**PPG, GE, Autonomic Materials**

- Alkyd and epoxy chemistries are improving waterborne coatings performance
- Widespread availability of polyols, esters, and other monomers from biological feedstocks has sparked new interest in bio-based binders

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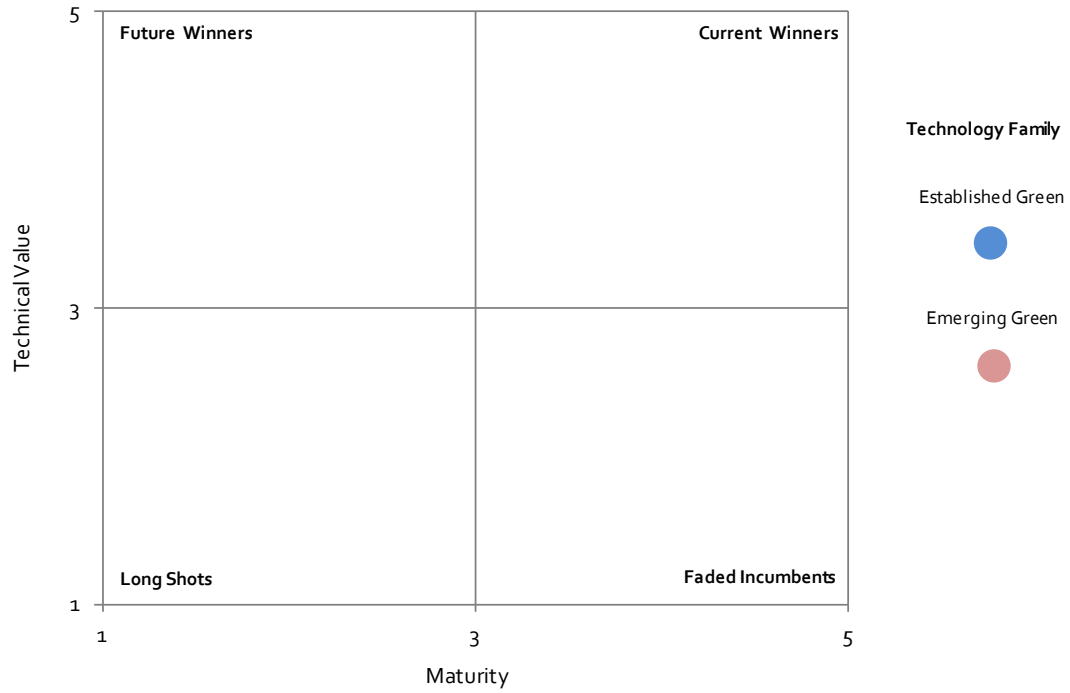
Lux Innovation Grid Provides a Reality Check for Adoption Challenges and Timeline



- Technologies that are "Current Winners" are widely deployed today
- "Future Winners" have great potential but face significant adoption hurdles
- "Long Shots" technologies are immature and have questionable technology value
- "Faded Incumbents" are technologies that are well-established but commoditized, with little scope for differentiation

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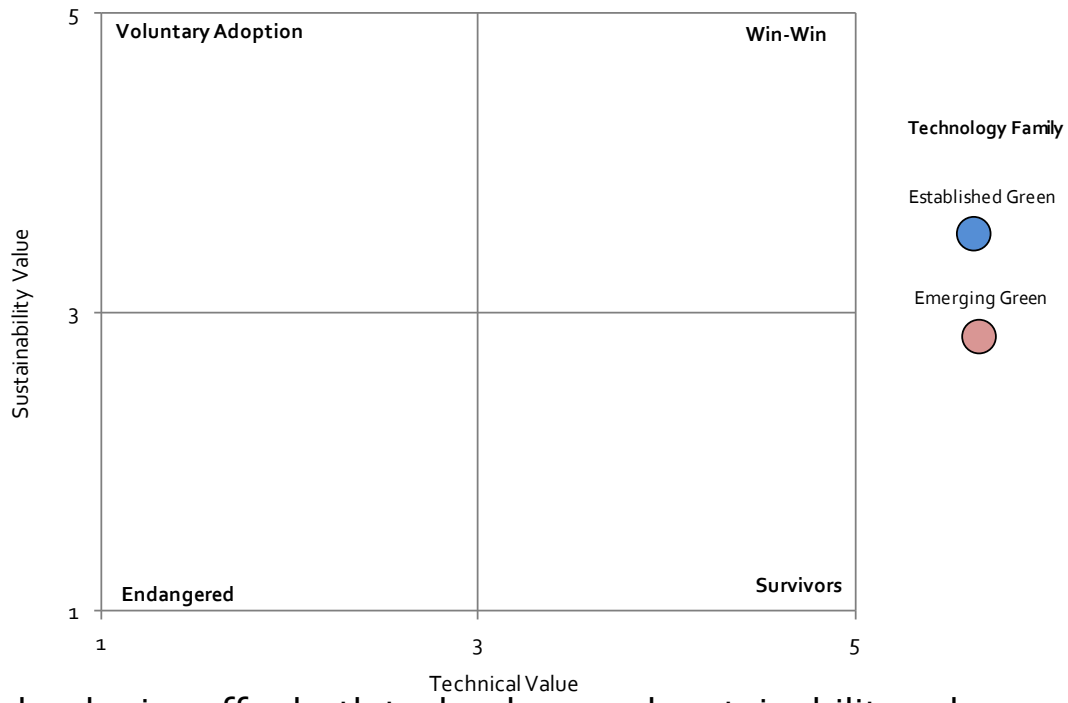
Lux Sustainability Grid Illustrates the challenges in Balancing Sustainability and End-User Value



- "Win-Win" technologies offer both technology and sustainability value
- "Voluntary Adoption" technologies offer significant sustainability value but are compromised on either performance or cost
- "Endangered" technologies have negative sustainability impact and questionable technology value
- "Survivor" technologies will provide enough technical value to the end users and developers to fight rising regulations

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Lux Innovation Grid: Technology Value Criteria

Criterion	Description	Weight
Coating performance	As measured by gloss, color, hardness, resistance to weathering and biological degradation	**20%**
Coating durability	Ability to maintain performance over a long period of time	**25%**
Cost	Cost of the coating including materials and labor	**25%**
Processibility	Ability to coating rheological properties to enable a wide variety of application processes, e.g. dip coating, roll coating, spray coating	**20%**
Geographic applicability	Ability to be applicable in a range of climates and geographies	**10%**

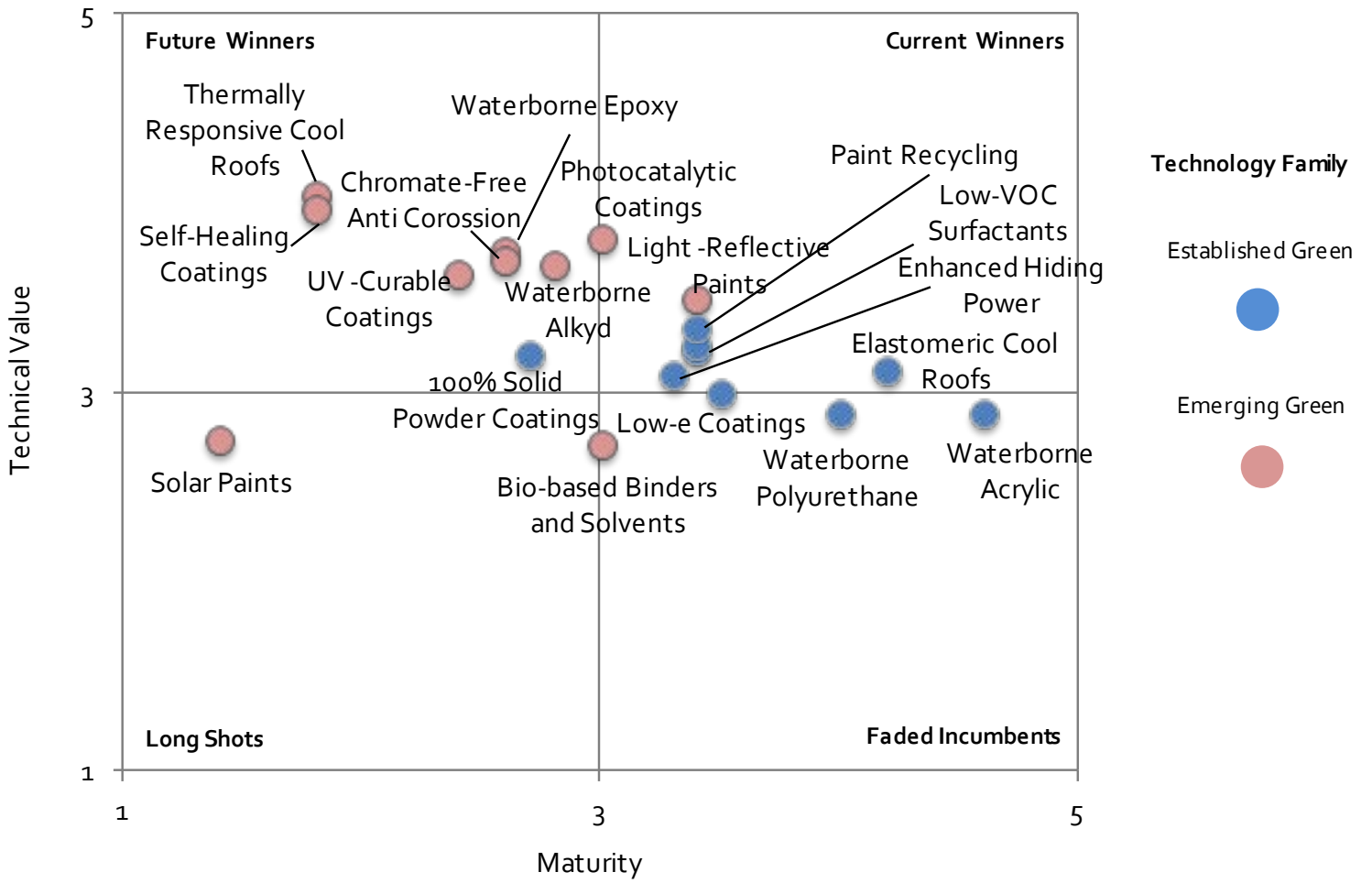
Lux Innovation Grid: Maturity Value Criteria

Criterion	Description	Weight
Probability of reaching performance goals	Will the technology achieve its promised performance goals at maturity	**20%**
Architect and construction firm familiarity	Are the architects familiar enough to specify the technology? Are the construction firms familiar enough to apply the coating properly?	**20%**
Size and reach of developers	Market share of the developers and the strength of their partnerships	**20%**
Present market share	Quantitative value of the market share of a given technology within a specific segment	**20%**
Time to market	Time required for a given technology to be commercially available	**20%**

Lux Sustainability Grid: Sustainability Value Criteria

Sustainability Axis	Criterion	Description	Weight
Resource efficiency	Energy consumption	Energy consumption during the manufacturing and application of the coating	**10%**
	Water consumption	Water consumption during the manufacturing and application of the coating	**10%**
	Petrochemical consumption	Non-renewable feedstock consumption during the manufacturing and application of the coating	**10%**
	Coating usage over the life of the building	Includes reapplication of coating for less durable coatings	**10%**
Energy efficiency	Energy efficiency of the building	Ability of the coating to reduce the heating, cooling, and lighting loads of the building	**30%**
Environmental impact	VOC release	Release of VOCs to the environment during manufacturing, application, and usage life of the coating	**10%**
	Heavy metal release	Release of heavy metals to the environment during manufacturing, application, and usage life of the coating	**10%**
	Mitigating air pollution	Ability of the coating to neutralize the pollutants from the ambient air surrounding the building	**10%**

Plotting Architectural Coating Technologies on Lux Innovation Grid



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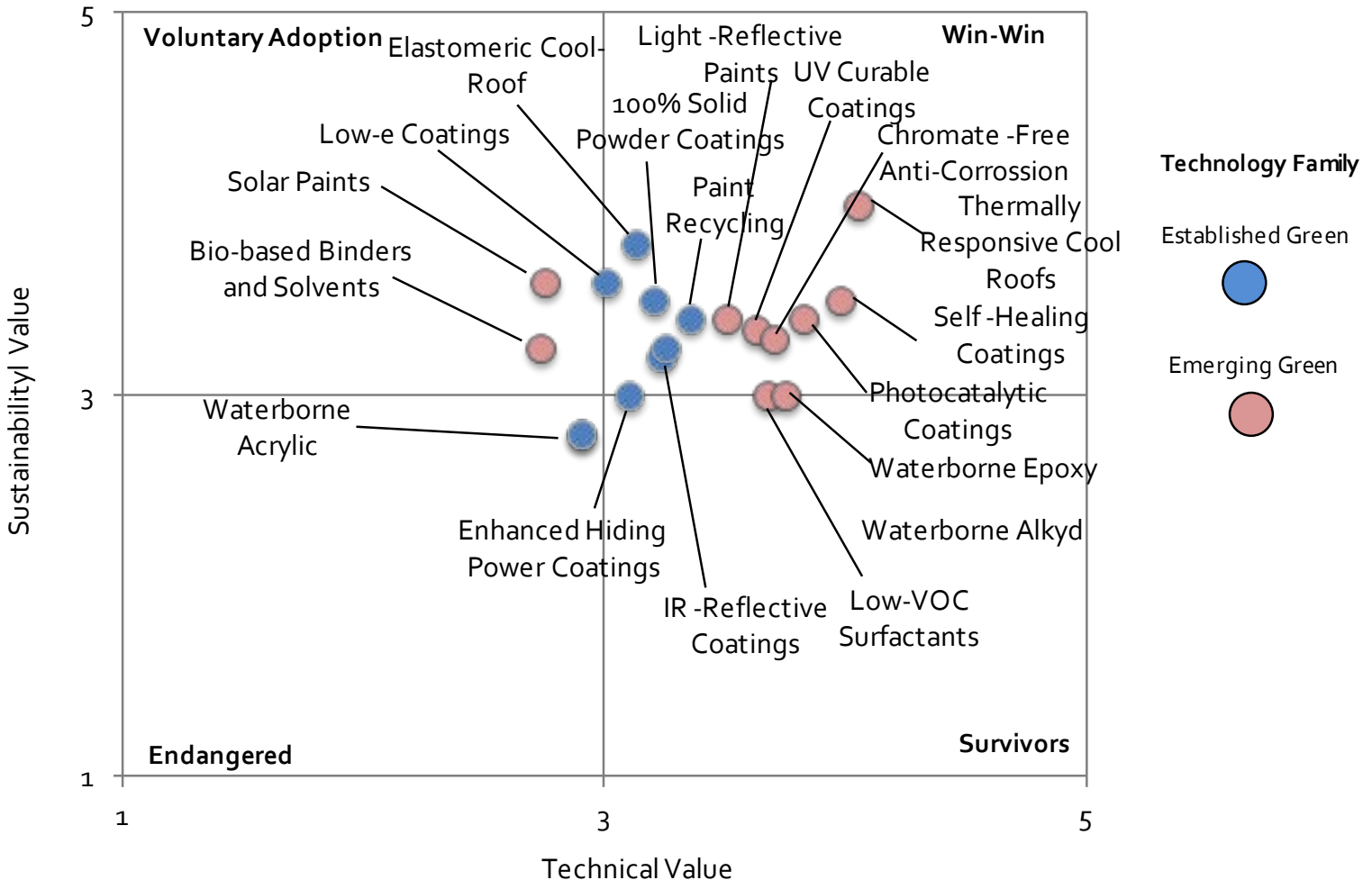
Plotting Architectural Coating Technologies on Lux Sustainability Grid



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Sustainable Coating Offerings Have Moved Beyond Just Low VOC Content Via Solvent Reduction

- Unsolved challenges in incumbent low-VOC technologies give rise to the future winners
- Cool roofs could expand their geographic footprint, thanks to thermally responsive optical coatings and become a future winner
- Solar paints remain a long-shot due to poor efficiency; bio-based binders farther along in maturity.

There Will Be Few Winners Purely Based on Sustainability

- Waterborne acrylics are no longer a competitive differentiator, unless coupled with other technologies
- Enhancing durability enables win-win technologies
- "Reduce, reuse, and recycle" is a key enabling principle New building norms and government regulations bring energy efficiency in focus

Outlook

- Regulations move beyond VOC and heavy metals to include energy efficiency during usage
- Environmental degradation and rising resource constraints drive innovation in emerging economies
- Unconventional oil will lift petrochemical feedstock constraints, negating a major driver for bio-based binders
- Architects increasingly view exterior coatings as an integral part of the building envelope design

Questions?

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