

USA systems selected in table 1 (criterion c): *CEEQUAL* and *GreenPave*. As it turns out, these two systems represent both infrastructure and pure pavement SPRS (criterion a). Following on, and given that road SPRS represent the bulk of available systems, two further systems were selected for evaluation from the roads category (criterion a): *Greenroads* and *BE²ST-in-Highways*. Through the literature review, it was found that *Greenroads* is the most researched system (criterion b), and that the *BE²ST-in-Highways* system was unique in its approach to sustainability quantification (criterion c); while many SPRS are based on the LEED building system (Barrella et al., 2017), *BE²ST* functions through a variety of third-party apps, which through their analysis provide key data for system evaluation, hence offering the highest potential of variance for this study.

This, in turn, correlates to the following systems being selected (in alphabetical order): *BE²ST-in-Highways*; *CEEQUAL*; *GreenPave*; *Greenroads*.

5.2 Introduction to Selected SPRS

From the systems selected, two originate from different US states; one from the west side and one from the central-eastern side. Both US systems in this study consider the roadway system (Anderson et al., 2017; UWM, 2010). The origin of the purely pavement systems can be found a little further north in Canada (Lane et al., 2017). Finally, from the European continent the *CEEQUAL* system can be found (BRE, 2012), which evaluates all forms of infrastructure projects.

Overall, the majority of the SPRS offer rating only in their local region, whereas the *Greenroads* system spans further and covers North America, Australasia, Africa, the Middle East and Asia. This reinforces the superior number of citations which *Greenroads* has. Furthermore, *GreenPave* and *Greenroads* provided updated manuals in 2017, counting as the most recent systems. On the other hand, *BE²ST* and *CEEQUAL* (despite being at version 5) haven't updated their manuals since 2010 and 2012, respectively. Sustainability measurement evolves over time, therefore systems must be updated accordingly (Zietsman et al., 2011).

Table 2: Introduction to Sustainable Pavement Rating Systems.

	BE²ST-in-Highways	CEEQUAL	GreenPave	Greenroads
Origin	Wisconsin, USA	United Kingdom	Ontario, Canada	Washington State, USA
Dispersion	Wisconsin, USA	UK & Ireland	Ontario, Canada	USA, Canada, Australasia, Africa, Middle East and Asia
Start – Latest Release	2010 – N.A.	2003 – 2012	2010 – 2017	2010 – 2017
Citations	2 (WoS) 1 (Sp)	5 (WoS) 2 (Sp)	3 (WoS) 2 (Sp)	20 (WoS) 11 (Sp)
Rating Type	Self-Assessment	Third-Party	Self-Assessment	Third-Party
Cost	N.A. - Internal	Based on project cost and award type ¹ .	N.A.- Internal	Based on project cost. Discounts for members.

With regards to the cost of the rating systems, this can be seen as linked to the rating type a system has chosen. For the *BE²ST* and *GreenPave* systems, they can be seen as internal rating tools for DoT application, whereas *CEEQUAL* and *Greenroads* have taken a more

commercial approach and rate external projects via a third-party, in turn, charging for the rating of projects. Projects to be evaluated by CEEQUAL and Greenroads have similar pricings when project budgets are around 5 million, but upon reaching budgets of 300 million Greenroads is roughly three times more expensive (CEEQUAL Ltd., 2017; Greenroads, 2019). Neither system will exceed 1% of project budget for rating. The more open approach of BE²ST and GreenPave is best as there is a growing adoption of rating tools in departments of transport (Eisenman and Meyer, 2013), especially considering CEEQUAL’s and Greenroads’ latest manuals are not publicly available.

5.3 Criteria and Method Evaluation

Briefly described in table 3, the criteria categories for each of the systems are displayed, along with the total number of categories available, the total number of indicators (Ind.) and whether the system demands any pre-requisites for evaluation (pre-req.). From the comparison of the categories of the rating systems, it can be found that all systems provide considerations for six key aspects: (i) *design process* (many mentioning relevant regulations), (ii) *energy and emissions*, (iii) *environment & land use*, (iv) *materials, resources* (including water) *and waste*, (v) *life-cycle considerations* (environmental and economic) and (vi) *social aspects*. These findings are similar to those of Clevenger et al. (2013). The authors would add two further categories for a more complete SPRS: *pavement technologies* (from GreenPave) and *construction activities* (Greenroads).

It is worth noting that the number of categories isn’t directly proportional to the complexity of the systems. For example, from table 3 we can see that BE²ST and CEEQUAL offer the highest amounts of credit categories, however BE²ST only offers two credits per category (excluding the pre-requisite, gives a total of 18 credits), whereas CEEQUAL offers a total of 5,010 credits in its system. In total, GreenPave offers 32 credits, and Greenroads offers 130 credits. With the exception of BE²ST, it can also be seen that the number of indicators is directly proportional to the complexity of the system (more indicators with more complexity), as paving activities have narrower boundaries than road and infrastructure projects (Bryce et al., 2017). In general, there is a recognised difference between infrastructure and roadway rating systems (Zietsman et al., 2011).

Table 3: SPRS Criteria Categories.

System	Criteria Categories	Total	Ind.	Pre-req.
BE²ST-in-Highways	Regulation & local ordinances (pre-requisite); Greenhouse gas emissions; Energy use; Waste reduction (ex-situ); Waste reduction (in-situ); Water consumption; Hazardous waste; Life-cycle cost; Traffic noise; Social carbon cost saving.	10	9	✓
CEEQUAL	Project environmental management; Land use; Landscape; Ecology & biodiversity; Archaeological & cultural heritage; Water issues; Energy; Use of materials; Waste transport; Nuisance to neighbours; Community relations.	12	179	X
GreenPave	Pavement technologies; Materials & resources; Energy & atmosphere; Innovation & design process.	4	14	X
Greenroads	Project requirements; Environment & water; Construction activities; Materials & resources; Utilities & controls; Access & liveability; Creativity & effort.	7	61	✓
Common Criteria	Design process management (inc. regulations); Energy & emissions; Environment & land use; Materials, resources (inc. water) & waste; Life-cycle; Social aspects.			

