

# Contents

|  | <i>page</i> |
|--|-------------|
| <b>Foreword</b>  | <b>v</b>    |
| <b>Summary</b>   | <b>1</b>    |
| <b>Target audience and aims of the report</b>                                      | <b>4</b>    |
| <b>Scope</b>   | <b>4</b>    |
| <b>Report structure</b>  | <b>4</b>    |
| <b>1 Introduction</b>  | <b>5</b>    |
| 1.1 The challenge of decarbonisation   | 5           |
| 1.2 The gap between GHG emission goals and expected market trends                  | 5           |
| 1.3 How to close the gap: framework for transport decarbonisation                  | 6           |
| <b>2 Transport demand</b>  | <b>9</b>    |
| 2.1 Links between transport demand, economic development and emissions             | 9           |
| 2.2 Containing transport demand and shifting to more efficient modes               | 9           |
| 2.2.1 Passenger transport  | 9           |
| 2.2.2 Freight transport  | 13          |
| <b>3 Transport supply options and technologies</b>                                 | <b>17</b>   |
| 3.1 Overview   | 17          |
| 3.2 Vehicle selection  | 18          |
| 3.3 Vehicle design   | 19          |
| 3.4 Powertrain technology and fuel substitution options                            | 19          |
| 3.4.1 Overview of transitional options and long-term sustainable options           | 19          |
| 3.4.2 Internal combustion engine vehicles and hybrid electric vehicles             | 20          |
| 3.4.3 Battery electric vehicles and plug-in hybrid electric vehicles               | 23          |
| 3.4.4 Hydrogen and fuel cell electric vehicles                                     | 25          |
| 3.4.5 Electric road systems  | 26          |
| 3.4.6 Costs and efficiencies of transport electrification options                  | 26          |
| 3.5 Coupling of transport, electricity, buildings and industry sectors             | 28          |
| 3.5.1 Overview of coupling interfaces  | 28          |
| 3.5.2 Future energy and power demands for transport electrification                | 29          |
| 3.5.3 Battery charging infrastructure  | 29          |
| 3.5.4 Markets for grid flexibility management services                             | 30          |
| 3.5.5 Standards, rules and tariffs for charging electric vehicles                  | 30          |
| 3.6 Timescales for decarbonisation using alternative technologies or fuels         | 31          |
| 3.6.1 Options for use in the transition phase                                      | 31          |
| 3.6.2 Sustainable solutions for the long term (2050)                               | 32          |
| 3.7 Life cycle emissions of vehicles with different powertrains                    | 32          |
| <b>4 Information and communications technologies (ICT) and autonomous vehicles</b> | <b>35</b>   |
| 4.1 ICT  | 35          |
| 4.1.1 ICT for avoiding/reducing transport demand                                   | 35          |
| 4.1.2 ICT for road transport demand and traffic management                         | 35          |
| 4.1.3 ICT with big data and artificial intelligence                                | 36          |
| 4.1.4 ICT in vehicles  | 36          |
| 4.1.5 ICT for charging electric vehicles   | 36          |
| 4.2 Autonomous vehicles  | 36          |

|                |   |           |
|----------------|---|-----------|
| <b>5</b>       | <b>Discussion and conclusions</b>   | <b>38</b> |
| 5.1            | Overview  | 38        |
| 5.2            | Emission reductions from innovative transport demand management           | 38        |
| 5.3            | Emission reductions from innovative vehicle technologies and fuels        | 38        |
| 5.4            | Promoting emission reductions with taxes, incentives and public financing | 41        |
| 5.5            | Promoting EU industries, jobs, skills and further research                | 42        |
| <b>6</b>       | <b>Advice for policy-makers</b>   | <b>43</b> |
|                | <b>References</b>   | <b>47</b> |
|                | <b>Abbreviations</b>  | <b>54</b> |
| <b>Annex 1</b> | <b>2014 IPCC assessment report</b>  | <b>55</b> |
| <b>Annex 2</b> | <b>Expected evolution of autonomous vehicles</b>                          | <b>56</b> |
| <b>Annex 3</b> | <b>Future availability of rare element resources</b>                      | <b>56</b> |
| <b>Annex 4</b> | <b>Working group composition and timetable</b>                            | <b>57</b> |
| <b>Annex 5</b> | <b>Acknowledgements</b>   | <b>58</b> |