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Advances and Prospects of Key Technologies for Dedicated Transmissions in New Energy Vehicles

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Abstract. Dedicated transmissions affect the efficiency, performance, durability, and noise, vibration and harshness (NVH) of new energy vehicles (NEVs). Previous reviews have examined battery-electric transmissions, hybrid architectures, control, and components separately. This systematic review connects these areas through an architecture–technology framework, comparing single-speed and two-speed battery electric vehicle transmissions with P2, power-split, and two-speed multi-mode hybrids. It covers five domains: thermal management, shift control, efficiency-oriented design, lightweight and NVH-aware optimization, and electromechanical integration. Evidence is assessed by study type and validation level. Additional ratios and modes can improve operating-point flexibility but add mechanical losses, shift events, calibration demands, and durability constraints. High-speed, integrated layouts can improve packaging and power density but increase thermal, lubrication, structural, and serviceability interactions. These trade-offs require system-level assessment. Rather than ranking architectures, the review identifies the conditions behind reported benefits and trade-offs that lack sufficient validation. Future priorities include common vehicle-level benchmarks, transparent system boundaries, and multi-domain experimental validation.

Keywords: new energy vehicles, dedicated transmission, dedicated hybrid transmission, systematic review, architecture–technology coupling, electromechanical integration

1. Introduction

New energy vehicles (NEVs) have changed the role of automotive transmissions. Here, NEVs include battery electric and hybrid vehicles with dedicated electrified transmissions; fuel cell vehicles are excluded. Internal combustion engines (ICEs) generally need several ratios because their useful torque and efficient operating ranges are limited. Electric machines offer high starting torque and a wider speed range, allowing simpler transmissions. Ratio selection must still account for motor efficiency, thermal limits, durability, and noise, vibration and harshness (NVH). Additional ratios may improve battery electric vehicle (BEV) acceleration, gradeability, or energy use, but added mass, drag, cost, and shift interruption can offset these gains [1]. Direct drive removes gearbox losses and complexity but increases motor torque-density and packaging demands [2]. Transmission value therefore depends on the whole powertrain, not gear count alone.

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The literature is divided by architecture and technical domain. Ahssan et al. reviewed multi-speed BEV performance, ratio selection, and shift interruption [1]. Wang et al. and Zhuang et al. classified planetary, series, parallel, power-split, and multi-mode hybrids, while Sieg and Küçükay compared dedicated hybrid transmission concepts [3-5]. Husain et al. and Wahid et al. covered broader electric-drive and drivetrain developments [6, 7]. Other studies examined lubrication and thermal management [8-10], shift control [11-13], gear efficiency [14-16], lightweight and acoustic design [17-19], and high-speed loading or power density [20, 21]. Evidence ranges from reviews and numerical models to component rigs, demonstrators, road measurements, and vehicle tests. These methods provide different levels of support and should not be treated as equivalent. Table 1 compares representative reviews and their cross-domain limitations.

The main gap is a systematic framework linking architectures to technical requirements and system-level trade-offs. Architecture choices change the operating conditions of gears, bearings, clutches, lubricants, housings, and controllers. Higher motor speed may reduce active-material demand but increase bearing speed, churning and windage losses, gear-mesh excitation, and cooling needs [20, 21]. A second BEV ratio may improve motor operating points, yet reported net benefits vary with motor maps, drive cycles, masses, loss models, and cost assumptions [1, 22-24]. Integrated drives reduce package volume and component count but strengthen thermal and vibration interactions [6, 8]. Each benefit must therefore be assessed with its architecture, boundary conditions, validation method, and related penalties.

A systematic search of Google Scholar, Web of Science, IEEE Xplore, and SAE Mobilus was updated in August 2026, covering publications from January 2013 to December 2025. Searches combined architecture terms—"new energy vehicle transmission", "electric vehicle gearbox", "multi-speed electric vehicle transmission", "dedicated hybrid transmission", "power-split", and "integrated electric drive axle" or "e-axle"—with "thermal management", "lubrication", "shift control", "efficiency", "topology optimization", "lightweight", "NVH", and "integration". Eligible English-language peer-reviewed journal articles and established conference papers examined dedicated NEV transmission architectures or directly addressed at least one of the five domains. Studies limited to conventional ICE transmissions, battery chemistry, or energy management without a transmission-design connection were excluded. Of 320 records, 26 remained after duplicate removal and title, abstract, and full-text screening. Reference metadata and DOI resolution were checked against publisher or journal records.

The review asks three questions: under what conditions do BEV and hybrid transmission architectures offer supported advantages; how does architecture affect the five technical domains; and where do differences in models, system boundaries, and validation prevent reliable comparison? Its architecture–technology evidence framework separates reported results from cross-study inference and records validation methods and cross-domain penalties, rather than assuming that component improvements produce vehicle-level gains.

Section 2 describes the review method; Section 3 compares BEV and hybrid architectures; Section 4 evaluates the five technology domains; Section 5 examines their interactions and system-level trade-offs; Section 6 identifies evidence gaps and research priorities; and Section 7 presents the conclusions. Figure 1 outlines this framework.

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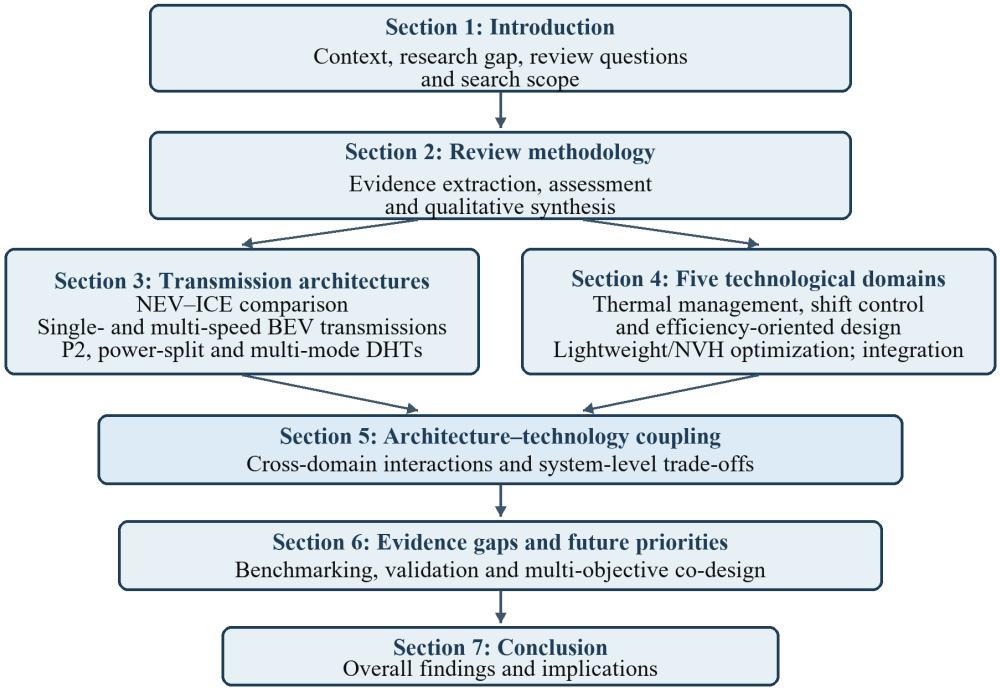


Figure 1. Architecture–technology framework and section structure of this review

Table 1. Comparison of representative reviews, their research scope and cross-domain limitations

Study	Primary scope	Cross-domain limitation
Ahssan et al.	Multi-speed BEV performance and complexity	Limited treatment of DHTs and integrated thermal/NVH trade-offs [1].
Wang et al.	Planetary hybrid architecture classification	Architecture-centered; limited component-technology synthesis [3].
Zhuang et al.	Hybrid powertrain configuration studies	Broad configuration survey; not focused on transmission component coupling [4].
Sieg and Küçükay	Benchmarking of DHT concepts	Limited coverage of thermal, lightweight and serviceability issues [5].
Husain et al.	Electric-drive technology trends	Broad electric-drive scope; limited transmission-architecture comparison [6].
Present review	BEV and hybrid architectures plus five enabling domains	Explicit architecture–technology coupling and evidence-gap analysis

2. Review methodology

2.1. Evidence extraction and assessment

The author alone screened records and extracted evidence, a limitation of this review. For each study, the extracted information covered architecture, objective, method, operating conditions, performance indicators, findings, validation level, and limitations. Reviews defined the scope and classifications, while original studies mainly supported design-specific conclusions. Numerical simulations, finite element analyses, component and powertrain rigs, road measurements, and vehicle tests were assessed separately because they provide different levels of evidence. Claims were included only when the cited study directly examined the relevant architecture or mechanism.

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2.2. Synthesis approach

Differences in vehicle mass, motor maps, ratios, drive cycles, thermal boundaries, loss definitions, and optimization constraints prevented quantitative meta-analysis. Evidence was therefore grouped by architecture and domain, then conflicting findings were examined for differences in assumptions, boundaries, or validation. For example, ratio-optimization simulations can show potential operating-point gains but cannot alone establish durability, production cost, or real-world energy savings. Table 2 summarizes the evidence categories and comparison limits. English-language selection, single-reviewer screening, and the absence of pooled effect estimates remain limitations.

Table 2. Evidence structure used in the synthesis

Domain	Evidence retained	Limit on inference
Architecture and ratio selection	Reviews; vehicle simulation; comparative optimization	Different motor maps, masses, drive cycles, component losses and cost assumptions
Thermal management and lubrication	Thermal models; demonstrator tests; road-temperature validation	Different fluids, speeds, cooling boundaries and durability periods
Shift control	Dynamic simulation; selected bench tests	Configuration-specific clutches, actuators and calibration conditions
Efficiency and gear design	Loss models; optimization; component experiments	Different duty cycles, geometries and auxiliary-loss boundaries
Lightweight and NVH	Finite element analysis; topology optimization; vehicle acoustic tests	Different structural constraints, materials and manufacturing assumptions
Integration and high-speed operation	Technology reviews; demonstrator powertrains	Limited comparative field durability, repairability and life-cycle evidence

3. Configurations of NEV dedicated transmissions

3.1. Essential differences between NEV dedicated transmissions and conventional ICE transmissions

Conventional multi-ratio transmissions keep an ICE within a useful operating region as vehicle speed and wheel-torque demand change. Electric machines have a wider speed range and high low-speed torque, so many BEVs can meet performance targets with one fixed reduction. Multiple ratios may still improve performance and efficiency, though they add mass, ratio-selection difficulties, and torque interruption [1]. Direct drive removes the gearbox but requires the motor to meet wheel-torque and packaging demands without mechanical reduction [2]. These architectures distribute speed, torque, loss, and mass differently across the powertrain.

Dedicated NEV transmissions are designed around electric-machine speed–torque characteristics, regenerative operation, and vehicle requirements rather than directly adapted from ICE platforms. They commonly use fewer ratios and components, but no layout suits every application [1, 2]. Comparisons therefore require common vehicle targets and system-loss boundaries.

Lower gear-mesh loss may not reduce vehicle energy use if it requires a larger motor, more cooling, or less efficient operation. An extra ratio offers a net benefit only when motor and inverter loss reductions outweigh added mechanical and actuator losses, mass, and control complexity.

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3.2. Single-speed reducers for mainstream battery electric vehicles

Single-speed reducers need no shift clutch or synchronizer and little control calibration. Their limitation is not a fixed vehicle-speed threshold: one ratio must meet launch torque, gradeability, maximum vehicle speed, motor-speed limits, and drive-cycle efficiency requirements. Results depend strongly on the motor map and duty cycle [1, 22, 24], making single speed a low-complexity baseline rather than an inherently inferior solution.

Ruan et al. compared single-speed, two-speed dual-clutch, and continuously variable BEV transmissions under common vehicle assumptions, finding trade-offs between energy use and customer cost [22]. Walker et al. showed that performance limits and range targets affect ratio selection [24]. Neither study establishes that a second ratio always benefits highway operation; its value depends on motor efficiency, added losses and mass, and the driving cycle. Figure 2 compares single-speed and two-speed structures.

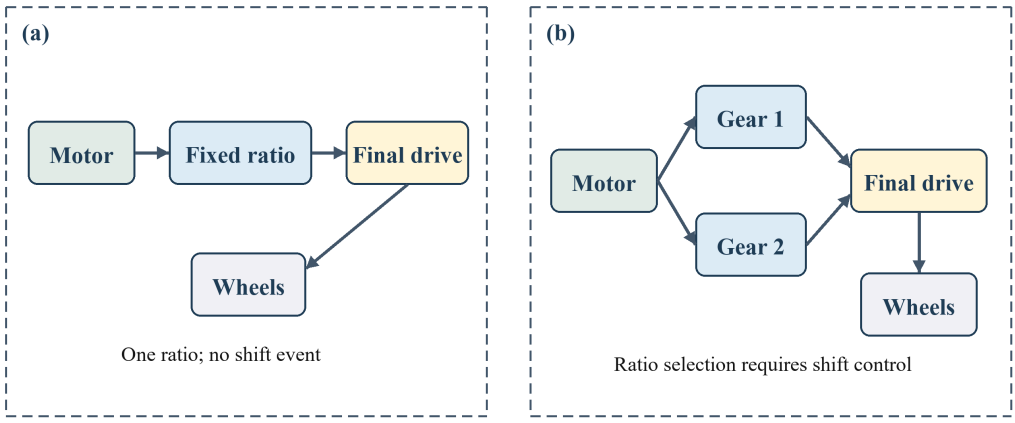


Figure 2. Conceptual structural comparison of (a) a single-speed reducer and (b) a two-speed BEV transmission

3.3. Multi-speed transmissions for high-performance battery electric vehicles

Two-speed BEV transmissions increase operating-point flexibility with fewer ratios than conventional transmissions. Ahssan et al. reported potential gains in acceleration, gradeability, and efficiency, alongside added mass and shift interruption [1]. Ruan et al. compared energy use and customer cost [22]; He et al. mainly simulated a two-speed layout and adaptive shift strategy [23]; and Walker et al. studied modelling and ratio selection without directly testing long-term durability [24]. Their reported gains cannot be compared numerically because vehicle assumptions, methods, and objectives differ.

The lower gear increases launch and climbing torque, while the higher gear can reduce motor speed in some high-speed conditions. Energy savings depend on the motor map, shift schedule, mechanical losses, and time spent in each operating region [22-24]. Evaluation therefore requires a defined duty cycle, not isolated operating points.

He et al. and Ruan et al. suggest that ratio design and shift control should be coordinated, but their simulation and comparative modelling lack vehicle-level experimental validation [22, 23]. They support conditional benefits rather than general replacement of single-speed reducers.

Torque interruption remains a key concern [1]. Tian et al. studied a novel two-speed BEV transmission through modelling and control analysis [13]. Tromayer et al. proposed a lightweight

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automatic powershift transmission for small BEVs, using load-point shifting to improve efficiency [25]. These studies offer ways to reduce interruption, but differences in structures and validation prevent identifying one mechanism suitable for every application.

Two-speed transmissions are worthwhile only when operating-point gains outweigh added mass, drag, actuators, control complexity, cost, and durability demands. Evidence supports selected duty cycles and performance requirements, but does not establish broad mainstream adoption; comparable long-term vehicle tests remain limited [1, 22, 23, 25].

3.4. Dedicated hybrid transmissions (DHTs) for hybrid electric vehicles

3.4.1. P2 hybrid configuration

In a P2 layout, the motor sits between the engine and transmission, with a disconnect clutch between the engine and motor. This parallel hybrid can retain existing transmission platforms and manufacturing systems, but still requires gear shifting and clutch coordination [4, 5]. Zhao et al. examined P2 shift control [11]; the original evidence reviewed here mainly addresses control performance, not adoption.

Motor-torque coordination can support P2 shifts, depending on clutch layout, actuator response, and calibration [11]. Unlike power-split systems, P2 retains stepped shifts, but generally has fewer power-flow modes than multi-mode DHTs and is easier to develop from an existing platform [4, 5].

3.4.2. Power-split hybrid configuration

Power-split DHTs connect an engine and two motor/generators through planetary gears, allowing engine speed to be partly independent of wheel speed. Wang et al. and Zhuang et al. classified different planetary arrangements, operating modes, and mechanical and electrical power paths [3, 4]. Sieg and Küçükay showed that comparisons also depend on vehicle and component assumptions [5]. One design therefore cannot represent all power-split DHTs.

Power-split layouts can vary the effective ratio without stepped shifts, reducing clutch-to-clutch torque interruption. However, power may circulate through both electric machines, with losses depending on component maps and planetary structure [3, 4]. Evidence supports smooth ratio control and flexible power flow, but not higher efficiency across every driving cycle.

Reviews emphasize power-split and multi-mode flexibility [3, 4], while benchmarking shows that relative performance changes with component sizes and operating assumptions [5]. High-speed electrical-path losses and manufacturing costs must therefore be treated as design-dependent.

3.4.3. Two-speed multi-mode DHTs for plug-in hybrid electric vehicles (PHEVs)

Two-speed multi-mode DHTs offer several power-flow states and more than one mechanical ratio. Zhuang et al. described multi-mode hybrids with series, parallel, and power-split operation [4]. The available modes depend on the gears, clutches, and electric machines, so they cannot be assumed identical across designs.

A supervisory controller can select the mode and ratio to match driving demand [4, 5], but this flexibility adds calibration cases and transitions. Liu et al. used simulation and bench tests to show that coordinated engine and motor torque reduced shift power interruption in a specific two-speed multi-mode DHT [12]. This validates the controller for the tested system, not a general efficiency advantage over P2 or power-split layouts.

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Reviews explain the potential of different power-flow paths [4, 5], while configuration-specific control studies address mode-switching transients [12]. It remains unclear whether extra modes provide a net vehicle-level benefit when actuator energy, clutch losses, calibration, durability, and cost are assessed consistently. Figure 3 shows the three hybrid power-flow arrangements.

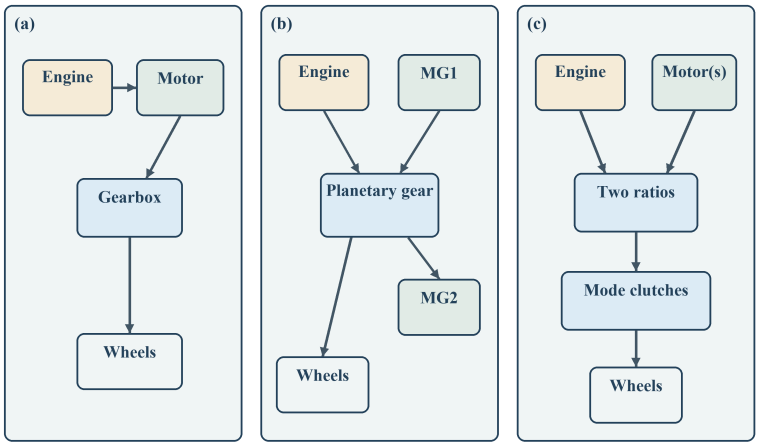


Figure 3. Conceptual power-flow representations of (a) a P2 hybrid, (b) a power-split hybrid, and (c) a multi-mode dedicated hybrid transmission (DHT)

Table 3. Conditional comparison of major transmission architectures.

Architecture	Principal benefit	Architecture-dependent burden	Best-supported application
Single-speed BEV reducer	Simplicity, low mass and no shift interruption	Ratio compromise between launch and sustained high-speed operation	Cost- and package-sensitive BEVs
Two-speed BEV transmission	Improved motor operating-point matching	Actuator, clutch/synchronizer loss and shift control	Selected performance or high-speed-duty BEVs
P2 hybrid	Compatibility with existing transmission families	Many mechanical elements and clutch coordination	Add-on hybrid platforms
Power-split DHT	Continuous ratio effect and smooth mode operation	Electrical-path loss and two-machine/control requirements	Full-hybrid duty with frequent speed/load variation
Two-speed multi-mode DHT	Flexible electric, series, parallel and direct-drive operation	High mode count, calibration and hardware complexity	PHEVs where operating-range flexibility justifies complexity

Table 3 presents architecture-dependent tendencies, not directly comparable numerical results. A common benchmark is needed before claiming universal efficiency advantages or a standard solution.

4. Key enabling technologies

4.1. Thermal management technology for high-speed transmission systems

High-speed operation changes the balance of gear-mesh, bearing, churning, windage, and pumping losses. Morhard et al. demonstrated demand-based lubrication with integrated thermal management in a high-speed powertrain [8]. Shore and Kadiric used a thermally coupled model validated by in-situ road-temperature measurements, finding that the lowest-loss lubricant viscosity depends on the drive cycle and balance of gear and bearing losses [9]. Shore et al. developed a related transmission-

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efficiency prediction method [10]. Despite different validation methods, these studies support joint lubrication and thermal design.

The Speed4E demonstrator reached 30,000 rpm with targeted oil delivery and integrated thermal management [8]. Its main contribution is the combined lubrication, cooling, and powertrain design; this speed is specific to the demonstrator and is not representative of all NEV transmissions.

Shore and Kadiric predicted the lowest loss with higher-viscosity fluid in low-speed stop-start driving, where gear-tooth friction mattered more, and lower-viscosity fluid in highway and WLTC operation, where bearing losses dominated [9]. Road-temperature data supported the model, but the results remain specific to the fluids, component models, and duties studied. Long-term lubricant durability in shared motor–gear circuits is still unproven.

4.2. Coordinated shift-control strategies

Coordinating motor torque with clutch and gear actions can maintain power continuity and limit shift disturbance. Zhao et al. aimed to balance P2 upshift jerk, clutch slipping work, and duration [11]. Liu et al. studied power continuity and torque impact in a two-speed multi-mode DHT through simulation and bench tests [12]. Tian et al. modelled a novel two-speed BEV transmission and analysed shifting [13]. Their general principle is similar, but different clutches, gears, and power sources require configuration-specific controllers.

The P2 and BEV studies are mainly model-based, while Liu et al. also provide bench validation [12]. None establishes robustness across temperature, wear, manufacturing variation, and repeated shifts over a full vehicle life. Evidence supports motor-torque coordination, but not a universal control trajectory or controller.

Load, road grade, temperature, friction, and aging can alter shift response outside calibration conditions. Ogawa et al. used deep reinforcement learning to reduce clutch judder in a simulated two-speed DCT under several friction coefficients [26]. Liu et al. instead developed and bench-tested observer-based control for a multi-mode DHT [12]. The first adapts control actions to changing conditions; the second uses a model-based observer to improve robustness. Both need broader hardware and safety validation.

4.3. High-efficiency transmission design

Transmission losses come from gear contacts, bearings, seals, lubricant churning, windage, and auxiliaries. Their shares vary with torque, speed, temperature, and lubricant condition [9, 10], so this review uses no universal transmission-loss percentage. System comparisons should include oil-pump, cooling-device, and shift-actuator energy.

Gear geometry can reduce loss while controlling transmission error and vibration. Ben Younes et al. optimized gear-unit loss and transmission error [14]; Gonzalez-Perez and Fuentes-Aznar studied double staggered helical gears with shortened teeth [15]; and Liu et al. considered torque and speed variation in high-speed gear reshaping [16]. Different gear forms, objectives, and validation conditions make their numerical gains design-specific.

Lower lubricant viscosity can reduce high-speed churning loss, but adequate oil films must protect loaded gear contacts [9, 10]. Geometry changes that reduce friction may also affect transmission error and manufacturing difficulty [14-16]. Efficiency comparisons should therefore state duty cycles, thermal conditions, durability constraints, and auxiliary-loss boundaries, rather than report peak efficiency alone.

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4.4. Topology optimization and lightweight design

Lightweight design must balance mass and material savings with stiffness, natural frequency, fatigue, manufacturability, and acoustic radiation. Liang et al. optimized a gearbox under multiple loads [17]. Shi et al. combined finite element analysis and vehicle tests to reduce two-speed BEV transmission noise [18]. Jäger and Linde combined housing topology optimization with manufacturing and cost analysis [19]. These studies address complementary objectives rather than mass alone.

Liang et al. mainly demonstrated a multi-load optimization method [17], while Shi et al. linked structural changes to vehicle acoustic measurements [18]. The latter provides stronger noise evidence for the tested design, but cannot be generalized to other housings. A simulated natural-frequency increase does not by itself establish lower vehicle noise.

Jäger and Linde reported about 21% simulated housing-mass reduction with only a small rise in rotational deformation [19]. Casting was more economical at higher production volumes, while additive manufacturing became more viable for small series. These findings depend on the housing, materials, production assumptions, and cost model; they cannot be extended to gears or shafts without separate evidence.

4.5. Electromechanical integration

Integration can reduce package volume and connection length while increasing power density. Husain et al. identified shared housings, shorter connections, compact power electronics, and higher power density as electric-drive trends [6]. Morhard et al. demonstrated powertrain-level lubrication and thermal design in one high-speed system [8]. These reviews and demonstrators support a development direction, not universal e-axle efficiency or cost benefits. Figure 4 compares separated and integrated three-in-one layouts.

Shared housings and cooling circuits require compatible fluids, electrical insulation, bearing lubrication, and adequate heat rejection [6, 8]. Speed4E illustrates integrated oil management, but does not show that one fluid suits every motor, inverter, bearing, and gear combination [8].

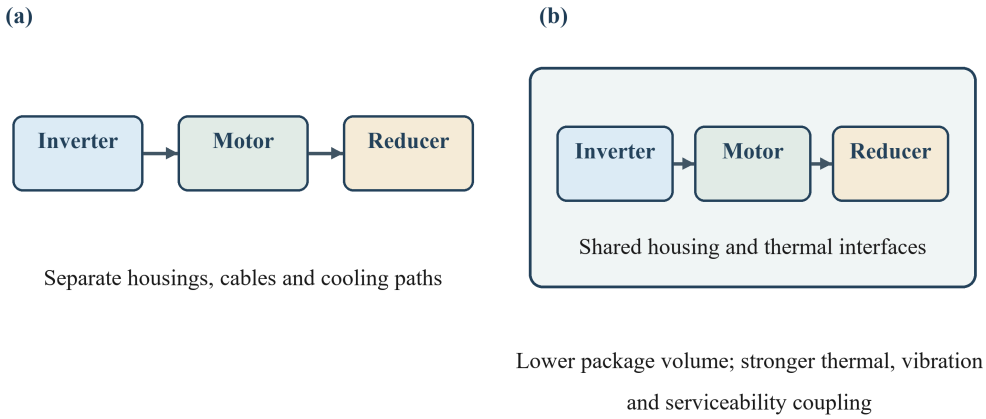


Figure 4. Conceptual comparison of (a) a separated electric drive and (b) an integrated three-in-one e-axle

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Integration connects motor, inverter, gear, and bearing heat paths, while a common rigid housing can transmit electromagnetic and gear-mesh vibration between subsystems [6, 8]. Evidence on serviceability, repair cost, electromagnetic compatibility, and field durability is less developed than package-density evidence. These remain research gaps rather than universal disadvantages. Section 4.1 discusses thermal requirements, and Table 4 summarizes the five domains.

Table 4. Five enabling domains, evidence and unresolved limitations

Domain	Supported design direction	Unresolved limitation
Thermal management	Targeted oil delivery and duty-dependent lubricant selection [8-10]	Long-term durability and fluid compatibility in shared motor–gear circuits
Shift control	Configuration-specific motor-torque coordination [11-13]	Robustness beyond model and selected bench conditions
Efficiency design	Duty-specific lubricant and gear-geometry optimization [9, 14-16]	Comparable system boundaries, durability and manufacturing constraints
Lightweight/NVH	Multi-load topology optimization and acoustic stiffness tuning [17-19]	Transfer from simulation to fatigue and vehicle-level acoustic performance
Electromechanical integration	Shared housing and powertrain-level thermal management [6, 8]	Comparative thermal, EMI, serviceability and life-cycle evidence

5. Architecture–technology coupling and system-level trade-offs

5.1. Why architecture and enabling technologies cannot be optimized separately

Architecture determines the distribution of speed, torque, losses, and shifts. Single-speed reducers avoid shift hardware but may require sustained high motor and bearing speeds. Two-speed and multi-mode systems add operating-point flexibility alongside actuators, rotating mass, torque paths, and calibration. Architecture selection therefore transfers losses and risks among components.

5.2. Coupling mechanisms

Four interactions matter most. Higher motor speed and reduction ratios connect power-density gains with bearing DN value, oil churning, gear-mesh frequency, and cooling needs [8-10, 20, 21]. Extra ratios improve motor operating points but add shifts, jerk, friction work, wear, and actuator-reliability demands [11-13]. Lower mass may reduce modal frequencies and increase sound radiation [17-19]. Integration improves package density but strengthens thermal and vibration interactions and raises unresolved serviceability questions [6, 8]. Peak efficiency or mass reduction alone cannot guide architecture selection because gains can transfer requirements to other domains. Table 5 links decisions, gains, penalties, and joint design needs.

Table 5. Architecture–technology coupling matrix.

Architecture decision	Primary gain	Coupled penalties	Required co-design response
Increase motor and input speed	Higher power density; smaller active material	Bearing speed, churning, windage, mesh excitation and heat	Ratio, bearing, oil circuit, gear microgeometry and housing modes
Add a second BEV ratio	Launch/highway operating-point flexibility	Shift interruption risk, actuator loss, mass and control complexity	Gear ratio and shift schedule optimized with thermal and wear limits
Add hybrid modes/clutches	More efficient power-flow choices	More transitions, calibration cases and failure modes	Topology and supervisory/shift control co-optimization

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Table 5. (continued)

Reduce housing/gear mass	Lower mass and material use	Reduced stiffness, altered modes and higher sound radiation	Multi-load, fatigue and acoustic constraints in topology optimization
Integrate motor, inverter and reducer	Compact package and shared subsystems	Thermal/EMI/vibration coupling and reduced serviceability	Joint electromagnetic–thermal–lubrication–structural design

6. Evidence gaps and future research priorities

6.1. Current evidence gaps

Three gaps limit comparison: inconsistent motor maps, masses, control objectives, duty cycles, and loss boundaries [1, 22-24]; uneven validation, with many simulation-led studies and only selected road, bench, or vehicle tests [9, 12, 18]; and incomplete reporting of auxiliary energy, cooling hardware, durability, manufacturing cost, and acoustics. The evidence therefore supports conditional design trends rather than a universal ranking.

6.2. Future priorities

Future studies should use common vehicle masses, performance targets, motor and inverter maps, duty cycles, temperature limits, and loss boundaries before increasing model complexity. High-speed designs need joint assessment of ratios, bearings, lubricants, oil delivery, and housings [8-10, 20, 21]. Shift controllers need common safety, robustness, and durability criteria: model-based robust control has configuration-specific bench validation [12], while learning-based control has mainly been tested under simulated friction variation [26]. Integrated e-axles need combined electromagnetic, thermal, lubrication, structural, serviceability, and life-cycle-cost assessment [6, 8]. Transparent assumptions and reusable experimental data would support quantitative meta-analysis.

7. Conclusion

This review linked dedicated NEV transmission architectures to five technology domains and distinguished review, numerical, rig, road, and vehicle evidence. No architecture ranks best universally. Single-speed reducers minimize shift hardware; extra BEV ratios can improve operating-point matching under selected conditions; and P2, power-split, and multi-mode hybrids distribute mechanical, electrical, and control demands differently [1, 3-5, 22, 23].

Benefits remain conditional because gains in speed, ratio flexibility, mass, or integration transfer requirements across mechanical, thermal, control, structural, and acoustic domains [1, 6, 8, 17-23]. Different validation methods also give these findings different strengths of evidence.

Future vehicle-level comparisons need transparent assumptions, consistent system boundaries, and validation across temperature, lubricant aging, clutch wear, and production variation. This would support quantitative effect-size comparisons in later reviews.

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