Original Research Article

Strategic Implications of Driver-Controlled Energy Deployment in the 2026 Formula One Power Units

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ABSTRACT

This paper analyzes how the Fédération Internationale de l'Automobile (FIA)'s changes to the 2026 Formula One (F1) regulations substantially alter how F1 cars will operate on track during races. Due to radical changes to the components in the 2026 power units, teams and drivers now have to optimize their energy harvesting and deployment strategies to be successful in this new era of F1. This paper examines how teams must adapt their energy optimization strategies to different circuit profiles under the 2026 regulations, which mandate a 50/50 power split and impose new battery energy constraints. Three circuits were analyzed: the Baku City Circuit, the Autodromo Nazionale Monza, and the Silverstone Circuit. For each circuit, energy harvesting in braking zones and energy depletion for straight segments were calculated to determine the total energy usage in megajoules (MJ) for a single lap. Publicly available telemetry data from 2024 qualifying sessions was extracted using a Python script with an open-source API from the FastF1 website. The analysis then examined whether the harvested energy was sufficient to meet the deployment needs or whether drivers would need different strategies to complete a lap around the circuit. Energy recovery potential varied by 2x (4.97 MJ - 9.94 MJ) across circuits, with only the Baku Circuit exceeding the 8.5 MJ regulatory limit. These findings demonstrate that the 2026 regulations shift competitive advantage towards driver skill in real-time energy management that is circuit-dependent versus a universal approach.

Keywords: Formula One; Power Unit Regulations; MGU-K; Energy Recovery System (ERS); Telemetry Analysis; Race Strategy

INTRODUCTION

The 2026 FIA technical regulations represent a fundamental shift in Formula One power unit architecture. The Motor Generator Unit – Heat (MGU-H) has been eliminated, and the MGU-K now operates at parity with the internal combustion engine in a 50/50 power split, substantially expanding the role of electrical energy in race performance (1). New driver-facing systems, including a Boost Button for configurable power deployment and an Overtake Mode that allows an additional 0.5 MJ of charging when racing within one second of a competitor, place energy allocation decisions at the center of race strategy in ways not seen under prior regulations (2).

Despite growing interest in F1 race optimization, the literature reveals a persistent gap at the intersection of within-lap energy management and circuit-level deployment opportunity. Existing frameworks by Fieni *et al*. (3), Heilmeier *et al*. (4–6), and Aguad & Thraves (7) treat energy management either as an input

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assumption or optimize it independently of the circuit characteristics that govern harvesting potential. No work has systematically characterized how braking zone structure, straight-line length, and throttle profile shape the balance between MGU-K harvesting and deployment across contrasting circuit types — a question made newly urgent by the 2026 regulations, which remove the MGU-H's continuous energy recovery buffer and force teams to rely entirely on kinetic and coasting recovery.

This paper addresses that gap by analyzing MGU-K energy recovery and deployment characteristics across three Formula One circuits — Baku, Monza, and Silverstone — under 2026 regulatory constraints, using FastF1 telemetry data to quantify the relationship between circuit profile and energy management opportunity.

METHODS AND MATERIALS

Study Design

This study employs computational modeling and secondary data analysis to evaluate energy recovery and deployment under the 2026 FIA F1 technical regulations. The analysis uses publicly available, anonymized telemetry data extracted from official F1 broadcasts via the FastF1 Python library (8). As Urdhwareshe (9) notes, cars generate continuous data streams related to tire wear, fuel consumption, engine performance, and track conditions. This telemetry enables real-time strategy adjustments. Each race circuit is divided into three sectors with lap times recorded to the thousandth of a second, providing the granular data resolution necessary for the braking zone analysis employed in the present study.

As the data are publicly accessible and contain no personally identifiable information, ethical approval was not required for this research.

Key Parameters

The following parameters were operationalized for energy calculations: regeneration efficiency (88%, representing MGU-K energy conversion efficiency during braking), deployment efficiency (95%, representing MGU-K energy conversion during acceleration), and brake-by-wire fraction (70%, representing the proportion of braking force directed to the MGU-K rather than mechanical brakes). Braking zones were defined as continuous braking events exceeding 50 meters in length with speed reduction greater than 20 km/h, ensuring capture of sustained deceleration events with meaningful kinetic energy loss while excluding brief brake applications and telemetry noise.

In order to establish the parameters of the system accurately, the study directly referenced (10), which provided specific data on the power unit. An energy flow diagram was developed based on the key energy transfer paths within the regulated vehicle as shown in Figure 1.

Using the diagram below, the energy regenerated and deployed for a single lap for 3 different types of F1 tracks was calculated. For these calculations, the profile of each track was analyzed for opportunities to regenerate or to deploy energy. The tracks selected for this analysis are Baku (street/heavy braking), Monza (power/ high speed), and Silverstone (high-speed corners). For these tracks, telemetry data were extracted from 2024 F1

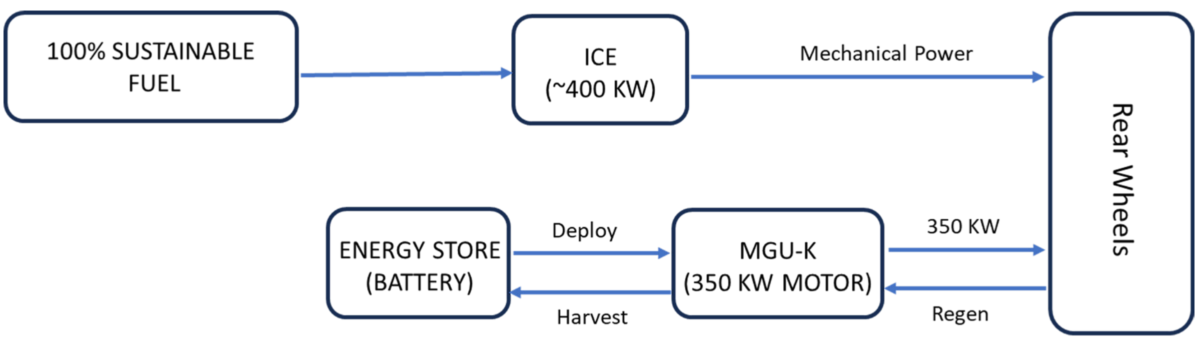

Figure 1. *Power unit diagram per the FIA 2026 F1 technical regulations (10). This diagram illustrates the simplified power unit architecture mandated for the 2026 Formula One season. The schematic shows the bidirectional energy flow between the internal combustion engine (ICE, 400 kW maximum), the Motor Generator Unit-Kinetic (MGU-K, 350 kW maximum), and the enlarged 3.6 kWh energy store (battery). The diagram indicates that the MGU-K can both harvest energy during deceleration (converting kinetic energy to electrical energy stored in the battery) and deploy energy during acceleration (converting stored electrical energy to additional motive power).*

qualifying sessions via the FastF1 Python library with ~4 Hz resolution (500 - 800 data points per lap) for speed, throttle position, brake application, and distance variables. For analysis, a braking zone was defined as one with a braking zone that had continuous braking (> 50 m with > 20 km/h speed reduction). The 50 m minimum was selected to ensure capture of sustained braking events rather than brief brake applications that do not provide meaningful energy recovery. The speed reduction threshold of > 20 km/h was selected to ensure substantial deceleration with significant kinetic energy loss. For energy calculation, the following formula was used:

$$E = 0.308m\,(v_{entry}^2 - v_{exit}^2) \text{ with mass: 798 kg | MGU-K efficiency: 88\% | Regen split: 70\%}$$

2026 F1 MGU-K Energy Model

The 2026 regulations were applied to define maximum energy usage and recovery redeployment parameters: MGU-K maximum power of 350 kW, an 8.5 MJ per-lap recovery and deployment limit, and a power taper between 290–345 km/h with a hard cutoff to 0 kW above 345 km/h. The full set of modeled parameters is presented in Table 1.

Track Selection and Data Sources

Three circuits were selected to represent contrasting energy management profiles: Baku (street circuit / heavy braking), Monza (power circuit / high speed), and Silverstone (high-speed corners / mixed character). For each circuit, telemetry data were extracted from the 2024 qualifying pole position lap via the FastF1 Python library at approximately 4 Hz resolution. The pole position lap was selected as the most representative high-performance lap, minimizing the effects of traffic and tire degradation. Data source parameters for all three circuits are consolidated in Table 2.

Baku Track

The Baku City Circuit shown in Figure 2 is characterized by its long main straight, along with smaller turns around its castle section. It is also the only circuit on the F1 calendar to feature 90º turns. This long straight implies high deployment demand to reach high speeds, paired with the shorter turn sections that will demand drivers to harvest energy in short “spikes”. This deployment is characterized as “spiky”. This circuit allowed the study to analyze how drivers have to strategize energy deployment and harvesting on a single main straight.

Table 1. *2026 FIA-compliant MGU-K energy model parameters. Regulated values are sourced from the 2026 FIA Technical Regulations; estimated values reflect assumptions applied in this study.*

Parameter	Value	Regulation Status
MGU-K Max Power (kW)	350	*FIA regulated*
MGU-K Max Recovery Rate (kW)	350	*FIA regulated*
Max Deployment per Lap (MJ)	8.5	*FIA regulated*
Battery SoC Delta Limit (MJ)	4	*FIA regulated*
ICE Power (kW)	400	*Estimated*
Battery Capacity (MJ)	4.5	*Estimated usable*
Min Vehicle Mass (kg)	798	*FIA regulated*
Fuel Load (kg)	100	*Adjustable - race start*
Regeneration Efficiency (%)	88	*MGU-K regen efficiency*
Deployment Efficiency (%)	95	*MGU-K deploy efficiency*
Brake-by-Wire Fraction (%)	70	*% braking to MGU-K*
Total Vehicle Mass (kg)	898	
MGU-K Power (KW)	350	
Full Deploy Duration (s) for 4 MJ	11.42	

Table 2. *Telemetry data source parameters for all three circuits. Data extracted from 2024 qualifying sessions via the FastF1 Python library.*

Parameter	Baku	Monza	Silverstone
Session	2024 Azerbaijan GP Qualifying	2024 Italian GP Qualifying	2024 British GP Qualifying
Lap type	Pole position lap	Pole position lap	Pole position lap
Tool	FastF1 Python library	FastF1 Python library	FastF1 Python library
Resolution	~4 Hz (795 pts/lap)	~4 Hz (616 pts/lap)	~4 Hz (496 pts/lap)
Data Quality	Verified	Verified	Verified

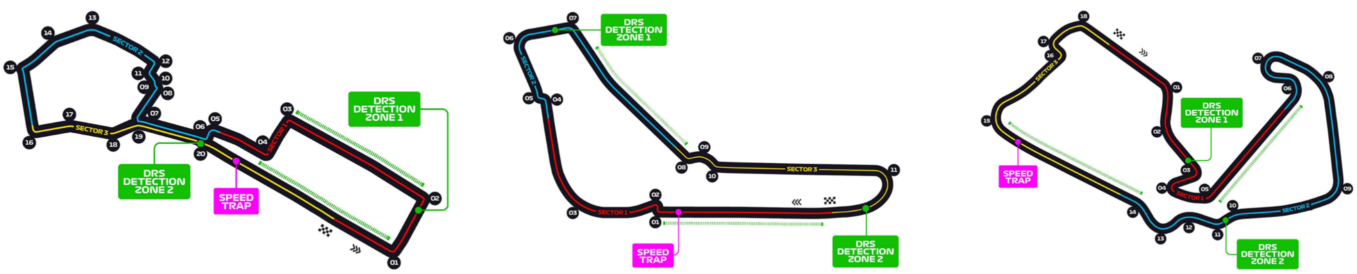

Figure 2. Left: *Baku F1 Grand Prix Track as of 2024. The Baku City Circuit is a 6.003 km street circuit located in Azerbaijan's capital, selected for this analysis as a representative "heavy braking" track type.* ***Middle****: Monza F1 Grand Prix Track as of 2024. Autodromo Nazionale Monza is a 5.793 km permanent circuit in Italy, selected for this analysis as a representative "high-speed/power" track type.* ***Right****: Silverstone F1 Grand Prix Track as of 2019. Silverstone Circuit is a 5.891 km permanent circuit in the United Kingdom, selected for this analysis as a representative "high-speed corners" track type. Source: Formula1.com. Official F1 website.*

Baku Track Sectors

Sector 1 (Start/Finish → T7)

Baku Sector 1 has a distance of ~2,500 m. It is characterized by heavy braking zones separated by acceleration. Key corners are T1 (heaviest braking), T2, T3 and the recovery potential is 5.88 MJ (59% of total).

Sector 2 (T7 → T15)

This sector spans approximately 1,200 meters and features the technical castle section before drivers accelerate toward Turn 15. The key corners include Turn 7 (the slowest point), Turns 8–12 through the castle complex, and Turns 13–14 which are taken flat-out. Recovery potential in this sector is 2.28 MJ, accounting for 23% of the total lap energy recovery.

Sector 3 (T15 → Start/Finish)

This sector covers approximately 2,300 meters, beginning with heavy braking into Turn 15 before drivers go flat-out onto the main straight. Turn 15 requires significant braking while Turns 16–20 are flat-out kinks. Recovery potential in this sector is 2.24 MJ, representing 23% of the total lap energy recovery.

Monza Track

The Autodromo Nazionale Monza shown in Figure 2 is a circuit known as the "Temple of Speed", since it is the fastest race of the year due to the majority of a single lap being completed at full throttle. This means that drivers have fewer braking zones to utilize throughout a lap. This year, this will translate to fewer energy harvesting opportunities since energy is harvested while braking. This circuit presented the study with a scenario where drivers are able to harvest less energy than they need to deploy in each lap.

Monza Track Sectors

Sector 1 (Start → Curva Grande)

This sector covers approximately 1,500 meters and is characterized by a long straight followed by heavy chicane braking. The braking zone is at Turn 1 (Variante del Rettifilo), with recovery potential of 1.92 MJ, representing 30% of the total.

Sector 2 (Curva Grande → Ascari)

This sector covers approximately 2,500 meters and features a technical section with multiple chicanes. The braking zones are at Turns 2, 3, 4, and 5, with recovery potential of 3.60 MJ, representing 57% of the total.

Sector 3 (Ascari → Start/Finish)

This sector covers approximately 1,800 meters, featuring the Ascari chicane followed by Parabolica acceleration. The braking zone is at Turn 6 (Ascari), with recovery potential of 0.85 MJ, representing 13% of the total.

Silverstone Track

The **S**ilverstone Circuit shown in Figure 2 has a profile that is between Monza and Baku. The circuit features numerous high-speed straights while also having challenging corners for drivers to navigate. This mixed profile allowed the study to analyze a more hybrid energy deployment and harvesting profile to consider optimizing driver strategies.

Silverstone Track Sectors

Sector 1 (Start/Finish → Loop exit)

The corners include Abbey (T1), Farm (T2), Village (T3), The Loop (T4), and Aintree (T5). The character is the Arena complex, featuring heavy braking zones and direction changes. Turn 4 of The Loop is one of the slowest corners on the track.

Sector 2 (Wellington Straight → Chapel exit)

The corners include Brooklands (T6), Luffield (T7), Woodcote (T8), Copse (T9), and Maggotts-Becketts-Chapel (T10-13). This entire sector only has one major braking zone, so it's all about speed and downforce. Maggots & Becketts is one of the most famous corner complexes in all of motorsport.

Sector 3 (Hangar Straight → Start/Finish)

The corners include Stowe (T15), Vale (T16), and Club (T17). This sector begins with the Hangar Straight heading down to the famous Stowe Corner, a high-speed right-hander. The uphill braking zone means you only really need to dab the brakes as you turn in.

Methodological Limitations

Several methodological limitations should be acknowledged. This study applied 2024 telemetry data to 2026 regulations, did not model tire degradation or fuel consumption, and used qualifying data rather than race conditions. Additionally, by omitting aerodynamic drag and rolling resistance, the energy recovery formula attributes all kinetic energy loss to recoverable braking energy, which overestimates actual recovery potential. The calculated recovery values of 9.94 MJ (Baku), 6.37 MJ (Monza), and 4.97 MJ (Silverstone) therefore represent theoretical upper bounds rather than achievable recovery values. However, since the same methodology was applied consistently across all three circuits, the relative comparisons and core strategic conclusions remain valid.

RESULTS

Baku F1 Track

Energy Recovery Potential

Across its braking zones, the Baku City Circuit generates a total recoverable energy of 9.94 MJ (Table 3), which exceeds the 2026 FIA regulatory limit of 8.50 MJ by 17%. The 1.44 MJ surplus indicates that the circuit produces more kinetic energy available than the regulations permit to be stored. Sector 1 alone contributes 5.88 MJ — 59% of the lap total — reflecting the concentration of heavy braking in the opening segment between the start/finish line and Turn 7. Sectors 2 and 3 contribute 2.28 MJ (23%) and 2.24 MJ (23%) respectively. Strategic implication: Baku is regulation-constrained. The binding limit on battery charge is the 8.5 MJ regulatory cap rather than the availability of braking events.

Table 3. *Baku City Circuit braking zone summary by sector. Recoverable energy per zone calculated from FastF1 telemetry using the kinetic energy recovery formula defined in Section 3.*

Corner	Entry Speed	Exit Speed	Braking Distance	Recoverable Energy
T1	328 km/h	129 km/h	105 m	1.862 MJ
T2	242 km/h	100 km/h	85 m	0.994 MJ
T3	286 km/h	99 km/h	106 m	1.474 MJ
T4	215 km/h	95 km/h	80 m	0.762 MJ
T5	224 km/h	114 km/h	65 m	0.761 MJ
T7	263 km/h	80 km/h	91 m	1.285 MJ
T8	206 km/h	124 km/h	53 m	0.554 MJ
T15	304 km/h	91 km/h	105 m	1.723 MJ
T16	205 km/h	129 km/h	59 m	0.520 MJ
TOTAL	—	—	**749 m**	**9.935 MJ**

Throttle State Distribution

The circuit is characterized by sharply bimodal throttle behavior. Full-throttle operation accounts for 59.6% of lap time at an average speed of 257 km/h, driven primarily by the 2.2 km main straight. Hard braking occupies 20.8% of the lap, leaving only 19.6% in partial-throttle states. Combined, full-throttle and braking phases account for approximately 80% of the lap with very little time spent in transitional throttle states. Table 4 presents the throttle state distribution across all three circuits; the high braking fraction is the direct consequence of Baku's frequent heavy-braking zones interspersed with flat-out acceleration, and it is this characteristic that drives the circuit's surplus energy recovery potential.

2026 MGU-K Strategy Implications

Baku's recorded top speed of 339 km/h falls within the 290–345 km/h taper zone but does not reach the 345 km/h cutoff. Full 350 kW MGU-K output is therefore available through the lower portion of the main straight acceleration phase, with a linear power reduction occurring in the upper speed range. Table 5 compares the power deployment profile across all three circuits; at Baku, the circuit never reaches the hard cutoff, making MGU-K deployment available throughout the entirety of the main straight.

Given that total recoverable energy of 9.94 MJ exceeds the 8.5 MJ regulatory cap, teams must actively manage which braking zones to prioritize for harvesting. The five highest-yield zones — T1 (1.862 MJ), T15 (1.723 MJ), T3 (1.474 MJ), T7 (1.285 MJ), and T2 (0.994 MJ) — together account for 7.338 MJ, or 73.8% of total recoverable energy (Table 6). An additional 1.16 MJ drawn from lower-yield zones T4, T5, T8, and T16 is sufficient to reach the regulatory limit. Two strategic options follow: Option A prioritizes the five highest-yield zones to front-load recovery efficiently; Option B front-loads recovery across T1–T5 to ensure maximum battery charge entering the main straight, optimizing for overtake and defense opportunities at the point of highest deployment demand.

Monza F1 Track

Energy Recovery Potential

Monza's six braking zones yield a combined recoverable energy of 6.37 MJ — 75% of the 8.50 MJ regulatory limit — as shown in Table 7. Unlike Baku,

Table 6. *Baku City Circuit Option A recovery strategy: prioritized harvesting by braking zone yield.*

Priority	Corner	Recovery
1	T1	1.862 MJ
2	T15	1.723 MJ
3	T3	1.474 MJ
4	T7	1.285 MJ
5	T2	0.994 MJ
Subtotal		7.338 MJ

Table 4. *Throttle state distribution across Baku, Monza, and Silverstone under 2026 MGU-K regulatory conditions. Full-throttle percentage determines the proportion of each lap unavailable for MGU-K energy harvesting. Each cell shows percentage of lap / average speed in that state.*

State	Definition	Baku	Monza	Silverstone
Full throttle	Throttle ≥95%, no braking	59.6% / 257 km/h	76.0% / 287 km/h	69.2% / 267 km/h
Braking	Any brake application	20.8% / 158 km/h	11.7% / 203 km/h	14.1% / 200 km/h
Partial throttle	Throttle <95%, no braking	19.6% / 116 km/h	12.3% / 169 km/h	16.7% / 168 km/h

Table 5. *MGU-K power deployment by speed zone across Baku, Monza, and Silverstone under 2026 FIA regulations.*

Speed Zone	MGU-K Power	Baku (339 km/h)	Monza (347 km/h)	Silverstone (324 km/h)
0–290 km/h	350 kW (full)	Full straight acceleration	~40% of straights	All acceleration phases
290–345 km/h	350→0 kW (taper)	Upper main straight	~50% of straights	Not reached
>345 km/h	0 kW (ICE only)	Not reached	Reached at 347 km/h	Not reached

Table 7. *Autodromo Nazionale Monza braking zone summary. Recoverable energy per zone calculated using the same kinetic energy recovery formula applied at Baku.*

Corner	Name	Entry Speed	Exit Speed	Braking Distance	Recoverable Energy
T1	Variante del Rettifilo	319 km/h	89 km/h	114 m	1.921 MJ
T2	Curva Grande approach	317 km/h	118 km/h	102 m	1.772 MJ
T3	Variante della Roggia entry	263 km/h	217 km/h	72 m	0.452 MJ
T4	Variante della Roggia exit	248 km/h	200 km/h	50 m	0.440 MJ
T5	Lesmo complex	296 km/h	205 km/h	62 m	0.933 MJ
T6	Ascari	307 km/h	230 km/h	81 m	0.847 MJ
TOTAL	—	—	—	481 m	6.365 MJ

the circuit does not generate sufficient braking energy to reach the allowable cap, leaving a 2.14 MJ per-lap shortfall. Recovery is heavily concentrated at T1 (Variante del Rettifilo) and T2 (Curva Grande approach), which together contribute 3.693 MJ — 58% of the circuit total. The four remaining zones each yield below 1.0 MJ. Strategic implication: Unlike Baku, Monza does NOT produce enough braking energy to fill the battery. Teams will be energy recovery-limited, not regulation-limited. Monza is recovery-constrained; Baku is regulation-constrained. They present opposite optimization challenges.

<u>Throttle State Distribution</u>

As shown in Table 4, Monza records the highest full-throttle percentage of the three circuits analyzed. Cars operate at maximum throttle for 76.0% of the lap, at an average speed of 287 km/h as shown in the table below. Braking accounts for just 11.7% of lap time across only six zones, and partial-throttle phases are correspondingly minimal at 12.3%. Monza is the most full-throttle dominant circuit on the calendar. Cars spend over 3/4 of the lap at maximum power, with only brief heavy braking into chicanes. The low braking percentage directly limits MGU-K energy recovery.

<u>2026 MGU-K Strategy Implications</u>

As shown in Table 5, Monza is distinguished as the only circuit in this analysis where cars exceed the 345 km/h MGU-K cutoff, reaching a recorded top speed of 347 km/h. At this speed, MGU-K output is zero and propulsion is provided by the ICE alone. Approximately 40% of straight-line running occurs below 290 km/h where full 350 kW output is available, while roughly 50% takes place within the taper zone. The combination of a recovery shortfall and a deployment cutoff at peak speed creates a compounding strategic constraint: teams cannot fully charge the battery from braking events alone, and cannot fully deploy MGU-K power at the point of highest vehicle speed. Deployment must therefore be concentrated in the lower-speed acceleration phases exiting the chicanes.

Silverstone F1 Track

<u>Energy Recovery Potential</u>

As shown in Table 8, Silverstone yields the lowest total recoverable energy of the three circuits, at 4.97 MJ which is 58% of the regulatory limit. Only five corners produce significant braking events, defined here as zones with approach distances above 50 m and speed differentials exceeding 20 km/h. The remaining corners are either taken flat or require only a lift, contributing negligible recovery energy. T2 Farm and T15 Stowe are the dominant recovery zones, contributing 1.424 MJ and 1.233 MJ respectively, for a combined 2.657 MJ — 53.5% of the circuit total. Entry speeds across all five zones are tightly clustered between 270–276 km/h, reflecting Silverstone's characteristically uniform high-speed approach velocities indicating that speed differential rather than entry speed is the primary driver of zone-to-zone variation in recovery yield.

<u>Throttle State Distribution</u>

As shown in Table 4, full-throttle operation accounts for 69.2% of lap time at an average speed of 267 km/h, placing Silverstone between Baku (59.6%) and Monza (76.0%) in full-throttle intensity. Braking occupies 14.1% of the lap across its five significant zones, and partial-throttle phases — associated with the circuit's high-speed lift-and-coast corners — account for 16.7%, the highest

Table 8. *Silverstone Circuit braking zone summary. Only five corners meet the significance threshold.*

Corner	Entry	Exit	Braking Distance	Recoverable Energy
T1 Abbey	270 km/h	150 km/h	72 m	1.032 MJ
T2 Farm	275 km/h	78 km/h	91 m	1.424 MJ
T6 Brooklands	271 km/h	201 km/h	69 m	0.676 MJ
T15 Stowe	271 km/h	115 km/h	90 m	1.233 MJ
T16 Vale	276 km/h	216 km/h	76 m	0.604 MJ
TOTAL	—	—	398 m	4.969 MJ

partial-throttle fraction of the three circuits. These lift-and-coast phases represent a secondary harvesting opportunity that is largely absent at Baku and Monza.

2026 MGU-K Strategy Implications

As shown in Table 5, Silverstone's recorded top speed of 324 km/h remains entirely below the taper threshold, meaning full 350 kW MGU-K output is available across all acceleration phases without restriction. However, with only 4.97 MJ recoverable per lap, teams face a structural energy deficit of 3.53 MJ relative to the regulatory limit. Silverstone therefore demands conservative deployment discipline — full MGU-K power is always available in principle, but the limited harvesting budget requires teams to prioritize deployment.

DISCUSSION

The energy calculations done across the three circuits demonstrate that energy recovery potential and deployment vary depending on track layout, as different layouts provide different turn braking zones and straight lengths that drivers need to traverse. These three circuits provide three examples of strategic profiles under the 2026 F1 regulations for MGU-K: spike deployment, depletion deployment, and hybrid deployment.

This selection tests whether the 2026 energy regulations will affect all circuits equally or create track-specific strategic challenges. For each circuit, braking zones were identified from 2024 qualifying telemetry, energy recovery potential was calculated using the methodology described above, and deployment requirements were assessed against the regulatory constraints. The results reveal that track characteristics produce substantial variation in both the quantity of recoverable energy and the strategic complexity of its deployment.

The Baku City Circuit is a prime example of a spike deployment circuit layout under the new 2026 regulations. This circuit's 9 braking zones, which total around 749 meters, allow around 9.94 MJ of energy recovery for a single lap, which is 117% of the 8.5 MJ regulated in the 2026 FIA technical booklet. This surplus of recoverable energy indicates that drivers are less energy-constrained while driving on this circuit, allowing for less of a focus on lift-and-coast strategies and battery energy management when deciding on primary strategies. Drivers cannot harvest all of this available energy; however, they will still have to optimize which braking zones to focus on for harvesting. The braking zones that allow for the most recovery of energy are T1, T3, and T15, each harvesting 1.862 MJ, 1.474 MJ, and 1.723 MJ, respectively, accounting alone for a recovery of 5.05 MJ. This is around 59% of the regulation's maximum limit. This means that the 2.2 km long main straight of the circuit has available MGU-K power for the full acceleration of the car. Baku has high-harvesting zones that allow for strategic deployment on the main straight, allowing for spikes of short, high-energy deployments.

The Baku analysis demonstrates that heavy-braking street circuits generate substantial energy recovery opportunities, nearly 10 MJ per lap, creating a potential energy surplus under 2026 regulations. However, not all circuits offer such favorable recovery conditions. Monza presents the opposite challenge: as the fastest circuit on the calendar, its extended full-throttle sections demand significant energy deployment while offering fewer heavy braking events for recovery. This contrast tests whether energy surplus at one track type translates to energy deficit at another.

The Autodromo Nazionale Monza represents a depletion deployment circuit profile. This circuit has drivers spending 76% on a lap at full throttle, which is the highest percentage of any of the circuits on the calendar.

This only leaves 481 meters total from 6 braking zones for cars to harvest energy from. Cars can recover around 6.37 MJ of energy, which is only 75% of the 8.5 MJ regulated in the 2026 FIA technical booklet, leaving a deficit of 2.14 MJ regardless of driver strategies. This means that drivers are not regulation-constrained on energy deployment for this circuit, but instead energy recovery constrained, requiring more strategizing for teams to plan for superclipping and lift-and-coast sections. Monza is also one of the only circuits on the calendar to have a straight that exceeds the regulated 345 km/h MGU-K limit, instead reaching up to 347 km/h. This means that momentarily, only ICE propulsion is used at this high speed straight, leading to less decisiveness for the MGU-K in comparison to other circuits on the calendar. Drivers must use their 6.37 MJ total harvested energy selectively at this circuit and should prioritize the Parabolica exit to enter onto the main straight to be able to reach a high-top speed at full throttle.

Where Baku and Monza represent opposite extremes, heavy braking versus high-speed straights, Silverstone introduces a third distinct profile: high-speed corners. Unlike Monza's chicane-based braking or Baku's stop-and-go character, Silverstone's flowing corners such as Maggots-Becketts-Chapel require drivers to scrub speed gradually through sustained lateral load rather than sharp deceleration. This track type tests whether the kinetic energy recovery formula, which depends on deceleration intensity, can capture sufficient energy when speed is lost through cornering rather than braking.

The Silverstone Circuit is a hybrid deployment circuit profile, yet it is more skewed towards being a depletion profile over a spike profile. Even though the circuit is characterized by its long straights with drivers reaching high speeds, this circuit has the lowest calculated energy recovery of all the analyzed circuits at just 4.97 MJ, which is just 58% of the regulated 8.5 MJ limit. This deficit of available energy is caused by its famous high-speed corners: Copse (264 km/h), the Maggots-Becketts-Chapel section (269 km/h), Farm (320 km/h), Aintree (230 km/h), and Luffield (233 km/h). All of these corners do not require braking zones for drivers, so they do not have any energy recovery opportunities throughout these high-speed sections. Only 5 of Silverstone's corners have braking zones for sufficient energy harvesting opportunity. The battery is never full, creating a severe deployment constraint. Village (T3) is critical, providing 1.42 MJ (29% of total).

The high-speed limit of 345 km/h is not reached, only getting as high as 324 km/h, meaning that MGU-K power is available throughout all acceleration zones for drivers to utilize. With only 4.97 MJ available per lap, drivers cannot sustain full deployment on all straights. They must prioritize the Wellington Straight, then Hangar Straight, then Pit Straight. Deployment should be saved for overtaking and defense moments. The driver may need to coast in some sections to preserve energy.

The strategic implication of this circuit's energy recovery deficit is that teams and drivers have to be largely selective in energy deployment, as well as having to superclipping and lift-and-coast in high-speed corners to make up for fewer deployment opportunities.

Comparing results across the three circuits reveals a clear pattern: track archetype fundamentally determines energy management strategy under the 2026 regulations. Baku's heavy-braking profile yields 9.94 MJ of theoretical recovery, nearly 117% of the 8.5 MJ deployment limit, suggesting teams could employ aggressive superclipping strategies to bank energy for critical race moments. Monza's 6.37 MJ recovery creates a tighter energy budget requiring precise allocation across its three chicanes and pit straight. Most critically, Silverstone's 4.97 MJ recovery falls below the deployment limit, indicating that high-speed-corner circuits may face structural energy deficits that no amount of driver skill can overcome. These findings suggest that the 2026 regulations will not simply change how teams manage energy—they will create fundamentally different strategic landscapes at different circuit types.

Comparison with Prior Literature

These findings align with and extend prior research on F1 energy management. Fieni *et al*. (3) identified energy allocation as the hardest optimization variable compared to tire and pit stop decisions, a finding strongly supported by the present analysis. The twofold variation in recovery potential across circuits (4.97–9.94 MJ) demonstrates why energy optimization cannot be standardized across the calendar. Furthermore, while Heilmeier and colleagues (4–6) developed race simulation tools incorporating tire degradation and fuel consumption, their models treated energy deployment as an input rather than an optimized output. The present study suggests this approach may be insufficient under 2026 regulations, where circuit-dependent recovery constraints will fundamentally shape deployment possibilities. The sector-wise analysis methodology employed here builds upon the approach demonstrated by Bopaiah and Samuel (11), who examined ERS performance across different track sectors during the 2019 season.

Limitations

Several limitations should be considered when interpreting these results. First, by applying 2024 telemetry data to 2026 regulations, absolute energy values carry uncertainty; however, since all three circuits were analyzed using identical methodology, relative comparisons remain valid. Second, the omission of aerodynamic drag and rolling resistance from the energy recovery formula means the calculated values (9.94 MJ, 6.37 MJ, 4.97 MJ) represent theoretical upper bounds rather than achievable recovery. Actual on-track recovery would be lower due to energy dissipated through these forces. Third, qualifying data represents optimal single-lap performance with fresh tires and low fuel, whereas race conditions involve tire degradation, higher fuel loads, traffic, and conservative braking—factors that would alter energy recovery patterns. Fourth, this analysis does not model the Overtake Mode (+0.5 MJ) or Boost Button features, which will introduce additional strategic complexity. Despite these limitations, the core finding—that most circuits are recovery-constrained rather than regulation-constrained—is robust to these uncertainties and has significant implications for 2026 race strategy development.

CONCLUSION

Driver-controlled energy deployment in the 2026 F1 regulation creates circuit-dependent strategic trade-offs that are not present under 2014–2025 regulations. The shift from automated to manual energy management transfers critical race decisions from engineers to drivers in real-time, putting more stress on driving skills versus car design. The results in this paper highlighted that recovery potential varies twice across circuits: 4.97 MJ in Silverstone and 9.94 MJ in Baku. Only Baku exceeds the 8.5 MJ regulatory limit. Most circuits are recovery-constrained, not regulation-constrained. High-speed corners (e.g., Copse, Maggotts-Becketts) provide zero recovery despite being iconic challenges. Furthermore, the first chicane dominates recovery at all three circuits (29–38% of total), and Monza is the only circuit where cars exceed the 345 km/h MGU-K cutoff, creating ICE-only zones

The strategic implications of these results are that teams must develop circuit-specific energy maps and cannot rely on a universal strategy. Drivers face real-time trade-offs: deploy instantaneously for position versus conserving for later defense. For example, the Overtake Mode (+0.5 MJ when within 1 second) rewards aggressive racing but, in trade, requires energy discipline. Recovery-limited circuits (Silverstone and Monza) demand maximizing every braking zone; drivers risk recovering significantly less energy than they need to deploy. Regulation-limited circuits (Baku) require prioritizing which zones to harvest.

The broader significance of the results is that 2026 regulations will likely shift competitive advantage toward driver skill in energy management as well as teams with superior models of the battery state-of-charge. Energy decisions will be further compounded by unpredictable events (safety cars, wet weather). This aligns with Fieni *et al.* (3) finding that energy allocation remains harder to optimize than tire/pit strategy.

Future research can be done to extend analysis to the full 22-race F1 calendar for 2026, model race conditions (tire degradation, fuel load, traffic), simulate the Overtake Mode and Boost Button features, simulate different activation patterns, and validate against 2026 season telemetry when it is available. These suggestions will better reflect applications of F1 cars in actual races under real-life, unpredictable circumstances. Research with these suggestions will also better reflect racing with multiple cars to model different energy strategies and modes. For example, modeling back-and-forth battles of cars on straights and corners on different circuits will allow for a better understanding of the strategic implications of energy usage as a reflection on the overall effectiveness of the 2026 regulation changes on the sport of F1.

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this work.

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